Annexure-5

UNIVERSITY OF DELHI
MASTER OF SCIENCE (ELECTRONICS)
based on
NEP-PGCF-2024

As approved in the meeting of 'Committee of Courses' held on 11th March 2025, in the meeting of 'Faculty of Interdisciplinary and Applied Sciences' held on ____17th March, 2025_________, and meeting of 'Standing Committee' held on _____________

PROGRAMME BROCHURE

XXXXX Revised Syllabus as approved by Academic Council on XXXX, 2025 and Executive Council on YYYY, 2025

I. About the Department

Background of Department

The Department of Electronic Science was established in 1985 and is widely recognised as one of the most prestigious Electronic Science Departments in the country.

The Department is conducting courses leading to M.Tech. in Microwave Electronics and M.Sc. in Electronics. The aim of these programmes is to provide the necessary theoretical background and practical experience in order to meet the requirements of the R&D Organizations and Industries. In addition, the M.Tech. students work for 6 months on projects in collaboration with Industry and R&D Organisations and the M.Sc. students do in-house six months projects in the final semester. The curriculum of these courses is updated regularly to keep it in consonance with the changing industrial environment. Workshops/ seminars and hands-on workshops are organized on a regular basis to bridge the gap between academia and industry, and to provide requisite exposure to the students about the latest technological developments taking place in varied areas related to microelectronics, microwaves, communication, photonics etc. The interface with industry is further enhanced by an annual seminar under the Visitors' Programme in which professionals from industry, R&D organizations and academics are invited. Our alumni, now spread over a large number of government and private organisations, facilitate these interactions.

A full range of resources and facilities are available to the students. The Department has a well-equipped computer laboratory with various circuit simulation and microwave design software for students. In addition, there are well equipped laboratories for experimental work in the following areas: Microwave Measurements, Communication Electronics, Circuit Design, Electronic Materials and Semiconductor Devices, Microprocessors and Digital Signal Processing, Optical Electronics, Anechoic chamber and Microwave Component Fabrication. An assessment of students' performance is made through continuous series of tests and presentations in addition to semester end examinations to ensure highest standards.

The Department is actively helping the students in their placement through Campus interviews. Students graduating from the Department have found positions in both government and private organizations working in the areas of Semiconductors, Information Technology, Telecommunications, Defence and Space Applications, etc. The students graduating from the programs have the necessary theoretical and practical skills to take on any R&D and Production responsibilities in today's complex and challenging environment. This is evident from the contributions and achievements of our alumni in organizations like ST Microelectronics, Cadence, HFCL, Aricent, Transwitch, SAMEER, ISRO, Keysight Technologies, VVDN Technologies, DRDO laboratories like DEAL, LRDE and many more.

Department Highlights

The Department is well established with thirteen faculty members. Extramural grants from DST, CSIR, DRDO, ISRO, etc as well as intramural grants from the University of Delhi, have strengthened the Department's research. The Department was also funded under the DST-FIST, UGC 12th plan and DU-DST PURSE programs. The Department has well-equipped teaching and research laboratories with state-of-the-art equipment for fabrication, characterization and measurement in the areas of microwave measurement, electronic materials and semiconductor devices, communication electronics, photonics etc. A large number of TCAD and EDA tools are also available that further enhances and strengthens teaching and research. The students graduating from these programmes acquire the necessary theoretical and practical skills to take up roles in R&D organizations, academia as well as industry. Since the inception of these programmes, the Department has witnessed several success stories and our students have done exceptionally well and are placed in some of the most reputed government as well as private organizations such as SSPL, NPL, DEAL, IRDE, BEL, SAMEER, ISRO, Keysight technologies, VVDN Technologies, ST Microelectronics, cadence, NXP ARM, etc.

About the Program

The M.Sc. Electronics program offered by University of Delhi is of two years' duration and is divided into four semesters. The various courses of the program are designed to include classroom teaching and lectures, laboratory work, project work, viva, seminars, and assignments. Six categories of courses are being offered in this program: Department Specific Core (DSC) Courses, Department Specific Elective (DSE) Courses, Generic Elective (GE) courses (student may opt for any of the Generic Elective courses offered by any other Department of the Faculty of Interdisciplinary and Applied Sciences), Skill Enhancement Courses (SEC), Research methods/ techniques of research writing, and Dissertation/Problem based Research work. The Core Courses and Discipline Specific Elective Courses are four-credit courses. The Generic Electives are also four-credit courses. The student is required to accumulate twenty-two credits each semester i.e. a total of eighty-eight credits over four semesters to fulfil the requirements for a Master of Science degree in Electronics (two-year program), and forty-four credits over two semesters to fulfil the requirements for a Master of Science degree in Electronics (one-year program).

About Post-Graduate Attributes

The curriculum is designed to train the students in basic and advanced areas of Electronics, keeping in mind the latest advances in the field. Particular emphasis is laid on the practical aspects of the field. Students are taught how to plan experiments, perform them carefully, analyze the data accurately, and present qualitative and quantitative results. To enable them to develop speaking and presentation skills they are encouraged to deliver seminars on a wide range of topics covering the different areas of Electronics. This enhances their assimilation abilities. A major component of their course in Structure 2 and Structure 3 is a research project they undertake in their final year. The student is guided in choosing a research problem, executing experiments related to it, collecting data and analyzing it, and presenting the results in the form of an oral presentation as well as a thesis. The student presents their research orally at the end of the final semester of the program, coupled with a viva-voce exam. This not only equips the student for a career in research/ industry, but also fosters self-confidence and self-reliance in the student as they learn to work and think independently. At the end of the program the student will be well-versed in essential electronics as well as the most recent advances in varied specialized areas. Thus, the program will prepare students for various opportunities in academia or industry, and equip them to pursue a career in research if so desired.

Program Objectives (POs):

At the time of completion of the program the student will have developed extensive knowledge in varied areas of Electronics. Through the stimulus of scholarly progression and intellectual development, the program aims to equip students with excellence in education and skills, thus enabling them to pursue a career of their choice. By cultivating talents and promoting all-round personality development through multidimensional education, a spirit of self-confidence and self-reliance will be infused in the student. The student will be instilled with values of professional ethics and be made ready to contribute to society as responsible individuals.

Program Specific Outcomes (PSOs):

At the end of the two-year program, the student will gain requisite exposure in different branches of Electronics such as Microelectronics, RF & Microwaves, Communication and Photonics, Digital Signal Processing, Terahertz Technology etc. They will be able to design and execute experiments related to advanced Analog and Digital Circuits, Signal Processing, Embedded Systems, RF& Microwave Systems, and Optical Communication. They will also be able to execute a research projects in varied areas under supervision. The student will be equipped to take up a suitable position in academia or industry, and pursue a career in research if desired.

About Program Structure

The M.Sc. Electronics program is a two-year program divided into four semesters, or a one-year program divided into two semesters. A student has to accumulate twenty-two credits in each semester. Under the two-year M.Sc. program a student is required to complete eighty-eight credits for completion and award of M.Sc. degree, while under the one-year M.Sc. program a student is required to complete forty-four credits for completion and award of M.Sc. degree. The program structure is based on the Post Graduate Curricular Framework (PGCF) under New Education Policy (NEP)-2020. Under PGCF, in the first year of the two-year program, the student is required to study mandatory Discipline Specific Core courses (three DSC in each semester) and a total of four / Discipline Specific Elective courses (two DSE in each Semester). In lieu of one DSE in each Semester, the student may choose to study a Generic Elective course offered by any other Department of FIAS. In addition, the student will also be required to study one mandatory Skill enhancement course (SEC) in each semester of the first year. In the second year of the two-year program, the student will have an option to choose any one of the three structures: Structure 1 (PG with only coursework), Structure 2 (PG with coursework and research), or Structure 3 (PG with coursework and more emphasis/weightage on research). The details regarding these structures have been summarized in tabular form.

Course Credit Scheme

Structure-1: (PG with only coursework)

Sem	*Core courses*		*Elective courses*		*Skill based courses*		*Res Method courses*		*Dissertation/ Project*		*Total Credits*
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	3	12	1	2	-	-	-	-	22
IV	2	8	3	12	1	2	-	-	-	-	22
Total Credits	**40**		**40**		**8**		**-**		**-**		**88**

Structure-2: (PG with coursework and research)

Sem	*Core courses*		*Elective courses*		*Skill based courses*		*Res Method courses*		*Dissertation/ Project*		*Total Credits*
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	2	8	-	-	-	-	1	6	22
IV	2	8	2	8	-	-	-	-	1	6	22
Total Credits	**40**		**32**		**4**		**-**		**12**		**88**

Structure-3: (PG with research)

Sem	*Core courses*		*Elective courses*		*Skill based courses*		*Res Method courses*		*Dissertation/ Project*		*Total Credits*
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	1	4	1	4	-	-	2	4	1	10	22
IV	-	-	1	4	-	-	1	2	1	16	22
Total Credits	**26**		**24**		**4**		**6**		**26**		**88**

SEMESTER-WISE PROGRAM STRUCTURE of M.Sc. ELECTRONICS COURSE (NEP-PGCF)

First year (common in Structure 1, 2 and 3)

Semester-1

	Credits in each course			
	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-01: Network Theory and Filter Design	3	1	0	4
DSC-02: CMOS Analog Circuit Design	3	1	0	4
DSC-03: Digital Circuit Design	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-01: Mathematical Techniques and Applications	3	1	0	4
DSE-02: Signal Processing and Control	3	1	0	4
DSE-03: Soft Computing Techniques	3	1	0	4
DSE-04: Advanced Sensors and Transducers	3	1	0	4
Generic Elective courses*				
GE-01: Modern Engineering Applications of RF and Microwave Spectrum	3	0	1	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
SEC-01: Fabrication & Testing Laboratory	0	2	0	2
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
-	-	-	-	-
Total credits				

***** *(a student can opt for either two DSE course, or one DSE with one GE)*

Semester-2

	Credits in each course			
Course	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-04: Advanced Electronic Materials and Devices	3	1	0	4
DSC-05: Real Time Embedded System Design & IoT	3	1	0	4
DSC-06: Electromagnetics, Antenna and Propagation	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-05: RF and Microwave Components	3	1	0	4
DSE-06: CMOS Digital Integrated Circuit Design	3	1	0	4
DSE-07: Opto-electronics	3	1	0	4
DSE-08: Terahertz Technology and Applications	3	1	0	4
Generic Elective courses*				
GE-02: Introduction to Brain-Computer Interface	3	0	1	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
SEC-02: Embedded-IoT Product Development and Testing	0	2	0	2
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
-	-	-	-	-
Total credits				22

***** *(a student can opt for either two DSE course, or one DSE with one GE)*

DISCIPLINE SPECIFIC CORE COURSE – DSC 01

Network Theory and Filter Design

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-01: Network Theory and Filter Design	4	3	-	1	Entry level	Circuit Theory and Network Analysis.

Learning Objectives

The Learning Objectives of this course are as follows:

- To discuss the concepts of graph theory and its role in network analysis.
- To conceptualize the analogous system and apply the network theorems to solve the network with dependent sources.
- To illustrate and outline the Multi-terminal network.
- To understand the synthesis of the Network function.
- To explain the concept of Modern filter theory.

Learning Outcomes

At the end of this course, students will be able

- To explain network problems using the concept of Graph theory.
- To describe the modeling of an analogous system and its solution by applying network tools.
- To determine the response of networks consisting of dependent sources.
- To synthesize the network with the help of Electrical Elements.
- To design the filters with the help of Electrical Elements.

SYLLABUS OF DSC-01 Total Hours: 45h

UNIT -I (12 Lectures)

Network Topology: Definition and properties, Matrices of Graph, Network Equations & Solutions: Node and Mesh transformation; Generalized element; Source transformation; Formulation of network equations; Network with controlled sources; Transform networks; Properties of network matrices;

Solution of equations; Linear time-invariant networks; Evaluation of initial conditions; Frequency and impedance scaling.

UNIT – II (10 Lectures)

Analogues System, Dependent Sources, Applications of Network Theorems for analyzing the Circuit with Dependent Sources, Compensation theorem, Tellegen's theorem. Multi-terminal Networks: Network function, transform networks, natural frequency (OCNF and SCNF); Two-port parameters, Equivalent networks.

UNIT – III (13 Lectures)

Network Synthesis: Network Function (Impedance & Admittance), Stability, Properties of Hurwitz Polynomial and Positive Real Function, Synthesis of LC, RC and RL Network, Foster form, and Cauer form.

UNIT – IV (10 Lectures)

Modern Filter theory, Approximation functions for filters, Maximally Flat Magnitude function, Synthesis of Butterworth and Chebyshev filters, Active filters.

List of Experiments: **Total Hours: 30h**

A. Software Based [Using PSpice Create netlist.]

1. Write the netlist for the circuit and run PSpice on it for dc analysis. [Independent Source]
2. Write the netlist for the circuit and run PSpice on it for dc analysis. [Dependent Source]
3. Write the source file for the given circuit in using commands [.DC, .PLOT, and .PROBE] to find the I-V characteristic equation for I varying from 0 to -2 A at the given terminal.
4. Use. TRAN and . PROBE to plot the voltage across the parallel RLC combination for R = 50 Ω and 150 Ω for 0 < t < 1.4 ms. The initial conditions are I(0) = 0.5 A and V(0) = 0.
5. Perform an AC analysis on the circuit. Find the complex magnitude of V2 for f varying from 100 Hz to 10 kHz in 10 steps.
6. Step response of the given circuits.

B. Hardware Based.

1. To study Analog Multiplier and Divider Circuits using OP-AMP.
2. To design the Circuit to get the solution of the Differential equation using OP-AMP.
3. To study OPAMP as an Antilog Amplifier (Exponential Amplifier) and Logarithmic Amplifier circuits and study their responses.
4. To study a Frequency Divider Circuit using a Monostable Multi-vibrator.
5. To study a Notch filter using OP-AMP for a given cut-off frequency.
6. Design and determine the characteristics of Active filters: Bandpass, Bandstop.

Essential/recommended readings:

Text Books:

1. V.K. Aatre, Network Theory & Filter Design, New Age International Pvt. Ltd, 2014
2. M.S. Sukhija, T.K. Nagsarkar, Circuits and Networks, Oxford University Press, 2016, 2nd ed.
3. Franklin F. Kuo, Network Analysis and Synthesis, Wiley, 2006, 2nd ed.

Reference Books:

1. M.E. Van Valkenburg, Introduction to Modern Network Synthesis, John Wiley & Sons (1 January 1966)
2. Balabanian, N. and T.A. Bickart, "Electric Network Theory", John Wiley & Sons, New York, 1969.
3. C. L. Wadhwa, Network Analysis and Synthesis, New Age International Pvt. Ltd., 2018

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – DSC 02

CMOS Analog Circuit Design

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-02: CMOS Analog Circuit Design	4	3	–	1	Entry level	Basic circuit theory, basic semiconductor physics

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the working and operation of novel and advanced devices
- To develop the ability to design and analyze MOSFET based Analog VLSI circuits
- To draw the equivalent circuits of MOS based Analog circuits and analyze their performance.
- To develop the skills to design analog VLSI circuits for a given specification.

Learning Outcomes

At the end of this course, students will be able

- To draw the equivalent circuits of MOS based analog circuits and analyze their performance.
- To analyze the frequency response of the different configurations of an amplifier.
- To appreciate the design features of the differential amplifiers.
- To use EDA tools and SPICE software for design and analysis of complex analog circuits

SYLLABUS OF DSC -02 Total Hours: 45h

UNIT -I (09 Lectures)

MOS device Physics: MOS I/V characteristics, long channel characteristics, MOS device models, short channel effects, mobility degradation and velocity saturation, channel length modulation, drain induced barrier lowering, subthreshold leakage, gate leakage, tunneling, impact ionization, dielectric breakdown, high-k dielectrics, concept of gate stack.

Advanced Semiconductor devices- Double Gate MOSFET, SOI, FinFETs, strained devices, etc

UNIT – II (12 Lectures)

Single-stage amplifiers: Single stage amplifiers - Impact of second order effects such as channel length modulation, calculation of characteristics such as voltage gain, input and output impedance - Common source (CS) stage with resistive load, substrate bias effect, Common Source stage with diode connected load, current source load, Common Source stage with source degeneration, Source follower, Common gate stage, Cascode stage

UNIT – III (12 Lectures)

Differential amplifiers: Single ended and differential operation, Basic differential pair (qualitative and quantitative analysis), Common-mode response, Differential pair with MOS loads, Gilbert cell.

Current mirrors: Basic current mirrors, Cascode current mirrors

UNIT – IV (12 Lectures)

Frequency response of amplifiers: Miller effect, High frequency response of Common source stage, Source followers, Common gate stage, Differential pair.

Noise: Types of noise, representation of noise in circuits, noise in single stage amplifiers

List of Experiments: Total Hours: 30h

1. Design nMOSFET and pMOSFET devices and draw the I-V characteristics
2. Design a single stage CS amplifier and study the characteristics
3. Design single stage amplifiers with active load and study the characteristics
4. Design a differential amplifier and study the characteristics
5. To study the high frequency response of CS amplifier.
6. To study the high frequency response of CD and CG amplifiers
7. To study the impact of second order effects on performance of amplifiers

Essential/recommended readings:

1. Behzad Razavi, Design of Analog CMOS Integrated Circuits, TMH Edition, 2017, ISBN-10 938706784X, ISBN-13 978-93259832742.
2. R. Jacob Baker, CMOS Mixed-Signal Circuit Design, Wiley Interscience, 2008, ISBN-10 9788126516575, ISBN-13 978-8126516575
3. Kenneth Martin Chan Carusone, David Johns, Analog Integrated Circuit Design, Wiley Student Edition, 2013, ISBN-10 9788126543939, ISBN-13 978-8126543939
4. Muhammad H. Rashid, Microelectronic Circuits - Analysis and Design, Cengage learning, 2011, 2nd Ed, ISBN-13: 978-0-495-66772-8
5. Sedra and Smith, Microelectronic Circuits, Oxford Series, 6th Ed.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – DSC 03 Digital Circuit Design

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-03: Digital Circuit Design	**4**	**3**	**0**	**1**	**Entry level**	**Basic knowledge of binary system and Boolean algebra**

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide knowledge of Digital systems are crucial in modern technology because they offer superior accuracy, reliability, flexibility, and ease of data manipulation compared to analog systems.
- To provide the comprehensive knowledge of designing of combinational and sequential circuits and their analysis too.
- To learn the use of computer aided tools and techniques for designing of synchronous & Asynchronous Sequential Circuits.
- To provide the concepts and techniques for Datapath and FSM design.

Learning Outcomes

At the end of this course, students will be able

- To design a combinational and sequential digital circuit design techniques.
- To learn the concepts and techniques for datapath and FSM design.
- To learn concept of fault detection and location in combinational circuits.
- To use computer aided tools and techniques for designing of synchronous & Asynchronous Sequential Circuits.

SYLLABUS OF DSC-03 Total Hours: 45h

UNIT -I (10 Lectures)

Combinational Circuit Design Principles: The tabulation method (Quin Mc-clusky), Determination of Prime implicants, Selection of Essential Prime implicants, Iterative Consensus method, Map-entered variables method of minimization. Design of Multiplexer.

UNIT – II (10 Lectures)

Synchronous Sequential Circuit Design: Basic memory elements, Analysis of clocked synchronous sequential circuits and modelling, State diagram, state table, state table assignment and ASM chart, Ripple Counters, Synchronous counters.

UNIT – III (12 Lectures)

Asynchronous Sequential Circuit Design: Analysis of asynchronous sequential circuit, flow table, primitive flow table, flow table reduction, races-state assignment, transition table and problems in transition table, design of asynchronous sequential circuit using SR latch. Static, Dynamic and Essential hazards, Elimination of static Hazards, Metastability and Synchronizers for Asynchronous signals, Clock skew, Set up and Hold time of a flip-flop.

UNIT – IV (13 Lectures)

Fault detection and location in combinational circuits:
Introduction to testing and fault diagnosis in digital circuits, Fault modelling, Fault detection and Fault location by path synthesizing method, Fault table method, Boolean difference method.

List of Experiments: **Total Hours: 30h**

1. Design and hardware implementation of 4-bit magnitude comparator.
2. Design and hardware implementation 4:1 Multiplexor using basic gates.
3. Design and Implementation of given Boolean function using multiplexer.
4. Design and hardware implementation of 3:8 Decoder using NAND gates.
5. Design and hardware implementation of Serial Adder.
6. Design and analyse a synchronous sequential circuit.
7. Realization of Mod 8 up-down ripple counter using flip-flops and gates.
8. Design and Hardware Implementation of 4-bit Sequence Detector.
9. Design a sequential circuit for given state diagram using flip-flops.

Essential/recommended readings:

1. S. C. Lee, Digital Circuit and Logic Design, Prentice-Hall, 1976.
2. Kohavi and Jha, Switching and Finite Automata, Cambridge university press, 2010, 3rd edition.
3. M. Morris R. Mano, Michael D. Ciletti, Digital Design, Pearson Education, 2012, 5th edition.
4. Cem Unsalan and bora Tar, Digital System Design with FPGA, Mc Graw Hill Education, 2017.
5. Michael Ciletti Advanced Digital Design with the Verilog HDL, Prentice Hall, 2011, 2nd edition.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 01

Mathematical Techniques and Applications

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-01: Mathematical Techniques and Applications	**4**	**3**	**–**	**1**	**Entry level**	**Basic mathematics and basic programming skills.**

Learning Objectives

The Learning Objectives of this course are as follows:

- To utilize the mathematical models to understand the device physics and their working.
- To formulate real-world problems into mathematical models.
- To utilize appropriate computational techniques to solve those models, analyze the results, and effectively communicate their findings using mathematical and computational tools.

Learning Outcomes

At the end of this course, students will be able

- To design mathematical models to understand the device physics and their working principle.
- To develop skill and ability to model real-world systems, draw inferences, and apply quantitative reasoning across various disciplines.
- To gain the ability to interpret and draw conclusions from data and mathematical models.
- To break down complex problems into smaller, manageable steps and develop computational solutions.

SYLLABUS OF DSE-01 — Total Hours: 45h

UNIT -I (12 Lectures)

Differential Equations: Introduction to First order, second order, homogeneous, non-homogeneous equations, system of equations and their applications to LTI systems.

Orthogonal Functions in Mathematical Physics and Engineering: Bessel Functions, Hermite Polynomials, Chebyshev Polynomials.

UNIT – II (11 Lectures)

Fourier Series & Transform: Definition and Properties, Fourier Series in the Interval, Uses of Fourier Series, Physical Examples of Fourier Series, Fourier sine and cosine transform of Derivatives, Finite Fourier Transform, Applications of Fourier Transform.

UNIT – III (12 Lectures)

Laplace Transform: The Region of Convergence for Laplace Transforms, Inverse Laplace Transform, Properties of the Laplace Transform, Laplace Transform Pairs. Evaluation of differential equations using Inverse Laplace Transform, Applications of Laplace Transform to Integral Equations and ODEs.

UNIT – IV (10 Lectures)

Computational Techniques using MATLAB: Managing the workspace, Matrix and Vectors, Matrix and Array operations, Arithmetic and Logical operations, MATLAB scripts and functions (m-files), Control structures (if, if-else, else-if, switch, for, while etc), Plotting of data: contour plot, surface plot, mesh plot, 3-D plot etc.

List of Experiments: **Total Hours: 30h**

1. Write a program to perform Statistical operation on random data (mean, var, standard Deviation).
2. Write a program to perform Functions and Control Structures (if, if-else, else-if, switch, for, while).
3. Write a program to perform Plotting of Data-Contour Plot, Surface, Mesh Plot, 3-D Plot & polar plot.
4. Write a program to perform/solve Differential Equations..
5. Write a script to Calculates factorial of a non-negative integer (with and without functions).
6. Using MATLAB/Python to plot the Fourier Transform of any Time Function of your choice.
7. Calculate the Laplace transform F(s) of a given function f(t) using MATLAB/Python and verify manually.
8. Program to perform Curve Fitting on any data using standard methods in MATLAB/Python.

Essential/recommended readings:

Text Books:

1. Simon & Haykins, Signals & Systems, Wiley Eastern Ltd.,
2. Zeimer, Signals & Systems, PHI.
3. B. S. Grewal: “Higher Engineering Mathematics”, Khanna publishers, 44th Ed. 2018
4. E. Kreyszig: “Advanced Engineering Mathematics”, John Wiley & Sons. 2016

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 02

Signal Processing and Control

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-02: Signal Processing and Control	4	3	–	1	Entry level	Higher Engineering Mathematics and Signals and Systems.

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the concepts of signal processing and its related terminology.
- To elaborate on the various transformations and their role in science and Engineering.
- To understanding the control Systems and their application.
- To know various Controllers/Compensators and their applications.
- To explore the stability of the system in the Frequency domain.

Learning Outcomes

At the end of this course, students will be able

- To describe the signal processing techniques and their application.
- To represent the signal and analyze the system in the Frequency domain.
- To illustrate the control Systems and their application.
- To design the various controllers/compensators and their application.
- To explain the stability of the system in the Frequency domain.

SYLLABUS OF DSE-02 Total Hours: 45h

UNIT -I (11 Lectures)

Z-transform; Frequency Analysis of Signals and Systems; Discrete Fourier Transform (DFT), FFT, and Window Function; Examples of control systems and applications, Basic components of control systems, Open loop and closed loop control systems.

UNIT – II (10 Lectures)

Digital filters; Digital Filter Design: Butterworth, Elliptic, Chebyshev low-pass filters. Filter Realizations: Convert low pass to high pass, band pass, and band stop filters. Discrete-time filters: IIR and FIR. Linear phase filters.

UNIT – III (10 Lectures)

Concepts of State, State Variables: State equations from transfer function Transfer function from state equations, State transition matrix, Time Response of Control Systems: Transient and steady-state response, typical test signals, Steady state error, and error constant.

UNIT – IV (14 Lectures)

Design of P, PI, PD, and PID controllers. Introduction to compensation design using Bode plot, Nyquist plot, Stability, Root Locus Methods: Root locus concept, Properties, and construction of root locus

List of Experiments: **Total Hours: 30h**

1. Write MATLAB code to compute the linear convolution of two finite-length sequences. Compare your result with that obtained by theoretical evaluation.
2. Write MATLAB code to verify the following general properties of the LTI system.
   a. Linearity
   b. Time-invariance
3. Write MATLAB code to generate the discrete time signal from the analog signal using the sampling theorem and analyze the aliasing effect. Plot the spectrum of the sampled signal—computation of N-point DFT and FFT of the length-N sequence.
4. Write MATLAB code to test the stability of the system.
5. Write MATLAB code to design a digital filter (FIR/IIR) and evaluate its performance.
6. Write MATLAB code to get the system's time response from the state space model.
7. Write MATLAB code to get the system's transfer function represented by the Block diagram.
8. Write MATLAB code to plot the system's root locus, Bode, and polar plot.
9. Write MATLAB code to get the Nyquist plot.
10. Write MATLAB code to show the time response of the Compensated and Uncompensated system.

Essential/recommended readings:

Text Books:

1. Oppenheim, A. S. Willsky and H. Nawab, "Signals and Systems," , Prentice-Hall, 1996, 2nd Ed.
2. Modern Control Engineering by K. Ogata, Pearson, 2015, 5th edition,
3. Automatic Control Systems by F. Golnaraghi and B.C.Kuo, Wiley Student Edition, 2014, 9th edition.

Reference Books:

1. A. V. Oppenheim, Ronald W. Schafer and John R. Buck, "Discrete-Time Signal Processing," 2nd Ed., Prentice Hall, 1999.

2. J. G. Proakis, and D. K. Manolakis, "Digital Signal Processing," Prentice Hall, 2006, 4th Ed. 2006.
3. Modern Control System Theory by M. Gopal, New Age International(P) Ltd., 1994, 2nd edition

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 03
Soft Computing Techniques

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-03: Soft Computing Techniques	**4**	**3**	**–**	**1**	**Entry level**	**Calculus and Set theory**

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the Conventional AI to Computational Intelligence.
- To demonstrate Machine Learning Techniques.
- To understand the Concept of fuzzy logic and its scope.
- To explain Fuzzy logic techniques for Control, Clustering, and Classification tasks.
- To develop Real-time applications using Machine learning and Fuzzy logic techniques.

Learning Outcomes

At the end of this course, students will be able

- To explain the components of Soft Computing and its role in Engineering.
- To describe the tools of Soft computing.
- To develop a Machine learning algorithm.
- To create a Fuzzy inference system based on fuzzy logic theory.
- To apply genetic algorithms to find optimal solutions.

SYLLABUS OF DSE-03 Total Hours: 45h

UNIT -I (12 Lectures)

Introduction to Soft Computing: Conventional AI to Computational Intelligence, Soft Computing Techniques, Importance of Soft Computing, Main Components of Soft Computing, Hybrid Intelligent Systems, Single and multi-objective optimization. Gradient-based methods: Newton-Raphson method, Bisection method, Secant method, Cauchy's steepest descent and Newton's method.

UNIT – II (10 Lectures)

Artificial Neural Network and Applications: Introduction, Artificial Neuron Structure, ANN Learning; Back-Propagation Learning, Properties of Neural Networks, Unsupervised learnings, Hopfield Networks, Application of GN Models, Statistical Classifier, Linear classifier

UNIT – III (12 Lectures)

Introduction to Fuzzy Logic: Introduction, Uncertainty and Information, Types of Uncertainty, Introduction of Fuzzy Logic, Fuzzy Sets and its properties, Fuzzy Intensification, α-Cuts, Characteristics of Fuzzy Sets, Various
Shapes of Fuzzy Membership Functions, Methods of Defining of Membership Functions, Fuzzy Relation, Defuzzification Methods.

UNIT – IV (11 Lectures)

Introduction to Genetic Algorithm, Crossover, Mutation, Survival of Fittest, Population Size, Evaluation of Fitness Function. Fuzzy inference systems: Introduction, Mamdani fuzzy model, Sugeno fuzzy model, Tekamoto fuzzy model, Neuro-fuzzy systems, applications to fuzzy control, clustering, and classification.

List of Experiments: **Total Hours: 30h**

1. Write MATLAB code to realize the logical AND function with a neural net that learns the desired function through Hebb learning.
2. Linear classification using least squares. Construct an ROC curve for a least squares linear classifier applied to a data set where the two classes overlap significantly. Set the distance between the centers of the two classes at two standard deviations to ensure a fair number of misclassifications.
3. Use the linear SVM to classify a linearly separable data set. Use gen _ data2 to produce a training set (N = 100) with two classes identified as class −1 and class +1, which are Gaussian distributed and separated by 5 standard deviations.
4. Example of k-nearest neighbors classification of Two nonlinearly separable classes. k = 5 and 15.
5. Classify a two-variable input pattern consisting of two classes. Each class consists of 50 patterns having a Gaussian distribution over both variables. The centers of the two classes are far enough apart so that the classes are linearly separable.
6. Single Neuron Training using the Delta algorithm.
7. Train a three-layer net to classify a training set that consists of two classes arranged diagonally across from one another. Use a 100-point training set and a net with six neurons in the input and hidden layers. Evaluate the trained net on a test set of 400 points.
8. Trains a three-layer neural net with and without momentum.
9. FIS Editor and its Application.
10. Understand the Graphical User Interface of Neural Networks.
11. Minimize the given objective function within the specified range using the GA tool.

Essential/recommended readings:

Text Books:

1. Siman Haykin, Neural Networks: A Comprehensive Foundation, IEEE, Press, MacMillan, N.Y. 1994.
2. S. Rajasekaran, G. A. Vijayalakshmi, Neural Networks, Fuzzy logic and Genetic algorithms, PHI publication, 2003.
3. Timothy J. Ross: Fuzzy logic with Engineering Applications - Wiley, 2011.
4. George J. Klir and Bo. Yuan: Fuzzy Sets and Fuzzy logic: Theory and Applications - Pearson, 2015.
5. Kalyanmoy Deb, Optimization for Engineering Design, PHI publication, 2012.
6. Kalyanmoy Deb, Multi-objective Optimization using Evolutionary Algorithms, Willey Publication, 2008.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 04
Advanced Sensors & Transducers

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-04: Advanced Sensors & Transducers	4	3	–	1	Entry level	Basic electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide an in-depth exploration of various types of transducers and their working mechanism.
- To provide the knowledge of data acquisition systems, and data transfer techniques.
- To understand fundamental principles of sensors and actuators, including their classifications, working mechanisms and characteristics.
- To develop the ability to use different type of sensors like mechanical, electrical, optical, chemical, and pressure sensors in in various fields

Learning Outcomes

At the end of this course, students will be able

- To learn the concept of transducers including the knowledge of various transducers based on industrial requirements.
- To understand about the data acquisition systems, data transfer techniques, and PC-based data acquisition systems.
- To identify the appropriate sensor for a given application.
- To use the knowledge of their construction, operation, signal conditioning, calibration techniques, and limitations across various applications.

SYLLABUS OF DSE-04 Total Hours: 45h

UNIT -I (12 Lectures)

Transducers: Transducers and their need, Primary and Secondary Transducer, Active and Passive Transducer, Unidirectional and Bi-Directional Transducer, Pressure to current Converter (Flapper

Nozzle Arrangement), Diaphragm Pressure Gauge, Piezoelectric transducer, Antenna as a Transducer, LVDT (Linear variable Differential Transformer), Transducers in HVAC (Heat Ventilation and Airconditioning), Interference, Grounding and Shielding

UNIT – II (10 Lectures)

Sensors-I: Capacitive sensors: Variable distance-parallel plate type, variable area- parallel plate, cylindrical type, variable dielectric constant type.

Radiation sensors: LDR, Photovoltaic cells, photodiodes, photo emissive cell types.

UNIT – III (12 Lectures)

Sensors-II: Thermal sensors: Material expansion type: solid, liquid, gas & vapor

Resistance change type: RTD materials, tip sensitive & stem sensitive type, Thermister material, shape, ranges and accuracy specification.

Thermo emf sensor: types, thermoelectric power, general consideration, Junction semiconductor type IC and PTAT type.

Magnetic sensors: Sensor based on Villari effect for assessment of force, torque, proximity, soil sensors.

UNIT – IV (11 Lectures)

Data Acquisition System:

Sample and Hold Circuit, Operational Amplifier, CMRR, Slew Rate, Gain, Band-width. Sample and hold circuits, Zero crossing detector, Peak detector, Window detector. Difference Amplifier, Instrumentation Amplifier AD 620, Interfacing of IA with sensors and transducer, Basic Bridge amplifier and its use with strain gauge and temperature sensors, Filters in instrumentation circuits.

Data Transfer Techniques: Serial data transmission methods and standards RS 232-C, GPIB/IEEE - 488, LAN, Universal serial bus, HART protocol, Foundation -Fieldbus, ModBus, Zigbee and Bluetooth,

Graphical Interface (GUI), PC - Based data acquisition system

List of Experiments: Total Hours: 30h

1. Design a VI Interface to study characteristics of inductive transducer LVDT.
2. Design a VI Interface for Monitoring and Controlling of Soil Humidity.
3. Design a VI Interface for Temperature and Pressure Sensors
4. Design a VI Interface to study to study about photodiode and photo transistor.
5. Design a VI Interface using DAQ for Real-Time Data Monitoring PV Solar Cell.
6. Design a VI for recognition of optical character in Speech Synthesis System
7. Design a VI for Fault Locating & Monitoring within Distribution Lines
8. Design a VI for RFID Automatic Identification & Database Management System
9. Measurement of level in a tank using capacitive type level probe

Essential/recommended readings:

Text Books:

1) Maurizio Di Paolo Emilio, “Data Acquisition Systems: From Fundamentals to Applied Design,” 2013, Springer.

2) H.R. Taylor, "Data Acquisition for Sensor Systems," 2010, Springer Science Business Media.
3) T. Karvinen, Kimmo Karvinen & Ville Valtokari, Make: Sensors, 2014, Shroff Publishers & Distributors.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE COURSE – GE 01

Modern Engineering Applications of RF and Microwave Spectrum

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-01: Modern Engineering Applications of RF and Microwave Spectrum	4	3	1	0	Entry level	Basic Physics

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide an in-depth exploration of engineering applications which are being used in modern industries in the spectrum of RF and microwave.
- To provide basic knowledge of electromagnetic waves.
- To provide special attention will be given to the applications in remote sensing and controlling.
- To understanding the applications of microwave in communication. Last portion of this course deals with high power microwave applications and radiation hazards.

Learning Outcomes

At the end of this course, students will be able

- To have the basic knowledge of signals, frequency spectrum, and electromagnetic travelling waves.
- To understand the applications of radio waves in remote sensing and controlling.
- To evaluate the performance of microwaves in communication and defense.
- To develop the ability to understand the concept of high-power microwave signals radiation hazards.

SYLLABUS OF GE-01 Total Hours: 45h

UNIT -I (11 Lectures)

Introduction to RF and Microwave: Signals, frequency and angular frequency, wavelength and velocity of waves in different mediums, Frequency Spectrums from extreme low-frequency to extreme high frequency, microwave frequency bands, electrical and magnetic signal, Faraday's Law, Generation of Electromagnetic (EM) Waves for static and time varying conditions, Travelling EM Waves; generation and characteristics, mechanism of dipole antenna, guided and un-guided medium, modes of propagation of EM waves.

UNIT – II (12 Lectures)

Applications in Remote Sensing and Controlling: RADAR, Light Detection and Ranging (LiDAR), Radio Frequency Identification (RFID), Remote Sensing; Active and Passive remote sensing, Moderate Resolution Imaging Spectroradiometer (MODIS), Remote Controlling, Internet of Things (I.O.T.), Advanced Driver Assistance System (ADAS).

UNIT – III (11 Lectures)

Applications in Communication; FM Radio, Television, Mobile phones, Bluetooth, WiFi, LiFi, Satellite Communication

Applications in defense, Stealth Technology, Applications in medical science, Applications in wearable technology, RF based Home appliances systems

UNIT – IV (11 Lectures)

High Power microwave signals: Generation of High-Power Microwave Signals; Klystron, Magnetron, High-power microwave weapons

RF radiations, Radiation Hazards, Electromagnetic Interference and Electromagnetic Compatibility (EMI/EMC).

Tutorial Component Total Hours: 30h

- Addressing general queries of students.
- Practical numerical problems on frequency, wavelength and velocity.
- Demonstration of travelling EM waves and practical numerical problems.
- Demonstration of RADAR and practical numerical problems.
- Demonstration of ADAS and practical numerical problems.
- Demonstration of satellite communication and practical numerical problems.

Essential/recommended readings:

1. Sadiku, M. N. O. (2018). Elements of Electromagnetics (7th). Oxford University Press.
2. M. Skolnik "Radar Handbook," 3rd Edition, McGraw-Hill, Boston, 1990.
3. Basudeb Bhatta (2008), Remote Sensing and GIS, Oxford Higher Education.
4. Simon Haykin (2006), Communications Systems, 4th Edition, Wiley.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SKILL ENHANCEMENT COURSE – SEC-01

Fabrication & Testing Laboratory

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
SEC-01: Fabrication & Testing Laboratory	2	0	0	2		Basic Electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- To devlope the entrepreneur skills in the students.
- To provide basic knowledge of tools and software's used in fabrication and testing.
- To provide the study of frequency effects on relative dielectric constant.

Learning Outcomes

At the end of this course, students will be able

- To design and fabricate the lumped PCB as well as high frequency planar circuits. Students will also be able to do the testing of developed circuits.

List of Experiments: Total Hours: 60h

[1] (i) Study of materials required for the fabrication of printed circuit for low and high frequency responses. Study of effect of frequency on relative dielectric constant and loss tangent of materials. (ii) Study of Surface Mount Technology (SMT) and Through Hole Technology (THT).

[2] Introduction of layout creation through different simulation software; (i) Autodesk Eagle, (ii) PCB Express, (iii) ADS, (iv) Auto-CAD, (v) CST Microwave studio/HFSS, (iv) any other open source software.

[3] Study of Photolithography Process; (i) Wafer cleaning, (ii) Photoresist application, (iii) Soft baking, (iv) Mask alignment, (v) UV Exposure, (vi) Development, (vii) Hard baking, (viii) Pattern transfer.

[4] To Study the instruments involved in PCB fabrication; (i) PCB Artwork Film Maker, (ii) PCB Curing machine, (iii) Photo Resist Dip Coating Machine, (iv) Proto-Dye/Developer, (v) Proto-Etch Etching Machine, (vi) Drilling Machine, (vii) Rollir Tinning Machine, (viii) UV Exposure Machine, (ix) PCB Shearing Machine, (x) soldering station

[5] Design and fabrication of electronic circuits using THT PCB and testing of fabricated circuit.

[6] Design and fabrication of Low pass/High pass/band pass filters and testing of fabricated circuit.

[7] Design, fabrication and testing of planar electronic component. Study of impedance matching and VSWR for high frequency designs.

[8] Design, fabrication and testing of a planar RF component.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER-II

DISCIPLINE SPECIFIC CORE COURSE – DSC 04
Advanced Electronic Materials and Devices

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-04: Advanced Electronic Materials and Devices	**4**	**3**	**--**	**1**	**Entry level**	Basics of Semiconductor Devices and Materials, Semiconductor Physics and fundamentals of nano-materials

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide a comprehensive knowledge and concepts of the electronic materials used to fabricate micro/nano electronics.
- To provides the knowledge of flexible electronics for various applications such as optoelectronics, sensors and actuators.
- To demonstrate theoretical knowledge on semiconductors, flexible materials and their micro/nano structures for various potential applications

Learning Outcomes

At the end of this course, students will be able

- To overview and outlook of electronic industry and role various materials in daily human life.
- To understand the fundamental concepts of Organic and Inorganic Semiconductor materials, classification of materials.
- To apply quantum principles for nano structures.
- To understand various nano structures and determine how these structures impact the intended application.
- To understand the basic operating principles of various micro and nano electronic devices used in modern life style.
- To understand structural fundamentals of flexible materials for Wearable devices and IoT applications

SYLLABUS OF DSC-04 Total Hours: 45h

UNIT -I (11 Lectures)

Fundamentals for Electronic materials: Overview on classification and applications of Electronic materials**,** Energy band formation in Organic and Inorganic semiconductors, Electronic Defects and their Role in Device Operation, Transport in Semiconductors, Radiative and Non-Radiative Recombination, Minority Carrier Lifetime. Optical Absorption, Photoluminescence and Electroluminescence. Introduction to Wide Bandgap Electronic Materials.

UNIT – II (12 Lectures)

Heterostructures and Devices: Heterojunction Materials, Energy-Band Diagrams, Band offset, Two-Dimensional Electron Gas, Schottky barrier diodes, High-Speed Devices: HEMT, Tunneling Electron Transistors, Resonant Tunneling Devices. Transferred Electron Devices, Energy conversion and Energy Storage Devices.

UNIT – III (12 Lectures)

Nano structures and materials: Key concepts of nanostructures: De-Brogle Relation, Confined Electron in a Infinite and finite Potential Well, Tunneling Phenomenon. 2D, 1D and 0D structures: Quantum wells, wires, dots. Nanotubes, CNTs, 2D materials: graphene, BN, MXenes etc

UNIT – IV (10 Lectures)

Flexible Materials and Devices: Fundamentals of flexible materials, Smart and self-healing materials for stretchable electronics, Interfaces properties in flexible and stretchable electronic. Applications: Photovoltaic devices, Memory, Display, Energy harvester, Energy storage, Sensors and Actuators. Integrated Flexible Systems: Wearable health monitoring system, IoT sensors

List of Experiments: Total Hours: 30h

1. Determination the type of semiconductor and carrier concentration in the given doped semiconductor using Hall-effect
2. Determine resistivity and energy band gap of given semiconductor sample using four probe method.
3. To design a MOSFET as switching regulator for given duty cycle and Plot the Current-Voltage (I- V) characteristic of MOSFET using Keithley.
4. To design a phase-controlled rectifier using SCR and Plot the I-V characteristic of SCR using Keithley.
5. To design a relaxation oscillator using UJT and Plot the I-V characteristic of UJT using Keithley.
6. Plot the I-V characteristics of Schottky Diode using Keithley source meter and determine Ideality factor, Barrier Height, Series Resistance of the diode.
7. Plot the I-V characteristics of LED device using Keithley source meter and determine its Ideality factor.
8. Determine size of nano particle using LASER.

Essential/recommended readings:

1. S. O. Kasap, Principles of Electronic Materials & Devices, Mc Graw Hill Education., 4th Edition.
2. S. M. Sze and Kwok K. Ng., Physics of Semiconductor Devices, Willey, 2008, 3rd Edition.
3. W. Bruetting (Ed.), Physics of Organic Semiconductors, Wiley, 2005.
4. Neaman D. A., Semiconductor Physics and Devices, McGraw Hill, 2012, 4th Edition.
5. P. Bhattacharya, Semiconductor Optoelectronic Devices, 1995, PHI.
6. Ben G, Streetman and Sanjay Banerjee, Solid State Electronic Devices, 2005. PHI, 5th Edition.
7. Guzheng Shen, Zhidong Fan, Flexible Electronics: from Materials to Devices, 2016, World Scientific Publishing Co. Pte. Ltd.
8. W.S. Wong and A. Salleo, Flexible Electronics: Materials and Applications, Springer, 2010, (Electronic Materials: Science & Technology).

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – DSC 05
Real Time Embedded System Design & IoT

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-05: Real Time Embedded System Design & IoT	4	3	--	1	**Entry level**	Microprocessor, Basic Programming

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop the knowledge and skills to design, develop, and implement systems that respond to real-time events and interact with the physical world.
- To Understand embedded software development, including programming languages (like embedded C), operating systems (RTOS), and real-time programming techniques.
- To understand the different layers of IoT architecture, including devices, gateways, networks, and cloud platforms.
- To understand how to collect, process, and analyze data from IoT devices.

Learning Outcomes

At the end of this course, students will be able

- To interface between microcontroller and peripheral devices.
- To understand the principles and functionalities of RTOS, including scheduling algorithms (priority-based, time-sliced), interrupt handling, task synchronization etc.
- To design and implement software for real-time embedded systems which control and monitor external hardware.
- To learn about the components of IoT architecture, and how to design IoT systems

SYLLABUS OF DSC-05 — Total Hours: 45h

UNIT -I(13 Lectures)

Embedded Processor Architectures and Design: Introduction to embedded system (ES) & its classification, Components of embedded system, Application areas, Design parameters and architecture, Introduction to microcontrollers & its applications, ARM internal architecture, Addressing modes, ARM Instruction Set, PWM and Interrupts, Programmer`s model, Development tools.

UNIT – II (12 Lectures)

Programming & RTOS: Embedded C programming, Input/Output interfacing, Port formation and communication, Timer configuration and interrupts. Real Time Operating Systems(RTOS) fundaments and its usefulness.

UNIT – III (10 Lectures)

Internet of Things (IoT): Fundamentals of IoT & applications, Evolution of IoT, Various Platforms for IoT, potential & challenge, Real Time IoT examples, Overview of IoT components and IoT Communication Technologies.

UNIT – IV(10 Lectures)

Embedded system for patient monitoring: ECG, EEG, EMG, blood pressure, respiratory, pulse oximeters, diagnosis devices etc. Application of IoT in healthcare, agricultures and vehiculation**.**

List of Experiments: Total Hours: 30h

1. Write a program for Breathing LED with different rate.
2. Use the switch to select the LED (from RGB led) and then the potentiometer to set the intensity of that LED and thus create your own colour from amongst 16million colours.
3. Program to interface seven segment display from no. 0 to 99.
4. Program to interface keypad. Whenever a key is pressed, it should be displayed on LCD.
5. Program to interface stepper Motor to rotate the motor in clockwise and anticlockwise Directions
6. Program to control the speed of DC motor.
7. Program to read data from temperature sensor and display the temperature value on LCD.
8. Read the ADC value of the voltage divider involving the LDR. Print the value on the serial monitor.
9. Use the thermistor to estimate the temperature and print the raw value on the serial monitor.
10. Program to measure distance using IR/ ultrasonic sensor.

Essential/recommended readings:

1. Embedded Systems- Architecture, Programming and Design by Rajkamal, 2007, TMH.
2. The AVR Microcontroller and Embedded Systems, Second Edison, By, M. Mazidi
3. Advanced UNIX Programming, Richard Stevens
4. Embedded Linux: Hardware, Software and Interfacing – Dr. Craig Hollabaugh
5. Designing Embedded System and IoTs with the ARM Mbed, John Wiley & Sons Ltd. 2018.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – DSC 06

Electromagnetics, Antenna and Propagation

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-06: Electromagnetics, Antenna and Propagation	4	3	–	1	Entry level	Basic Physics, Electrostatic and Magnetostatics, Maxwell's equations

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand Maxwell's equations and their application in wave propagation across various media and guided structures.
- To analyze and model transmission lines using the RLCG model, and study different line configurations such as matched, open, short-circuit lines, and quarter-wave transformers.
- To explore waveguide modes (TE, TM, Hybrid) and their field distributions in rectangular and circular waveguides, dielectric slabs, and cavities.
- To familiarize with key antenna parameters and radiation mechanisms, and understand their impact on antenna performance and design.
- To investigate wireless propagation methods (ground, space, and ionospheric) and their importance in electromagnetic systems.
- To gain an understanding of link budget in ground transmission

Learning Outcomes

At the end of this course, students will be able

- To understand and apply Maxwell's equations and boundary conditions in EM wave propagation across various media.
- To analyze the propagation of EM waves in lossy and lossless dielectrics, including power and energy transfer.

- To solve transmission line problems using telegrapher's equations, including reflection, matching, and dispersion.
- To analyze waveguides and their modes, including rectangular and circular waveguides, for efficient EM wave transmission.
- To apply the Smith Chart for impedance matching and solve problems related to wave propagation in transmission lines.
- To understand radiation mechanisms and key antenna parameters such as polarization, radiation patterns, and beamwidth.
- To understand various types of antennas, including dipole, microstrip, and horn antennas.
- To investigate wireless propagation methods including ground wave, space wave, and ionospheric propagation.

SYLLABUS OF DSC-06 Total Hours: 45h

UNIT -I (11 Lectures)

Electromagnetic (EM) Wave Propagation in different media: Maxwell's equations, constitutive relations, Boundary conditions, Helmohtz equation, plane wave functions, wave propagation in lossy dielectric (sea water), plane waves in lossless dielectrics, power and Poynting vector, EM wave interaction with different media at normal/oblique incidences, and reflection & refraction due to change of media, Microwave Absorber.

UNIT – II (11 Lectures)

EM wave propagation in Transmission line structures: Telegrapher's equations in time and frequency domain, losses and dispersion, reflection from an unknown load; quarter wavelength line, half wavelength lines, Left hand, Right handed transmission lines, single stub matching; Smith Chart and its applications, Different transmission lines like Coaxial lines, Microstrip, Strip lines, Slot lines, Co-planar Waveguide (CPW).

UNIT – III (12 Lectures)

EM wave propagation in Guided wave structures: Field components in rectangular waveguide, Bessel's functions and circular waveguide, Dielectric loaded waveguides, dielectric slab waveguide surface guided waves, Analysis of various supporting Modes, waveguide components.

UNIT – IV (11 Lectures)

Radiating Structures and wireless propagation: Radiation mechanism, Antenna parameters: Radiation pattern, Major Lobe, Side Lobes, Side lobe level (SLL), Back Lobe, Half power beamwidth, Polarization, Co and Cross Polarization, radiation from simple dipole and aperture, concept of antenna, arrays, end-fire and broadside arrays, horn antenna, microstrip antenna, parabolic disc antenna. Ground wave, space wave and ionospheric propagation, Communication link budget for ground transmission.

List of Experiments: **Total Hours: 30h**

1. Study of Electromagnetic Spectrum and Microwave Components used Microwave Bench.
2. Study of VI Characteristics of Gunn Diode using Microwave Test Bench, Also, find the all possible transmitting modes at operating frequencies.
3. Study of attenuation using variable attenuator on Microwave Test Bench
4. Measurement of Frequency, Guided Wavelength, VSWR, using Microwave Bench
5. Measurement of Low and High VSWR for Matched, Short, and Open Termination
6. Measurement of S-Parameters matrix for Magic Tee using Microwave Test Bench
7. Estimation of unknown impedance (IRIS) used to terminate the line (slotted section) by VSWR measurements (shift in minima position method)
8. Estimation of Near and Frafield and measurement of the dimensions of the HORN Antenna.
9. Measurement of Radiation Pattern for HORN antenna Using Microwave Test Bench

Essential/recommended readings:

1. D. K. Cheng, "Field and Wave Electromagnetics," 2nd Edition, Addison Wesley
2. Matthew N. O. Sadiku, "Principles of Electromagnetics"Oxford University Press
3. Kraus, Daniel A. Fleisch, "Electromagnetics: With Applications", WCB/McGraw-Hill
4. C.A. Balanis, "Advanced Engineering Electromagnetics," John Wiley & Sons
5. C.A Balanis, “Antenna Theory Analysis and Design”, John Wiley & Sons, February 2016

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DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 05

RF and Microwave Components

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-05: RF and Microwave Components	04	03	–	01	Entry level	Foundation in circuit analysis, electromagnetics, and transmission lines.

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide knowledge of RF and microwave technology in developing mobile communication, satellite, and RADAR systems.
- To provide schematics and working of microwave passive and active components.
- To design the concept for RF and microwave components
- To enable students to use their expertise in the relevant industry and R & D institutions.

Learning Outcomes

At the end of this course, students will be able

- To understand the basic concepts of microwave network theory and the behavior of the microwave components.
- To learn the requirements of impedance matching and techniques.
- To understand the working of microwave passive and active components.
- To learn the characterization methods at the microwave frequencies.
- To gain knowledge about applications of RF and microwave components.

SYLLABUS OF DSE-05 Total Hours: 45h

UNIT -I (09 Lectures)

Introduction to microwave networks: Overview of RF system design, distributed transmission lines, microwave network analysis, scattering parameters, ABCD parameters, ABCD to S-parameters conversion, T- network and Pi-network, Attenuator design, Cascaded network.

UNIT – II (12 Lectures)

Passive components I: Planar transmission lines, Even-odd modes, Impedance matching; L-network, quarter wave transformer design; tapered lines; Transmission line resonators; RF switch; Microstrip filters; Insertion loss method; Low-pass prototype; High-pass, band pass, and band stop filters; coupled line filters, Characterization of the filters.

UNIT – III (12 Lectures)

Passive components II: Resistive power divider, Wilkinson power divider, Equal and unequal power divider, Isolator, Circulator, Diplexer, Duplexer, 3-port and 4-port directional coupler, Branch-line coupler, Rat-race coupler.

UNIT – IV (12 Lectures)

Active components: Basics of Microwave Diodes and Transistors, Gunn diode, Tunnel diode, IMPATT diode, TRAPATT diode, BARITT diode and PIN diode, Microwave FET, HEMT. Overview of microwave amplifier, oscillator, and mixer.

List of Experiments: Total Hours: 30h

Simulation and Vector network analyzer-based Measurement of Microwave passive components.

1. To design and simulate the matching networks.
2. To design and simulate the microstrip low-pass and high-pass filters.
3. To design and simulate the microstrip band-pass and band-stop filters.
4. To design and simulate the power dividers.
5. To design and simulate the directional couplers.
6. To measure and study the characteristics of microwave filters.
7. To measure and study the characteristics of microwave power dividers.
8. To measure and study the characteristics of microwave directional couplers

Essential/recommended readings:

1. G. Kennedy, D. Bernard and S. R. M. Prasanna, Electronic Communication Systems, McGraw Hill Publication, 2017, 6th edition.

2. Subal Kar, Microwave Engineering: Fundamentals, Design, and Applications, Universities Press, 2016.

3. S. Y. Liao, Microwave Devices and Circuits, Pearson Education, 2003, 3rd edition.

4. D. M. Pozar, Microwave Engineering, John Wiley & Sons, Inc., 2012, 4th edition.

5. A. Das and S. K. Das, Microwave Engineering, Tata McGraw Hill, 2000.

6. S. Kumar and S. Shukla, Concept of Microwave Engineering, PHI Learning Pvt. Ltd., 2014.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 06

CMOS Digital Integrated Circuit Design

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-06: CMOS Digital Integrated Circuit Design	4	3	–	1	Entry level	Basic Digital Electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide students with rigorous foundation in MOS and CMOS devices and circuits.
- To train students to enable them to design and analyze circuits using VHDL/ Verilog
- To provide students hands-on skills in layout design
- To provide exposure to students and to equip them for semiconductor and VLSI industry, R & D organization in the area of microelectronics.

Learning Outcomes

At the end of the course student will be able

- To implement the logic circuits using MOS and CMOS technology.
- To design and analyze circuits using hardware descriptive languages.
- To understand the design of memories.
- To use the EDA tools for circuit simulation, layout verification and parasitic extraction.

SYLLABUS OF DSE-06 Total Hours: 45h

UNIT -I (12 Lectures)

Introduction to VHDL/Verilog: Introduction to VHDL/Verilog Programming language, data objects, classes and data types, Operators, Overloading, and logical operators. Types of delays Entity and Architecture declaration, Introduction to behavioral, dataflow and structural models Application of Functions and Procedures, Structural Modelling, component declaration, structural layout and generics

UNIT – II (12 Lectures)

MOS inverter design: Voltage transfer characteristics, logic threshold, inverter with resistive, enhancement and depletion loads – calculation of critical voltages, noise margins, power consumption and chip area considerations, noise margin, transit time and inverter delay; CMOS inverter: calculation of critical voltages, noise margins; analysis of an nMOS Inverter driven by another nMOS Inverter, nMOS inverter driven through pass transistors, ring oscillator, switch level RC delay model

UNIT – III (12 Lectures)

CMOS logic Design: Combinational and sequential CMOS logic design, OAI and AOI logic circuits, voltage bootstrapping

Semiconductor MOS memories: Static Random Access Memories (SRAMs), SRAM Cell Structures, MOS SRAM Architecture, 6T SRAM cell design, read & write operation, DRAM architecture, DRAM cell

UNIT – IV (09 Lectures)

Verification and reliability analysis: MOS layers, Stick diagrams, CMOS design rules and layout design

Verification methodologies, logic verification, physical verification**,** Lambda and micron design rules, DRC, layout versus schematic checks, electrical rule check, antenna check, electromigration, time dependent dielectric breakdown, negative bias temperature instability, latch-up

List of Experiments: **Total Hours: 30h**

1. Design gates using VHDL/ Verilog
2. Design a half adder and full adder using VHDL/ Verilog
3. Design a counter using VHDL/ Verilog
4. Design a MUX using VHDL/ Verilog
5. Design an nMOS inverter with various loads and study the characteristics
6. Design a CMOS inverter and study its characteristics
7. Draw the stick diagram of basic gates and nMOS inverters
8. Draw the stick diagram of CMOS inverter and create the layout
9. Perform design rule checks of basic gates and inverters
10. Perform layout check and post layout simulation for CMOS inverter and extract parasitic.

Essential/recommended readings:

1. J. Bhasker : A Verilog HDL Primer, BSP, 2003, ISBN: 9788178000114, 9788178000114
2. Samir Palnitkar : Verilog HDL-A guide to digital design and synthesis-, Pearson, 2003, ISBN-10 8177589180, ISBN-13 978-8177589184
3. Wayne Wolf : Modern VLSI Design: IP-Based Design, PHI, 2008, ISBN-10 0137145004; ISBN-13 978-0137145003
4. Weste and Harris: CMOS VLSI Design: Circuits and Systems Perspective, Addison-Wesley,2015, ISBN-10 9789332542884; ISBN-13 978-9332542884
5. Kang and Lebelbigi: CMOS Digital IC Circuit Analysis and Design, McGraw Hill, 2002, ISBN-10 0072460539; ISBN-13 978-0072460537
6. Jan M. Rabaey, Anantha Chandrakasan, and Borivoje Nikolic: Digital Integrated Circuits: A Design Perspective, Prentice Hall Electronics, 2003, ISBN-10 0130909963; ISBN-13 978-0130909961

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 07
Opto-Electronics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-07: Opto-Electronics	**4**	**3**	**–**	**1**	**Entry level**	Ray Optics and Wave Optics

Learning Objectives

The Learning Objectives of this course are as follows:

- To gain a comprehensive understanding of the Electrodynamic Theory of Light, including electromagnetic theory, energy transport, and polarisation states using Stokes and Jones formalisms.
- To learn about polarisation optics, covering Jones vector and matrix transformations, elliptically polarised states, and the Poincare sphere representation.
- To explore photonic detectors and instruments, including thermal and quantum detectors, various photoelectric devices, and optical instruments like spectrometers and interferometers.
- To learn technical knowledge of crystals, their optical properties, and the sensors.

Learning Outcomes

At the end of this course, students will be able

- To analyse and describe the polarisation states of light using Stokes and Jones formalisms.
- To apply Jones vector and matrix transformations to understand polarisation optics.
- To identify and explain the operation of various photonics detectors and optical instruments.
- To describe the principles of optical waveguides and thin film optical devices.
- To skill of MEEP simulation software.

SYLLABUS OF DSE-07 Total Hours: 45h

UNIT -I (11 Lectures)

Electrodynamic Theory of Light: Electromagnetic theory of light, Wave-Particle Duality of Light, Energy Transport - Polarization States- Strokes and Jones Formalism, Polarization Optics, Transformation of Jones Vectors and Matrices, Elliptically Polarized States, Poincare Sphere. Inhomogeneous Waves and Fresnel equations.

UNIT – II (12 Lectures)

Optical Components and Thin Film - Optical Waveguide, Dielectric Interface, Optical Coupler, Optical Divider, Reflection from a Metallic Surface, Anti-reflection Coating, Multilayer Dielectric Mirror, Beam Splitter and Optical Gates. Thin Film Optical Sensors. Introduction to MEEP simulation platform.

UNIT – III (10 Lectures)

Anisotropic Media and Crystal Optics: Plane waves in anisotropic media, wave refractive index, uniaxial and biaxial media, wave plates and analysis of polarised light, electro-optic effect acousto-optic effect, application to modulators. Quantum Cryptography and Optics.

UNIT – IV (12 Lectures)

Optical Detectors and Instruments: Thermal and Quantum Detectors. Application of Spectroscope and Characterization using Spectroscopic Techniques, Type of Spectrometer. Working of Refractometers, Monochromator, and Michelson Morley Interferometer.

List of Experiments: Total Hours: 30h

1. Measurement of Polarizer and Analyzer, Half Wave Plate and Quatre Wave Plate using Power Meter.
2. Measurement of LEDs Gaussian profile and Gratings effect Laser Lights.
3. To measure the wavelength of spectral lines of Hydrogen Emission and its Absorption Spectra.
4. To measure the wavelength of spectral lines of iodine (I_2) source using diffraction grating and spectrometer.
5. Designing a webcam spectrometer for Emission and Absorption Spectra.
6. Measurement of Quantum Cryptography Entanglement.
7. Simulation of Fields in a Waveguide for a straight waveguide and 90° bend using MEEP.
8. Simulation of Modes of a Ring Resonator using MEEP.

Essential/recommended readings:

1. Degiorgio, Vittorio, and Ilaria Cristiani, Photonics, Springer, 2015.
2. Ganguly, Amar K. Optical and Optoelectronic Instrumentation, Alpha Science International, Limited, 2010.
3. Ajoy Ghatak, Optics, Multicolor Edition, McGraw Hill, New Delhi, 2000.
4. Mukherji, Uma, Engineering Physics, Alpha Science International Limited, 2007.
5. Reider, Georg A, Photonics, Springer, 2016.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 08

Terahertz Technology and Applications

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-08: Terahertz Technology and Applications	**4**	**3**	**–**	**1**	**Entry level**	**Basic Physics, Electrostatic and Magnetostatics, Optics.**

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand why the THz range is important for science and technology.
- To understand why this field was underdeveloped.
- To learn about different THz sources with their advantages, disadvantages and limitations.
- To learn about different THz detection methods.
- To understand the principle of broadband THz time-domain spectroscopy.
- To grasp the scope of numerous THz applications.

Learning Outcomes

At the end of this course, students will be able

- To understand terahertz Technology Fundamentals:
- To use the application of Terahertz Sources and Detectors
- To use passive components such as Terahertz Antennas, splitters, combiners, polarizers, etc.
- To use application areas of Terahertz Technology.
- To use terahertz time-domain spectroscopy (thz-TDS), Terahertz sensing and non-destructive testing.

SYLLABUS OF DSE-08 Total Hours: 45h

UNIT -I (10 Lectures)

Introduction to terahertz technology, The concept of terahertz gap, Frequency Spectrum, Terahertz Principles, Key technological issues for Terahertz technology, Fundamental limits, Terahertz technology Applications and opportunities.

UNIT – II (12 Lectures)

Terahertz Sources and Detectors: Terahertz pulse generation using photo-mixing and laser interferometry, overview of semiconductor technology, Terahertz power generation in Silicon technology, working principle of HEMT and DHBT, Si-Ge HBT, III–V/Schottky diode-based diode detectors, planar and spatial power combining techniques, direct detection versus heterodyne detection, transistor detector circuits, active and passive mode detection.

UNIT – III (12 Lectures)

Terahertz passive components: Terahertz Microstrip Antenna, Terahertz photoconductive antenna, Terahertz Onchip Antenna, Terahertz Sensors, splitter, combiner, polarizer, isolator, diplexer, directional couplers, open resonator design, Bragg reflector, tunable properties for Terahertz devices using Graphene, liquid crystals.

UNIT – IV (11 Lectures)

Application of Terahertz: Terahertz time-domain spectroscopy (THz-TDS), Terahertz sensing and non-destructive testing, Material analysis Application, Molecular analysis application, THz imaging and tomography, Pharmaceutical analysis application

List of Experiments: **Total Hours: 30h**

1. Study of the Frequency Spectrum of Electromagnetic Spectrum and Terahertz Gap with their application and challenges.
2. Study of various sources and detectors of Terahertz
3. Study and Design of Terahertz sensor Using Vanadium dioxide (VO_2)
4. Study and Design of Photo Conductive Sensor
5. Study and design of Terahertz Microstrip Antenna
6. Study and Design of Photo Conductive Terahertz Antenna
7. Study and Design of Power Splitter
8. Study and Design of Filters

Essential/recommended readings:

1. J.S. Rieh, "Introduction to Terahertz Electronics," Springer, 2001
2. Yun-Shik Lee, "Principles of terahertz science and technology" (Springer, 2009).
3. R. E. Miles, P. Harrison, and D. Lippens, "Terahertz Sources and Systems," NATO Science Series.
4. E. Bruendermann, H-W. Huebers, M.F. Kimmitt, "Terahertz Techniques", Springer Series in Optical Sciences 151 (Springer, 2012)
5. D. W. Woolard, W. R. Loerop, and M. S. Shur, "Terahertz Sensing Technology," World Scientific
6. J. M. Chamberlain and R. E. Miles, "New Directions in Terahertz Technology," NATO ASI Series
7. P. F. Goldsmith, "Quasi-Optical Systems," IEEE Press Series

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE – GE-02

Introduction to Brain-Computer Interface

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-02: Introduction to Brain-Computer Interface	4	3	1	-	Entry level	Knowledge of Basic Sciences and Mathematics

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the Physiology of the Human Brain.
- To measure the Bio Signal in response to Various cognitive loads.
- To understand the Role of Signal theory in explaining Brain Signals.
- To describe the synchronization and desynchronization phenomenon of neural Circuit.
- To develop the user interface for neurorehabilitation.

Learning Outcomes

At the end of this course, students will be able

- To describe the Physiology of the Human Brain.
- To identify the Cognitive State Estimation Problem.
- To transformation of Brain Signal in Frequency Domain.
- To quantify the phenomenon of ERD and ERS of the Neural Circuit.
- To develop a paradigm for the User Interface.

SYLLABUS OF GE-02 Total Hours: 45h

UNIT -I (10 Lectures)

Brain Structures and Scalp Potentials, Neural Activities, Measuring Electric Activity in the Brain, Methods of Acquiring Brain Signals, Brain Signal Modelling, Brain Rhythms. Event-Related Potentials

UNIT – II (10 Lectures)

10-20 Electrode Placement System, EEG Recording and Measurement, Artefact, Spatial Filter, Common Spatial Pattern, Laplacian Referencing, Common Average Referencing. Cognitive State Estimation Problem.

UNIT – III (15 Lectures)

Signals and Systems; Linear Algebra Basics-Vectors, Orthogonality, Eigenvalues and Eigenvectors. Classification of Signals, System Properties, Continuous Signals and Systems, Sampling, Signal Transformation, Transfer Functions, Causality, Stability, Convolution, Digital Filter, Spectral analysis (FFT-based)

UNIT – IV (10 Lectures)

BCI Inference system, BCI Paradigm, ERD and ERS, BCI performance Evaluation parameters, Feature Extraction (Time domain and Frequency domain), Linear classification.

Tutorial Component — Total Hours: 15h

- To learn about the fundamentals of the Human Brain and mathematical modelling of it.
- To measure the response of the brain Activity using an electronic system.
- To explore different rhythmic bands.
- To explain concept of signal, system, and filtering with MATLAB simulation.
- To develop a machine learning classification algorithm.
- To demonstrate the BCI system.

Essential/recommended readings:

Textbooks:

1. Saied Sanei and J.A. Chambers, EEG Signal Processing, John Wiley & Sons Ltd., 2007.

2. Guido Dornhege, Jos´e del R. Mill´an Thilo Hinterberger, Dennis J. McFarland, KlausRobert Muller,
Toward Brain-Computer Interfacing, MIT Press Cambridge, 2007.

3. Rangaraj M. Rangayyan, Biomedical Signal Analysis- A case-study approach, IEEE Press, 2005.

4. D.C. Reddy, Biomedical Signal Processing – principles and techniques, Tata McGraw-Hill, New Delhi, 2009.

Reference books:

1. Simon Haykin "Neural Networks: A Comprehensive Foundation" – Pearson Education, 1998

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SKILL ENHANCEMENT COURSE – SEC-02

Embedded-IoT Product Development and Testing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
SEC-02: Embedded-IoT Product Development and Testing	**2**	**0**	**0**	**2**	**Entry level**	**Basic knowledge of Microprocessor**

Learning Objectives

The Learning Objectives of this course are as follows:

- To study of embedded system which is one of the major focus areas in electronics supported by relevant projects.
- To devlope the entrepreneur skills in the area of embedded system product and also in IoT product.
- To design the embedded system and IoT in real time applications.

Learning Outcomes

At the end of this course, students will be able

- To design and fabricate the embedded and IoT based projects using various sensors and advanced microcontroller.
- To use different types of sensors are designed, implemented, and interfaced with embedded systems to collect physical data from the environment.
- To use Integrated Development Environment for real time design of embedded projects.

List of Experiments: Total Hours: 60h

1. The study of smart sensors used in embedded systems that will focuses on understanding how different types of sensors are designed, implemented, and interfaced with embedded systems to collect physical data from the environment, converting it into electrical signals that can be processed by the system to make informed decisions or trigger actions based on the sensed information.
   i. Physical Sensors
   ii. Chemical Sensors
   iii. Biological Sensors
2. Introduction of IDE (Integrated Development Environment) that provides a comprehensive set of tools for writing, compiling, debugging, and managing the embedded software project.
   1. Keil MDK (Microcontroller Development Kit),
   2. MPLAB X IDE from Microchip,
   3. Visual Studio,
   4. Arduino IDE.
3. Study of Programming Languages and their instructions for embedded system.
4. Study the process of connecting and controlling physical devices like sensors, actuators, displays, and other external components to a microcontroller within an embedded system, allowing it to interact with the physical environment and perform real-world tasks like measuring temperature, controlling motors, or displaying data on a screen; essentially bridging the gap between the digital world of the microcontroller and the analog world of physical sensors and actuators.
5. Design and Testing of RFID based Security System.
7. Design and Testing of speed monitoring system.
8. Design and testing of Embedded System for Hazardous Gas Detection and Alerting.
9. Design and Testing of Embedded System for monitoring of ECG,EEG for telemetry.
10. Design and Testing of Embedded System for environment monitoring.
11. Design and Testing of Embedded System for soil monitoring.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.