Course Structure and Curriculum
B Tech Programme

ELECTRONICS AND COMMUNICATION ENGINEERING

Department of Electronics and Communication Engineering
Motilal Nehru National Institute of Technology Allahabad
Prayagraj-211004

DEGREE FORMAT AND NOMENCLATURE

Sl. No.	Program Category	Branch	Nomenclature
1	4 Year Undergraduate Program	ECED	B Tech (Electronics and Communication Engineering)
2	4 Year Undergraduate Program with Minor	For Other Branches	B Tech (XXXX) and Minor in (VLSI Design)
3	4 Year Undergraduate Program with Minor	For Other Branches	B Tech (XXXX) and Minor in (Signal Processing)
4	4 Year Undergraduate Program with Minor	For Other Branches	B Tech (XXXX) and Minor in (Digital Systems)
5	4 Year Undergraduate Program with Minor	For Other Branches	B Tech (XXXX) and Minor in (Communication Systems)
6	4 Year Undergraduate Program with Honours	ECED	B Tech Honours (Electronics and Communication Engineering)
7	4 Year Undergraduate Program with Research	ECED	B Tech (Electronics and Communication Engineering) with Research (in VLSI)
8	4 Year Undergraduate Program with Research	ECED	B Tech (Electronics and Communication Engineering) with Research (in Signal Processing)
9	4 Year Undergraduate Program with Research	ECED	B Tech (Electronics and Communication Engineering) with Research (in Communication Systems)

CREDIT MATRIX AT VARIOUS LEVELS

Sl. No.	Program Category	Credit Distribution				Total
		Base Credit	Minor	Honours	Research	
1	B Tech (Electronics and Communication Engineering)	168	--	--	--	168
2	B Tech (XXXX) Minor in (VLSI Design) (Minor in VLSI Design will be offered in 3rd ,4th, 5th, 6th, and 7th semesters)	160-170 (From Other Branches)	17	--	--	177-187
3	B Tech (XXXX) Minor in (Signal Processing) (Minor in Signal Processing will be offered in 3rd, 5th, 6th, and 7th semesters)	160-170 (From Other Branches)	16	--	--	176-186
4	B Tech (XXXX) Minor in (Digital Systems) (Minor in Digital Systems will be offered in 3rd ,4th, 5th, and 7th semesters)	160-170 (From Other Branches)	16	--	--	176-186
5	B Tech (XXXX) Minor in (Communication Systems) (Minor in Communication Systems will be offered in 3rd ,4th, 5th, 6th, and 7th semesters)	160-170 (From Other Branches)	20	--	--	180-190
6	B Tech Honours (Electronics and Communication Engineering) (Honours Programme will be offered in 5th, 6th and 7th semesters)	168	--	20	--	188
7	B Tech (Electronics and Communication Engineering) with Research (in VLSI)	168	--	--	20	188
8	B Tech (Electronics and Communication Engineering) with Research (in Signal Processing)	168	--	--	20	188
9	B Tech (Electronics and Communication Engineering) with Research (in Communication Systems)	168	--	--	20	188

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Credits of B Tech ECE Courses as per proposed requirement

Course Category Nomenclature	Courses offered in First Year as per the recommendations of First Year Course Committee May2022 (Accepted)	Reference Total Credits for 4 Years B Tech	Credits 1st year (Accepted)	Balance Credits for remaining 3 years	Total Credits of B Tech ECE for 4 Years
PCE (Professional competence enhancing Courses	Professional Communication, Extra Academic Activities-A, Professional ethics and Social Values	14 (8.3%)	05	09 (Balanced)	**14(8.3%)**
	Introduction to Artificial Intelligence and Machine Learning, Engg. Graphics, Workshop and Manufacturing Processes	23 (13.7%)	07	NIL	**23 (13.7%)**
CEF (Core Engineering Foundation courses)	Physics, Chemistry, Mathematics-I, Mathematics-II		16		
CES	Core Engineering Supporting Courses	111 (66.1%)	03	99 (Balanced)	**111 (66.1%)**
CEE	Core Engineering Essential Courses, Electives		09		
Extra Academic Activity Related Courses (EAA)-Group B	Extra Academic Activity (EAA)-Group B	06 (3.6%)	02	04 (Balanced)	**06 (3.6%)**
	Industrial Training/ Group Project	14 (8.3%)	--	14 (Balanced)	**14 (8.3%)**
	TOTAL	**168**	**42**	**126**	**168 (100.00%)**

1. PROGRAM: B Tech (Electronics and Communication Engineering)

COURSE STRUCTURE UG PROGRAM (B Tech ECE)

First Semester (Electronics and Communication Engineering)

Sl. No.	Course name	Cat	L	T	P	Credit	Contact Hours	Remarks
1	Physics/Chemistry	CEF	2	1	2	4	5	Branch Specific Physics and Chemistry Courses (Alternatively in each semester)
2	Mathematics-I	CEF	3	1	0	4	4	Common Course for all Branches
3	Professional Communication/Introduction to Artificial Intelligence and Machine Learning	PCE	2	0	2	3	4	Common Course for all Branches As per the clause 23.13 of the NEP 2020
4	Core Engineering Essential Course I (Flexible L-T-P) **Basic Electronics**	CEE	2	0	2	3	4	Branch Specific Course of that branch only here ECE
5	Core Engineering Essential Course II (Flexible L-T-P) **Digital Electronics**	CEE	2	0	2	3	4	Branch Specific Course of that branch only here ECE
6	**Electronics Workshop and Manufacturing Processes/CAD for Electronics**	PCE/ CEE	1	0	2	2	3	Common Course (Alternatively in each semester) If any department does not want to adopt this/these course(s) for the specific branch, the department may float branch specific course(s) in that/those places here ECE
7	Environment and Climate Change	PCE	2	0	0	0	2	Common Course for all Branches (This is an Audit Course)
8	Extra Academic Activity-A/ Extra Academic Activity-B	EAA	0	0	4	2	4**	Common Course for all Branches (With different titles) *Engagement beyond Academic Activity Duration *Evaluation of Grading system to be worked on
	Total		14	2	14	21	26+4**	

Second Semester (Electronics and Communication Engineering)

Sl. No.	Course name	Cat	L	T	P	Credit	Contact Hours	Remarks
1	Chemistry/Physics	CEF	2	1	2	4	5	Branch Specific Physics and Chemistry Courses (Alternatively in each semester)
2	Mathematics-II	CEF	3	1	0	4	4	Branch Specific Mathematics Course
3	Introduction to Artificial Intelligence and Machine Learning/ Professional Communication	PCE	2	0	2	3	4	Common Course for all Branches As per the clause 23.13 of the NEP 2020
4	Core Engineering Supporting Course (Flexible L-T-P) **Principles of Electronics Engineering**	CES	2	0	2	3	4	Course to be floated by each department (here ECE) only for the students of other Branches
5	Core Engineering Essential Course III (Flexible L-T-P) **Principles of Communication Engineering**	CEE	2	0	2	3	4	Branch Specific Course of that branch only here ECE
6	**CAD for Electronics/ Electronics Workshop and Manufacturing Processes**	CEE/PCE	1	0	2	2	3	Common Course (Alternatively in each semester) If any department does not want to adopt this/these course(s) for the specific branch, the department may float branch specific course(s) in that/those places here ECE
7	Extra Academic Activity-A/ Extra Academic Activity-B	EAA	0	0	4	2	4**	Common Course for all Branches (With different titles) *Engagement beyond Academic Activity Duration *Evaluation of Grading system to be worked on
	Total		12	2	14	21	24+4**	

N.B. Course Structure and Curriculum for B Tech First Year comprising of First and Second Semesters have already been finalized and accepted at Institute level.

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Third Semester (Electronics and Communication Engineering)

Course Code	Course name	L	T	P	Credit
ECN13101	Electromagnetic Theory	3	0	0	3
ECN13102	Signals and Systems	3	0	0	3
CSN13404	Data Structures and Operating Systems	3	0	2	4
EEN13401	Networks and Systems	3	0	0	3
ECN13103	Microprocessor and Its Applications	3	0	2	4
ECN13104	Solid State Devices and Circuits	3	0	2	4
HSN13602	Business Economics	3	0	0	3
EAN13700	Extra Academic Activity-B-II	0	0	4	2
	Total	21	0	10	26

Fourth Semester (Electronics and Communication Engineering)

Course Code	Course name	L	T	P	Credit
ECN14101	VLSI Technology	3	0	0	3
ECN14102	Digital Communication	3	0	2	4
EEN14401	Automatic Control Systems	3	0	2	4
ECN14103	Antenna and Wave Propagation	3	0	0	3
ECN14104	Microcontrollers and Embedded Systems	3	0	2	4
HSN14601	Management Concepts and Applications	3	0	0	3
EAN14700, 14701, 14702	Extra Academic Activity-B-II (Choice based Course)	0	0	4	2
	Total	18	0	10	23

Fifth Semester (Electronics and Communication Engineering)

Course Code	Course name	L	T	P	Credit
ECN15101	Digital Signal Processing	3	1	2	5
ECN15102	Computer Architecture	3	0	0	3
ECN15103	Data Communication Networks	3	0	0	3
ECN15104	Electronic Circuit Design	3	1	2	5
ECN15105	Optical Communication	3	0	0	3
ECN15106	VLSI Design	3	0	2	4
ECN15250,15251,15252,15253, 15254, 15255	Elective-I	3	0	0	3
	Total	21	2	6	26

Sixth Semester (Electronics and Communication Engineering)

Course Code	Course name	L	T	P	Credit
ECN16101	Digital Image Processing	3	0	2	4
ECN16102	RF and Microwave Engineering	3	0	2	4
ECN16103	Semiconductor Devices and Modeling	3	0	0	3
HSN16XXX	Soft Skills and Personality Development	3	0	0	3
ECN16250,16251, 16252, 16253,16254,16255, 16256, 16257	Elective-II	3	0	0	3
ECN16275,16276,16277,16278, 16279, 16280, 16281, 16282	Elective-III	3	0	0	3
	Total	18	0	4	20

Seventh Semester (Electronics and Communication Engineering)

Course Code	Course name	L	T	P	Credit
ECN17101	Mobile and Wireless Communication	3	1	0	4
ECN17102	Nano Electronics and Its Applications	3	0	0	3
ECN17250,17251,17252,17253,17254,17255, 17256	Elective – IV	3	0	0	3
ECN17275,17276,17277,17278,17279, 17280, 17281	Elective-V	3	0	0	3
ECN17351	Project	0	0	4	4
	Total	12	1	4	17

8th Semester (Electronics and Communication Engineering)

Course Code	Course name	L	T	P	Credit
ECN18351	Project/Internship	0	0	14	14
	Total	0	0	14	14

Total Credits=168

Professional Elective- I

Communication

1. ECN15250 Modern Radar Systems
2. ECN15251 Multimedia Communication

Signal Processing

1. ECN15252 Advanced Microcontrollers

VLSI

1. ECN15253 Advanced Analog Design
2. ECN15254 MEMS and Integrated Sensors
3. ECN15255 Emerging Technologies, Devices and Applications

Professional Elective-II

Communication

1. ECN16250 Advanced Digital transmission
2. ECN16251 Satellite Communication
3. ECN16252 Optical Wireless Communication

Signal Processing

1. ECN16253 VLSI for Signal Processing
2. ECN16254 Adaptive Signal Processing

VLSI

1. ECN16255 Testing & Verification of VLSI Circuits
2. ECN16256 VLSI Interconnects
3. ECN16257 Design of Current Mode Circuits

Professional Elective-III

Communication

1. ECN16275 Wireless Communication Network
2. ECN16276 Intelligent Communication Systems

Signal Processing

1. ECN16277 Two-dimensional Signals and Systems
2. ECN16278 Mathematics for Signal Processing
3. ECN16279 Switching Circuits and Finite Automata Theory

VLSI

1. ECN16280 VLSI Physical Design & Automation
2. ECN16281 Low Power VLSI Design
3. ECN16282 Optoelectronic Devices and Applications

Professional Elective-IV

Communication

1. ECN17250 WDM Optical Networks
2. ECN17251 Advanced Wireless Communication

Signal Processing

1. ECN17252 Advanced DSP Architecture
2. ECN17253 Advanced Computer Architecture

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VLSI

1. ECN17254 Mixed Mode VLSI Design
2. ECN17255 RF IC Design
3. ECN17256 Memory Design and Testing

Professional Elective-V

Communication

1. ECN17275 Adaptive and Smart Antenna
2. ECN17276 Electromagnetic Interference and Compatibility

Signal Processing

1. ECN17277 Pattern Recognition and Analysis
2. ECN17278 Signal Compression Techniques

VLSI

1. ECN17279 VLSI for IOT
2. ECN17280 Organic Electronics
3. ECN17281 Wearable Electronic Devices

MINOR BASKETS

The following Undergraduate Programs (with Sl. No. 2, 3, 4 and 5) are exclusively applicable for the students of other Disciplines other than ECE.

2. PROGRAM: B Tech (XXXX) Minor in VLSI Design

Minor courses in VLSI Design will be offered for B.Tech students of other branches in 5th, 6th, and 7th semesters.

MINOR in VLSI Design

Sl. No.	Course Code	Course	Credit	Core/Elective
1.	ECN13104	Solid State Devices and Circuits	4	Core
2.	ECN14101	VLSI Technology	3	Core
3.	ECN15104/ ECN15106	Electronic Circuit Design/ VLSI Design	4	Core
4.	ECN15250-15255/ECN16250-16257	Elective-I/Elective-II	3	Elective
5.	ECN16275-16282	Elective-III	3	Elective
		Total	17	

N.B. Course contents and other details of this Program are available in the respective regular semester courses in B Tech ECE Program. Elective courses are of VLSI wing.

3. PROGRAM: B Tech (XXXX) Minor in Signal Processing

Minor courses in Signal Processing will be offered for B.Tech students of other branches in 5th, 6th, and 7th semesters.

Minor in Signal Processing

Sl. No.	Course Code	Course	Credit	Core/Elective
1.	ECN13102	Signals & Systems	3	Core
2.	ECN15101	Digital Signal Processing	5	Core
3.	ECN16104	Digital Image Processing	5	Core
4.	ECN15250-15255/ECN16250-16257	Elective-I/Elective-II	3	Elective
		Total	16	

N.B. Course contents and other details of this Program are available in the respective regular semester courses in B Tech ECE Program. Elective courses are of Signal Processing wing.

4. PROGRAM: B Tech (XXXX) Minor in Digital Systems

Minor courses in Digital Systems will be offered for B.Tech students of other branches in 5th, 6th, and 7th semesters.

Minor in Digital Systems

Sl. No.	Subject Code	Subject	Credit	Core/Elective
1.	ECN11102	Digital Electronics	4	Core
2.	ECN14XXX	Microprocessors	4	Core
3.	EC-15102	Computer Architecture	4	Core
4.	EC-15401/EC-17401/EC-17402/EC-XXXXX*	Elective-I/Elective-II	4	Elective
		Total	16	

N.B. Course contents and other details of this Program are available in the respective semester courses in B Tech ECE Program. Elective courses are of Signal Processing wing.

5. PROGRAM: B Tech (XXXX) Minor in Communication Systems

Minor courses in Communication Systems will be offered for B.Tech students of other branches in 5th, 6th, and 7th semesters.

Minor in Communication Systems

Sl. No.	Subject Code	Subject	Credit	Core/Elective
1.	EC-13102	Signals & Systems	03	Core
2.	EC-14102	Digital Communication	04	Core
3.	EC-16102	RF and Microwave Engineering	04	Core
4.	EC-17101	Mobile & Wireless Communication	03	Core
5.	EC-15103/EC-15105	Elective-I/Elective-II	03	Elective
		Total	17	

N.B. Course contents and other details of this Program are available in the respective semester courses in B Tech ECE Program. Elective courses are of Communication Systems wing.

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6. **PROGRAM: B Tech Honours (Electronics and Communication Engineering)**

Honours Programme courses will be offered in 5th, 6th, and 7th semesters

This Undergraduate Program is applicable to ECE students only.

Sl. No.	Subject Code	Subject	Credit	Core/Elective
1.	ECN16105	Multidimensional Digital Signal Processing	4	Core
2.	ECN17296	Advanced Communication Systems	4	Core
3.	ECN15108	VLSI Circuits and Systems	4	Core
4.	ECN17260, 17261,17262	Statistical Signal Processing/Advanced Analog IC Design/ /Information theory and coding	4	Elective VI
5.	ECN17290,17291, 17292	Speech Signal Processing/Low Power VLSI Design/Antenna Design and MIMO Systems	4	Elective VII
		Total	20	

N.B. Course contents and other details of this Honours Program are available in the respective semester courses in M Tech Communication Systems, M Tech Signal Processing and M Tech Micro Electronics and VLSI Design Programs.

RESEARCH BASKET

The following Undergraduate Programs (with Sl. No. 7, 8 and 9) are applicable to students of ECE Discipline only.

7. **PROGRAM: B Tech (Electronics and Communication Engineering) with Research (in VLSI Design)**

The Research courses in VLSI Design will be offered in 5th,6th, and 7th semesters.

Sl. No.	Course Code	Course	L	T	P	Credits	Core/Elective
1.	ECN15108	VLSI Circuits and Systems	3	1	0	04	Core
2.	ECN16106/ECN17291	Nanoelectronic Devices and Engineering	3	1	0	04	Core
3.	ECN16260-16264	Elective VIII	3	1	0	04	Elective
4.	ECN16260-16264	Elective VIII	3	1	0	04	Elective
5.	ECN17352	Research Project				04	Elective
		Total				20	

N.B. These specialization courses in B Tech Research (Electronics and Communication Engineering, VLSI Design) Program are of M Tech Microelectronics and VLSI design Program.

8. **PROGRAM: B Tech (Electronics and Communication Engineering) with Research (in Signal Processing)**

The Research courses in Signal Processing will be offered in 5th,6th, and 7th semesters.

Sl. No.	Course Code	Course	L	T	P	Credit	Core/Elective
1.	ECN15109	Advances in Digital Signal Processing	3	1	0	04	Core
2.	ECN16107	DSP Processors and Architecture	3	1	0	04	Core
3.	ECN16105	Multidimensional Digital Signal Processing	3	1	0	04	Core
4.	ECN17293-17298	Elective IX	3	1	0	04	Elective
5	ECN17353	Research Project				04	Elective
		Total				20	

N.B. The specialization courses in B Tech Research (Electronics and Communication Engineering, Signal Processing) Program are of M Tech Signal Processing Program.

9. PROGRAM: B Tech (Electronics and Communication Engineering) with Research (in Communication Systems)

The Research Programme courses in Communication Systems will be offered in 5th, 6th, and 7th semesters.

Sl. No.	Subject Code	Subject	L	T	P	Credit	Core/Elective
1.	ECN17296/ECN15110	Detection and Estimation Theory	3	1	0	04	Core
2.	ECN16108	Advanced Communication Systems	3	1	0	04	Core
3.	ECN16109	Communication Networks	3	1	0	04	Core
4.	ECN17265-17268/ECN17292, 17294,17295	Elective X	3	1	0	04	Elective
5	ECN17354	Research Project				04	Elective
					Total	20	

N.B. The specialization courses in B Tech Research (Electronics and Communication Engineering, Communication Systems) Program are of M Tech Communication Systems Program.

Courses offered by ECED in First Semester B Tech ECE

Course Code	Course name	L	T	P	Credit
ECN11101	Basic Electronics	2	0	2	3
ECN11102	Digital Electronics	2	0	2	3
ECN11103	Electronics Workshop and Manufacturing Process	1	0	2	2

BASIC ELECTRONICS (ECN11101)

Course Outcomes:

On successful completion of the course students will be able:

a. To understand the basics of PN junction diode and its applications in electronic circuit design.
b. To introduce different special purpose diode devices.
c. To introduce the basics of transistor devices, characteristics, and its applications.
d. To understand the operation of BJTs at low frequency.
e. To introduce the basics of Field Effect Transistors.
f. To acquire basic knowledge of operational amplifier and its applications as arithmetic circuits

UNIT 1: Transport Phenomenon in Semiconductor: Crystal Properties and charge Carriers in Semiconductors, Elemental and compound semiconductor materials, crystal lattice structure, Bonding forces, band theory, energy bands in solids, Intrinsic and Extrinsic semiconductors, charge carriers in semiconductors, carrier concentrations, drift of carriers in electric and magnetic fields. 5(L)

UNIT 2: Diodes- Introduction to *pn* diode and its applications as rectifier, rectifier as DC Power Supply,Clamper, Clipper, Voltage multiplier etc., Zener diode and its applications as regulator, Operation and characteristics of Varactor diode, Tunnel diode, LED, Photo diode, and Schottky diodes etc. 5(L)

UNIT 3: Bipolar Junction Transistors- Junction Transistor, transistor current components, Transistor as an amplifier, transistor construction, CB, CE, CC Configurations, analytical expressions for transistor characteristics, maximum voltage rating, phototransistor, biasing of bipolar junction transistors. Introduction to hybrid model. 5(L)

UNIT4: Field Effect Transistors-Basics of JFET and MOSFET, construction, working, concept of p I n c h -off, characteristics of JFET, MOSFET (Enhancement and Depletion), CG, CS, CD Configuration, JFET Biasing, FET as a voltage variable resistor. 5(L)

UNIT 5: Operational Amplifier-Ideal & non-ideal characteristics, concept of summing junction and virtual ground. Application of operational amplifier as: Adder, Subtractor, Differentiator, Integrator, Multiplier, Unity gain amplifier, Logarithmic amplifier, Square & Triangular wave generator, Schmitt Trigger, Precision rectifier & Timing Circuits. 4(L)

Text/ Reference Books:

i. Electronic devices and circuit theory by Robert Boylested and Louis Nashelsky
ii. Electronics Devices and Circuits by Millman & Halkias
iii. Electronic Devices and Circuits, An Introduction, EEE Publication by Allen Mottershed
iv. Electronic Devices and Circuits, Tata McGraw Hill by Y N Bapat
v. Solid State Electronic Devices, Prentice Hall of India by B G Streetman.

BASIC ELECTRONICS LAB

Experiment 1: Familiarization to basic test and measuring instruments like Cathode Ray Oscilloscope(CRO), Function Generator, Power supply, Breadboard etc.
Experiment 2: To measure the frequency and amplitude of various waveforms using CRO.

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Experiment 3: To verify the truth tables of different logic gates by using Ics and implement differentlogic gates using IC 7400.
Experiment 4: To study the *pn* junction diode characteristics under forward and reverse bias conditions.
Experiment 5: To study the application of a Zener diode as voltage regulator.
Experiment 6: To determine the ripple factor of Half-Wave and Full-wave (Bridge) rectifiers.
Experiment 7: To observe the clipping wave forms in different clipping configurations.
Experiment 8: To observe the clamping wave forms in different clamping configurations.
Experiment 9: To determine the CE (Common Emitter) characteristics of a given BJT.
Experiment 10: To plot the drain and transfer characteristics of a given FET and to find drain resistance.
Experiment 11: To verify the addition and subtraction operation using op-amp 741.

DIGITAL ELECTRONICS (ECN11102)

Course outcomes:
On successful completion of the course, the students will be able to:

- Have a basic understanding of the minimization techniques used in digital electronics.
- Have a thorough understanding of the concepts and design of different combinational logic circuits.
- Understand, analyze and design various programmable logic devices.
- Understand and investigate the fundamental concepts of sequential logic circuits.
- Have a rigorous study of the various sequential logic circuits and to learn the design methods of the same.
- Acquire knowledge and analyze the design of different counters and shift register circuits.
- Have a detailed understanding of design and working of multivibrators.
- Know about different characteristics of logic families and also analyze their design and working.

UNIT 1: COMBINATIONAL LOGIC: A brief review of minimization techniques, introduction to combinational logic, design procedure, adders, subtractors, code converters, magnitude comparator, BCD to Seven segment decoder, parity generator and checker, decoders, encoders, multiplexers, demultiplexers, ROMs, design of the circuits using decoders, multiplexers and ROMs 6(L)

UNIT 2: PROGRAMMABLE LOGIC DEVICES: Programmable Logic Array (PLA), Programmable Array Logic (PAL), design of the circuits using PLA and PAL, Field Programmable Gate Array (FPGA). 3(L)

UNIT 3: SEQUENTIAL LOGIC: Introduction, flip-flops, flip-flop excitation tables, triggering of flip-flops, analysis of clocked sequential circuits, state reduction and assignment, race around condition, Master-slave flip-flops, Conversion of flip-flops, sequence detector. 4(L)

UNIT 4: COUNTERS AND REGISTERS: Design of synchronous and ripple counters, Mod-k or Divide-by-k counters, decade counter, BCD counter, Up/Down counters, lock out problem, design with state equations, shift register, serial to parallel converter, parallel to serial converter, ring counters,twisted-ring counter, sequence Generator 6(L)

UNIT 5: TIMING CIRCUITS and LOGIC FAMILIES: Multivibrators, characteristics of digital Ics, DTL, TTL, ECL, MOS logic and CMOS logic calculation of noise margins and fan-out 5(L)

Text Book:
- M. Morris Mano, Digital Design, Third Edition, Prentice Hall.

Reference Books:
- Taub and Schilling, Digital Integrated Electronics, McGraw HILL
- R. P. Jain, Modern Digital Electronics, Third Edition, TMH.
- Richard S. Sandige, Digital concepts using standard Ics, J. Williams Book Co.
- R. J. Tocci, Digital Systems: Principles and Applications, Fourth Edition, Prentice Hall.

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DIGITAL ELECTRONICS LAB

Course outcomes:

On successful completion of the course, the students will be able to:

- Understand the basics of digital logic design.
- Be familiar with the practical implementation of combinational/ sequential digital systems.
- Analyze and synthesize digital circuits using finite state machines.
- Implementation of combinational/ sequential logic using virtual system modelling/VHDL

Experiment 1: Verification of operation of Full Adder and Full Subtractor.
Experiment 2: Design & verification of 4-bit binary adder/subtractor using binary adder IC.
Experiment 3: Realization of operation of full adder and full subtractor using IC 74151/74153 MUX.
Experiment 4: Design & verification of full adder and full subtractor using an inverted output 3-to-8-line decoder.
Experiment 5: Design and verification of operation of a BCD Adder using IC 7483.
Experiment 6: Realization of 4 X 1 Multiplexer using basic gates.
Experiment 7: Verification of operation of BCD to Seven segment code conversion using IC 7447.
Experiment 8: Verification of Truth Tables of SR Flip flop, D Flip flop, Master Slave JK Flip-Flop.
Experiment 9: Design of MOD-8 Up/Down synchronous counter, BCD ripple counter and Universal Shift Register.
Experiment 10: Design of a sequential circuit from a given state diagram.
Experiment 11: Design and verification of Astable and Monostable Multivibrators using IC 555.
Experiment 12: Implementation of basic Combinational and sequential circuits
(a) Using VSM (Virtual System Modelling) (b) Using VHDL

ELECTRONICS WORKSHOP AND MANUFACTURING PROCESS (ECN11103)

Course outcomes:

On successful completion of the course in theory and practical approach students will be able to:

- Have a basic understanding of the electronic components, Ics.
- Have an understanding of the use of electronic devices
- Understand, the process of soldering and securing the components on PCB
- Familiarize with 3-D printer and its uses
- Familiarize with the use spectrum analyzer and signal generator
- Familiarize with software tools used in circuit implementation
- Familiarize with semiconductor device manufacturing process

THEORY:

UNIT 1: Basics of CRO, DSO, Function Generator, Multimeter, Bread Board, Power Supply. Active and Passive Components, Types of Ics and Their uses [4]

UNIT 2: Introduction to soldering process, types of soldering. [1]

UNIT 3: Regulated DC power supply and its uses. [1]

UNIT 4: Introduction to advanced electronic devices like Spectrum Analyzer, Signal Generator. [2]

UNIT 5: Introduction to 3-D Printer and its uses [2]

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UNIT 6: Introduction to semiconductor manufacturing process. [2]

LAB:

Experiment 1: Familiarization with Multimeter, Power Supply, Bread Board, Function Generator
Experiment 2: Use of DSO as measuring device and its functionalities
Experiment 3: Identification of Active and Passive components and their testing using Multimeter and DSO
Experiment 4: Soldering of components on PCB and their functionality testing on DSO
Experiment 5: Design and Implementation of Full wave Rectifier on PCB
Experiment 6: Design and Implementation of Regulated DC Power Supply on PCB
Experiment 7: Familiarization with Spectrum Analyzer and Signal Generator
Experiment 8: Study and familiarization of electronic 3-D Printer
Experiment 9: Familiarization with Verilog software for circuit implementation.
Experiment 10: Familiarization with Semiconductor Device Manufacturing Processes

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Courses offered by ECED in Second Semester B Tech ECE

Course Code	Course name	L	T	P	Credit
ECN12401	Principles of Electronics Engineering	2	0	2	3
ECN12101	Principles of Communication Engineering	2	0	2	3
ECN12102	CAD for Electronics	1	0	2	2

PRINCIPLES OF ELECTRONICS ENGINEERING (ECN12401)

Course Outcomes:

On successful completion of the course students will be able:

g. To understand the basics of PN junction diode and its applications in electronic circuit design.
h. To introduce different special purpose diode devices.
i. To introduce the basics of transistor devices, characteristics, and its applications.
j. To understand the operation of BJTs at low frequency.

- To have a thorough understanding of the concepts and design of different combinational logiccircuits.
- To understand and investigate the fundamental concepts of sequential logic circuits.

UNIT 1: Transport Phenomenon in Semiconductor: Crystal Properties and charge Carriers in Semiconductors, Elemental and compound semiconductor materials, crystal lattice structure, Bonding forces, band theory, energy bands in solids, Intrinsic and Extrinsic semiconductors, charge carriers in semiconductors, carrier concentrations, drift of carriers in electric and magnetic fields. 4(L)

UNIT 2: Diodes- Introduction to *pn* diode and its applications as rectifier, rectifier as DC Power Supply,Clamper, Clipper, Voltage multiplier etc., Zener diode and its applications as regulator, Operation and characteristics of Varactor diode, Tunnel diode, LED, Photo diode, and Schottky diodes etc. 5(L)

UNIT 3: Transistors- Junction Transistor, transistor current components, Transistor as an amplifier, transistor construction, CB, CE, CC Configurations, analytical expressions for transistor characteristics, maximum voltage rating, phototransistor, biasing of bipolar junction transistors. Introduction of JFET, MOSFET & its operation. Practical application circuits. 6(L)

UNIT 4: Combinational Logic: Introduction, Design Procedure, Adders, Subtractors, Code Converters, Magnitude Comparator, BCD to Seven Segment decoder, Parity generator and Checker, Decoders, Encoders, Multiplexers, Demultiplexers, ROMs, Design of the circuits using Decoders, Multiplexers, ROMs. 5(L)

UNIT 5: Sequential Logic: Introduction, Flip-Flops, Flip-Flop Excitation Tables, Triggering of Flip-Flops, Analysis of Clocked Sequential Circuits, State Reduction and Assignment, Race Around Condition, Master-Slave flip-flops, Conversion design of flip-flops, sequence detector. 4(L)

Text/ Reference Books:

i. Electronic devices and circuit theory by Robert Boylested and Louis Nashelsky
ii. Electronics Devices and Circuits by Millman & Halkias
iii. Digital design by Morris Mano
iv. Modern Digital Electronics by R. P. Jain
v. Taub and Schilling: Digital Integrated Electronics, McGraw HILL
vi. Richard S. Sandige: Digital concept using standard Ics
vii. R. J. Tocci: Digital Systems: Principles and Applications, Fourth Edition, Prentice Hall

PRINCIPLE OF ELECTRONICS ENGINEERING LAB

Experiment 1: Familiarization to basic test and measuring instruments like Cathode Ray Oscilloscope(CRO), Function Generator, Power supply, Breadboard etc.

Experiment 2: To measure the frequency and amplitude of various waveforms using CRO.

Experiment 3: To verify the truth tables of different logic gates by using Ics and implement differentlogic gates using IC 7400.

Experiment 4: To study the *pn* junction diode characteristics under forward and reverse bias conditions.

Experiment 5: To study the application of a Zener diode as voltage regulator.

Experiment 6: To determine the ripple factor of Half-Wave and Full-wave (Bridge) rectifiers.

Experiment 7: To observe the clipping wave forms in different clipping configurations.

Experiment 8: To observe the clamping wave forms in different clamping configurations.

Experiment 9: To determine the CE (Common Emitter) characteristics of a given BJT.

Experiment 10: Verification of operation of Full Adder and Full Subtractor.

Experiment11: Design & verification of 4-bit binary adder/subtractor using binary adder IC.

Experiment 12: Realization of operation of full adder and full subtractor using IC 74151/74153 MUX.

PRINCIPLES OF COMMUNICATION ENGINEERING (ECN12101)

Course Outcomes:
On successful completion of the course students will be able to:

- Understand the basic concepts of signals and random variables
- Understand the basic concepts of various AM modulators and demodulators.
- Understand the basic concepts of various FM and PM modulators and demodulators.
- Learn the working and application of Radio receivers.
- Understand the performance of Communication Systems in presence of Noise.
- Understand Sampling and various types of pulse modulation.

UNIT 1: Review of Signal Representations, Frequency domain analysis of signals using Fourier Transforms, Random Variables, PSD, PDF, CDF, Different types of PDFs, Gaussian, Rayleigh PDF, Random Processes, Auto-correlation function, Introduction to Communication systems, guided and unguided transmission media, radio frequency spectrum, Concept of bandwidth, Mathematical models for communication channels, Linear filter channel, Linear time-invariant channel 8(L)

UNIT 2: Amplitude modulation and demodulation: DSB-AM SSB-AM, VSB-AM, Quadrature Carrier multiplexing, and FDM. 5(L)

UNIT 3: Modulation and demodulation of FM, NBFM, WBFM, and Phase lock loop. 3(L)

UNIT 4: Radio receivers: Super-heterodyne receiver Sensitivity and selectivity, selection of IF, Communication Receiver. 2(L)

UNIT 5: Noise in Communication Systems: S/N ratio, noise Equivalent bandwidth, Noise performance of AM and FM

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systems under AWGN 3(L)

UNIT 6: Sampling Theorem, Quantization Process, PCM, Applications of AM, FM, PAM, PWM 3(L)

Text/ Reference Books:

- Communication System Engineering – John G Proakis
- Communication Systems- Simon Haykin, Wiley Publication, 5th edition, 2009
- Modern Digital and Analog Communication Systems- B.P. Lathi, 3rd edition, Oxford UniversityPress, 1998.
- Contemporary Communication Systems using MATLAB- John G Proakis

PRINCIPLES OF COMMUNICATION ENGINEERING LAB

Experiment 1: To implement Amplitude Modulation (AM), Demodulation and calculate the modulation index.

Experiment 2: To implement Frequency Modulation (FM) uses IC 2206 and Demodulation using IC 565.

Experiment 3: To implement analog pulse Amplitude Modulation and Demodulation

Experiment 4: Pulse Position Modulation and Demodulation

Experiment 5: To implement Phase Locked Loop (PLL) and find out the lock range and capture range.

Experiment 6: To study and observe frequency response of Low-pass, High-pass, Band-pass and Notch filter using Spectrum Analyzer.

Experiment 7: To Implement AM using MATLAB/ System View.

Experiment 8: To Implement FM using MATLAB/ System View.

Experiment 9: To Design transmitter (AM and FM) using MATLAB/ System View.

Experiment 10: To design receiver (AM and FM) using MATLAB/ System View.

CAD FOR ELECTRONICS (ECN12102)

Theory Contents:

UNIT 1: Pspice overview, Symbols and Conventions, Basic Analyses, DC Sweep and other DC Calculations, AC Sweep [3]

UNIT 2: Analyzing waveforms with Pspice, Pspice Stimulus Editor, Pspice Model Editor [2]

UNIT 3: Files needed for Simulations, Netlist File, Circuit File, Model Library, Stimulus File, Include File, Wave Form Data File, Pspice Output File [3]

UNIT 4: Simulation Examples, Example Circuit Creations, Preparing Design for Simulations, Creating Parts for Modeling, Creating and Editing Models [4]

CAD FOR ELECTRONICS LAB

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1. (a)Transient Analysis of BJT inverter using step input. (b)DC Analysis (VTC) of BJT inverter
2. To verify the Characteristics of Low Pass and High Pass filters
3. Verification of Half Wave and Full Wave Rectifier
4. To verify the characteristics of Basic Logic Gates
5. Implementation of XOR gate using NOR gate
6. To verify the Characteristics of CE Amplifier
7. Synthesis and Simulation of Full Adder
8. Synthesis and Simulation of Full Subtractor
9. Synthesis and Simulation of 3 X 8 Decoder
10. Synthesis and Simulation of 8 X 1 Multiplexer
11. Synthesis and simulation of Comparator
12. Analysis OPAMP based low pass filter and High Pass Filter

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Courses offered by ECED in Third Semester B Tech ECE

Course Code	Course name	L	T	P	Credit
ECN13101	Electromagnetic Theory	3	0	0	3
ECN13102	Signals and Systems	3	0	0	3
CSN13404	Data Structures and Operating Systems*	3	0	2	4
EEN13401	Networks and Systems	3	0	0	3
ECN13103	Microprocessor and Its Applications*	3	0	2	4
ECN13104	Solid State Devices and Circuits*	3	0	2	4
HSN13602	Business Economics	3	0	0	3
EAN13700	Extra Academic Activity-B-II	0	0	4	2
	Total	21	0	10	26

* **Theory and Lab Course**

ELECTROMAGNETIC THEORY (ECN13101)

Course Outcomes:
On successful completion of the course students will be able to:

- Identify different coordinate systems and their applications in solving the problems of electromagnetic field theory as well as explain the concept of static electric and magneticfield
- Learn the fundamental laws governing time varying electromagnetic fields
- Learn Electromagnetic wave propagation in different media and wave polarization
- Understand the different parameter of transmission line, concept of impedance matching,graphical approach to solve the problem of transmission line
- Learn the concept of waveguide, its classification and respective modes of propagation.

UNIT 1: Introduction- Review of Physical interpretation of gradient, divergence and curl, Divergence and Stokes theorem, Different coordinate systems. Electrostatic fields and magneto static fields. 4(L)

UNIT 2: TIME VARYING ELECTROMAGNETIC FIELDS- Continuity equation, Displacement current, Maxwell's equations in point form and integral form, Retarded vector potential 4(L)

UNIT 3: PLANE WAVE PROPAGATION- Plain wave equation and its solution in conducting and non-conducting mediums, Phase velocity, Group velocity, Plane waves in lossy dielectrics, Propagation in good conductors: skin effect, impedance of conducting medium, Poynting Vector, Poynting theorem and power considerations Polarization, Reflection and Refraction of plain waves at plain boundaries. 8(L)

UNIT 4: TRANSMISSION LINES- Transmission line equations, parameters- primary and secondary constants, Analogy of transmission lines, Determination of α, β, γ and vp, characteristics impedance, Input impedance of a lossless line, open and short-circuited lines, distortion-less lines, reflection coefficient and standing wave ratio, matched transmission line, Impedance matching, Smith-chart and its applications. 8(L)

UNIT 5: WAVEGUIDES- Rectangular waveguide, Circular Waveguides. Solution of wave equation in rectangular and cylindrical co-ordinates, Derivation of field equations for TE & TM modes, degenerate and dominant mode, Power Transmission and Power loss, Excitation of waveguides, Introduction to Cavity Resonator and Substrate Integrated Waveguide 8(L)

UNIT 6: COMPUTATIONAL ELECTROMAGNETICS- Method of Moments, Finite element method (FEM), Finite difference time domain method (FDTD) and Asymptotic Methods {Uniform theory of Diffraction (UTD) and Geometric Theory of Diffraction (GTD)}, Hybrid Methods 4(L)

Text/ Reference Books:

❖ Matthew N.O. Sadiku 'Elements of Electromagnetics' Oxford University Press, 6th Edition, 2015

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- Kraus J.D, "Electromagnetics" Tata Mc Graw Hill, 5th Edition, 2012
- Jordan E.C. and Balmain K.G., "Electromagnetic waves and Radiating Systems" PHI, 2nd Edition, 2015
- Samuel Y. Liao "Microwave Devices and Circuits" PHI, 3rd Edition, 2005
- X.Q. Sheng and W. Song "Essentials of Computational Electromagnetics" John Wiley & Sons, First Edition, 2012

SIGNALS AND SYSTEMS (ECN13102)

Course outcomes:
On successful completion of the course, the students will be able to:

k. Understand the mathematical description and representation of various types of signals – continuous-time and discrete-time. Classify systems based on their properties.
l. Analyze the spectral characteristics of continuous-time/discrete-time periodic and aperiodic signals using Fourier analysis.
m. Analyze system properties based on impulse response and Fourier analysis.
n. Apply the Laplace transform for the analysis of continuous-time signals. Understand the concept of Z-transform for discrete-time signals.
o. Convert a continuous-time signal into discrete-time signal and reconstruct the continuous-time signal back from its samples.

UNIT 1: SIGNALS AND THEIR REPRESENTATION: Analogy between vectors and signals, continuous-time and discrete-time signals: energy and power signals, periodic and aperiodic signals, even and odd signals, exponential and sinusoidal signals etc., transformations of the independent variable, concepts of unit impulse and unit sample signals, signum function. SYSTEMS: Continuous-time and discrete-time systems, basic system properties. 6(L)

UNIT 2: LINEAR TIME-INVARIANT (LTI) SYSTEMS: Continuous and discrete-time LTI systems, convolution sum, convolution Integral, properties of LTI systems, stability and causality, causal LTI systems described by difference equations, singularity functions. 6(L)

UNIT 3: FOURIER SERIES REPRESENTATION OF PERIODIC SIGNALS: Continuous-time and discrete- time signals and their Fourier series representation, properties of Fourier series, Dirichlet's conditions, complex Fourier spectrum. 6(L)

UNIT 4: REPRESENTATION OF APERIODIC SIGNALS BY FOURIER TRANSFORMS: Continuous-time and discrete-time signals and their Fourier transforms, Fourier transforms of periodic signals and standard signals, properties of Fourier Transforms, systems characterized by linear constant coefficient differential equations and difference equations. 6(L)

UNIT 5: LAPLACE TRANSFORMS AND Z-TRANSFORMS: Introduction to Laplace transform and Region of Convergence (ROC), Inverse Laplace transform, properties of Laplace transform. Analysis and characterization of LTI systems using Laplace transform. Introduction to Z-transform, definition, ROC, properties of ROC, relationship between Z-transform and Fourier transform, properties of Z-transform. 8(L)

UNIT 6: SAMPLING: Representation of continuous-time signals by its samples, Sampling theorem, impulse train sampling, sampling with Zero Order Hold (ZOH), natural and flat top sampling, reconstruction of signal from its samples using interpolation, effect of under sampling – aliasing, sampling of band pass signals. 4(L)

Text Books:

- A. V. Oppenheim, A. S Willsky and S. H. Nawab, Signals and Systems, Prentice-Hall, Englewood Cliffs.
- Michel J. Robert, Fundamentals of Signals and Systems, MGH International Edition, 2008.

Reference Books:

- Simon Haykin and Van Veen, Signals and Systems, Wiley, 2nd Edition.
- M. Mandal and A. Asif, Continuous and Discrete Signals and Systems, Cambridge, 2007.

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MICROPROCESSORS AND ITS APPLICATIONS (ECN13103)

Course Outcomes:

On successful completion of the course, the students will be able to:

- To understand architectural features of microprocessors.
- To understand assembly language programming of microprocessors.
- To understand interfacing of I/O devices with microprocessors.
- To understand and design microprocessors-based system.

UNIT 1: ARCHITECTURE OF A 16-BIT MICROPROCESSOR: Programming model of 8086, BIU, EU, segment-offset addressing, addressing modes, instructions and assembler directives, string Operations. 8(L)

UNIT 2: CPU MODULE: Pin description, bus organization and timing, buffered and non-buffered operation, minimum & maximum mode of operation, 8288 bus controller, physical memory organization and interfacing. 7(L)

UNIT 3: INTERRUPT HANDLING: Interrupt vector table, the IRET instruction, writing ISRs, interrupts due to errors, interfacing priority interrupt controller 8259 and its programming. 7(L)

UNIT 4: INTERFACING EXTERNAL DEVICES: Memory interfacing, Programmable peripheral interface (8255), Programmable Interval Timer (8253/8254) and operating modes, Interfacing A/D and D/A converters and measurement of physical & electrical quantities, basic DMA operations and timings, 8237 programmable DMA controller and its interfacing. 9(L)

UNIT 5: INTRODUCTION TO PENTIUM: Introduction to Pentium and Pentium pro processors, cache structure, superscalar architecture, introduction to Core 2 microprocessors. 5(L)

Text Books:

- Douglas V. Hal, Microprocessors and Interfacing, 3/e, McGraw hill.

Reference Books:

- Barry B. Brey, The Intel Microprocessors 8086/8088, 80186/80188, 80286, 80386, Pentium, Pentium Pro Processor, Pentium II, Pentium III, Pentium 4 and Core 2 with 64-bit Extensions, 8/e, Pearson Education.
- Liu and Gibson, Microcomputer Systems: The 8086/8088 family, 2/e, PHI.
- K Bhurchandi, A. K. Ray, Advanced Microprocessor and Peripherals, 3/e, McGraw hill.

MICROPROCESSORS AND ITS APPLICATIONS LAB

Outcomes:

On successful completion of the experiments in this lab, the students will be able to:

- To understand the organization of microprocessor trainer kits.
- To execute assembly language programming on the trainer kit.
- To verify operation of I/O interfacing devices.

Experiment 1: Familiarization with kit:
Decoding, storing and executing programs in trainer kit: Register addition, Indirect subtraction and Immediate Add with Carry.

Experiment 2: Write a program to Add/ Subtract two BCD numbers stored in memory.

Experiment 3: Write a program to find out smallest/largest data from a table.

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Experiment 4: Write a program to find out
(a) Sort out a table in ascending/descending order.
(b) Search a data from a given table.

Experiment 5: By using a Lookup Table stored in memory, write a program to find out
(a) ASCII code of a hexadecimal integer from a look table.
(b) Hexadecimal integer corresponding to given ASCII code.

Experiment 6: Write a program to multiply and divide two 8-bit numbers; result may be 16-bits.

Experiment 7: Study and verification of interrupts.

Interfacing Experiments:

Experiment 8: Study and verification of Mode 0 operation and BSR mode operation of 8255.

Experiment 9: Study and verification of various operating modes of PIT 8253/8254.

Experiment 10: Study and verification of various operating modes of Priority Interrupt Controller 8259.

SOLID STATE DEVICES AND CIRCUITS (ECN13104)

Course Outcomes:
On successful completion of the course students will be able:

- To understand the concept of band theory in solid crystals.
- To introduce basics of BJT biasing and thermal stability.
- To understand the operation of BJTs at high frequency.
- To understand the basics of Field Effect Transistors and their analysis at low and high frequencies.
- To understand the concept of Feedback Amplifier.
- To introduce the concept of oscillators and its type.
- To acquire basic knowledge of power amplifier.

UNIT 1: Bipolar Junction Transistor: Transistor switching characteristics, small signal low frequency transistor hybrid model, simplified hybrid model, breakdown in Transistors, Ebers- Moll transistor equations, Analysis of transistor cutoff and saturation regions, Review of Biasing and Thermal Stability, effect of *Ce* and *Cc* on low frequency and high frequency response, High frequency model of a transistor-hybrid *pi* model. 10(L)

UNIT 2: MOSFET: Review of device structure operation and V-I characteristics. Introduction of MOSFET, CMOS and BiCMOS. MOS CV Characteristic, MOSFET as an Amplifier and switch, Biasing of MOSFET amplifier circuits, small - signal operation and models, single stage MOSFET amplifier, CS, CD and CG amplifiers, MOSFET internal capacitances and high frequency model, frequency response of CS amplifier, large signal analysis. 10(L)

UNIT 3: Feedback amplifiers: Classification of amplifiers, Concept of feedback, transfer gain with feedback, General characteristics of negative feedback amplifiers, Effect of feedback on amplifier characteristics, Method of analysis of a feedback amplifier using BJT/MOSFET, Voltage -Series feedback, Current-Series feedback, Current-Shunt feedback, Voltage-Shunt feedback. 8(L)

UNIT 4: Oscillators: Basic principles of sinusoidal oscillators, Phase Shift oscillators, Resonant -Circuit oscillators, General f o r m of an oscillator c I r c ui t (Hartley and Colpitts oscillators), Wien-bridge oscillator, Crystal oscillators, Frequency Stability. 4(L)

UNIT 6: Power amplifiers: Classification of power amplifiers, class A, AB, B and C power amplifiers and their efficiency, push-pull and complimentary Symmetry amplifiers. 4(L)

Text/ Reference Books:

- Electronic circuits: Discrete and Integrated by D. L. Schilling, Charles Belove.
- Microelectronic Circuits by A. S. Sedra and K. C. Smith.
- Integrated Electronics by J. Milliman and C. C. Halkias
- Microelectronics by J. Milliman and A. Grabel

SOLID STATE DEVICES AND CIRCUITS LAB

Experiment 1: To determine the quiescent operating conditions of fixed and self -biased BJT Configurations

Experiment 2: Measurement of h-parameters of a BJT in CB, CE and CC configurations

Experiment 3: To plot the drain and transfer characteristics of a given FET and find the drain resistance,amplification factor and transconductance.

Experiment 4: To study the frequency response of an *RC* coupled amplifier and compute its bandwidth.

Experiment 5: To study the frequency response of a *CC* amplifier and compute its bandwidth

Experiment 6: To study the frequency response of a *CS FET* amplifier and compute its bandwidth

Experiment 7: To find the Gain and Bandwidth of a voltage series feedback amplifier.

Experiment 8: Design a current series feedback amplifier of given Gain and Bandwidth.

Experiment 9: Design RC-phase shift and Wien-Bridge oscillators of given frequency and amplitude.

Experiment 10: Study of Power amplifiers a) Class A power amplifier b) Class B complementarysymmetry power amplifier

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Courses offered by ECED in Fourth Semester ECE

Course Code	Course name	L	T	P	Credit
ECN14101	VLSI Technology	3	0	0	3
ECN14102	Digital Communication*	3	0	2	4
EEN14401	Automatic Control Systems*	3	0	2	4
ECN14103	Antenna and Wave Propagation	3	0	0	3
ECN14104	Microcontrollers and Embedded Systems*	3	0	2	4
HSN14601	Management Concepts and Applications	3	0	0	3
EAN14700, 14701, 14702	Extra Academic Activity-B-II	0	0	4	2
	Total	18	0	10	23

* Theory and Lab Course

VLSI TECHNOLOGY (ECN14101)

Course Outcome:
On successful completion of the course students will be able to:

- Identify the various design limits material used for fabrication.
- Describe the Performance of technology scaling.
- Understand the complexities involved in the integrated circuits fabrication.
- Plan a sequence of processing steps to fabricate a solid-state device to meet geometric, electrical and/or processing parameters.
- Understand and design solid state devices by keeping technological process constraints in mind.
- Understand the relevance of a process or device, either proposed, past or existing, to current manufacturing practices.

UNIT 1: Introduction to VLSI Technology: Classification of Ics, features of Ics, monolithic and hybrid Ics.
Crystal Growth and Wafer Preparation: silicon crystal growth from the melt, GaAs crystal growth techniques, crystal orientations, various defects in crystal, wafer preparation and wafer specifications. 6(L)

UNIT 2: Epitaxy: Epitaxy and its concepts, growth kinetics of epitaxy, vapor phase epitaxy, molecular beam epitaxy, silicon on insulator epitaxy. Advanced epitaxial methods.
Oxidation: Theory of growth of silicon dioxide layer, calculation of SiO2 thickness and oxidation kinetics, dry, wet and high-pressure oxidation, plasma oxidation, properties of oxidation, defects induced due to oxidation. 8(L)

UNIT 3: Lithography- Photolithography and pattern transfer, optical and electron photolithography, X-ray and ion- beam lithography, photo-resist, types of photo-resists, Etching- dry & wet etching, basic regimes of plasma etching, reactive ion etching and its damages, sputter etching, merits and demerits of etching. 8(L)

UNIT 4: Diffusion Process- Diffusion models of solid, ficks theory of diffusion, diffusivities, measurement techniques, diffusion in polycrystalline silicon and silicon dioxide.
Ion implantation- Implantation equipment, high energy implantation, scattering phenomenon, range of implanted ions, implantation damage, annealing.
Metallization- Metallization applications, metallization choices, physical vapor deposition, patterning & problems in metallization. 9(L)

UNIT 5: Process Modelling &Simulation- Need and importance of semiconductor device simulators, understanding of Poisson's and continuity equation for semiconductor device simulation, key elements of physical device simulation, second order effects, introduction to simulation tools. 5(L)

Text/Reference Books:

- VLSI Technology – S M Sze, McGraw Hill, 2nd Ed.
- VLSI Fabrication Principles – S.K Gandhi, Wiley, 2nd Ed.

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- The Science & Engineering of Microelectronic Fabrication – Stephen A Campbell, 2nd Oxford University Press.

DIGITAL COMMUNICATION (ECN14102)

Course Outcomes:

On successful completion of the course students will be able to:

- Understand the concepts of digital communication systems.
- Learn the basic concepts of random processes that are involved in communication systems
- Understand the concepts of baseband data transmission
- Understand the representation of signals in vector spaces
- Understand the concepts of passband data transmission
- Understand the information theory, channel capacity
- Learn different types error control coding schemes and their implications

UNIT 1: Review of Random Processes, Introduction to digital communication systems, Principles of digital data transmission. 3(L)

UNIT 2: Baseband data transmission systems, Matched Filter, Error probability due to noise, ISI, pulse shaping, Correlative-Level coding, Baseband M-ary Transmission and Line codes, Equalization, Geometric Representation of Signals, Gram-Schmitt orthogonalization Procedure, Conversion of the continuous AWGN Channel into Vector channel, Correlation Receiver , Probability of Error, Union Bound on Probability of Error. 9(L)

UNIT 3: Digital modulation schemes, ASK, PSK, QPSK, DPSK, M-ary PSK, FSK, MSK, Phase Trellis to represent Message Sequence in MSK, GMSK and QAM systems, Matched Filter and Correlator equivalence, Signal-space representation of each Digital Modulation schemes, Probability of error in AWGN. 10(L)

UNIT 4: Information and channel capacity, Entropy, Discrete and Continuous channels, BSC, Source coding theorem, Shannon Fano and Huffman's coding, Lempel-Ziv Source coding, Rate Distortion Theory, Differential Entropy, Rate distortion Function, Shannon's Channel Capacity theorem, Trading bandwidth for S/N etc. Shannon's limit. Performance of digital communication system. 8(L)

UNIT 5: Error control coding, Linear block codes, Cyclic codes, Convolution codes, Code generation and detection methods 4(L)

UNIT 6: Digital Link Design, Modern applications of Digital Communications 2(L)

Text/Reference Books:

- Communication Systems, 5th Edition, John Wiley & Sons, 2009– Simon Haykin
- Digital Communications, 5th Edition, McGraw Hill Publication,2008 – John G. Proakis, Masoud Salehi
- Modern Digital and Analog Communication Systems", 3rd edition, Oxford University Press, 1998- B.P. Lathi
- B. Sklar, Digital Communications: Fundamentals & Applications, 2nd ed., Prentice Hall, 2001.

DIGITAL COMMUNICATION LAB

Experiments to be implemented on Bread Board:

Experiment 1: To implement Binary Amplitude Shift Keying (BASK) modulation and demodulation

Experiment 2: To implement Binary Frequency Shift Keying (BFSK) modulation and demodulation

Experiment 3: To implement Binary Phase Shift Keying (BPSK) modulation and demodulation

Experiment 4: To study and implement Digital Phase Detector and to detect the phase difference between two sinusoidal

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waves.

Experiments to be implemented on MATLAB/ SYSTEMVIEW:

Experiment 5: BER Performance of BASK in AWGN

Experiment 6: BER Performance of BFSK in AWGN

Experiment 7: BER Performance of BPSK in AWGN

Experiment 8: DVB-S.2 Link including LDPC Coding in MATLAB Simulink

Experiment 9: To generate a bit error rate versus Eb/No curve for a link that uses 16-QAM modulation and a rate 2/3 convolutional code in AWGN

Experiment 10: Transmit and receive standard and shortened RS-encoded, 64-QAM-modulated data through an AWGN channel. Compare the performance of the standard and shortened codes.

ANTENNA AND WAVE PROPAGATION (ECN14103)

Course Outcomes:

On successful completion of the course students will be able to:

- Learn the basic parameters of an antenna and its radiation mechanism
- Understand the design and analyze of various wire antenna, and antenna arrays
- Understand the design and analyze of various broadband and planar antennas
- Learn the concept of aperture as well as high gain reflector antennas
- Express the basic concepts of ground, space, sky wave propagation mechanism

UNIT 1: Electromagnetic Radiation and Antenna Fundamentals- Review of Maxwell's equations: Retarded vector potential, Solution of wave equation in retarded case, Concept of radiation, Antenna equivalent circuits, Antenna characteristics: Radiation pattern, Beam solid angle, Radiation intensity, Directivity, Gain, Input impedance, Polarization, Bandwidth, Effective aperture, Antenna effective height, Antenna temperature. 6(L)

UNIT 2: Wire Antenna and Antenna Arrays-Wire antennas: Hertzian dipole, short dipole, Radiation resistance and Directivity, Half wave Dipole, Monopole, Small loop antennas. Antenna Arrays: Linear Array and Pattern Multiplication, Two-element Array, Uniform Array, Array with non-uniform Excitation, Binomial Array. 6(L)

UNIT 3: Special and Broad band Antennas-Special Antennas: Long wire, V and Rhombic Antenna, Yagi-Uda Antenna, Turnstile Antenna, Helical Antenna- Axial and Normal mode helix, Bi- conical Antenna, Frequency Independent Antenna, Log periodic Dipole Array, Spiral Antenna, Microstrip. 6(L)

UNIT 4: Aperture Antennas- Aperture Antennas: Slot antenna, Horn Antenna, Pyramidal Horn Antenna, Reflector Antenna-Flat reflector, Corner Reflector, Common curved reflector shapes, parabolic reflector, Lens Antenna, Patch Antennas. 6(L)

UNIT 5: Radio Wave Propagation- Ground Wave Propagation, Free-space Propagation, Ground Reflection, Surface waves, Diffraction, Wave propagation in complex Environments, Tropospheric Propagation, Space waves, Ionosphere propagation: Structure of ionosphere, Skywaves, Skip distance, Virtual height, Critical frequency, MUF, Electrical properties of ionosphere, Effects of earth's magnetic fields, Faraday rotation. 6(L)

UNIT 6: Modern Antennas- Phase Array Antennas, Smart Antennas for Mobile Communication, MIMO Antennas for 5G Communication System, Reconfigurable Antenna 6(L)

Text/Reference Books:

- John D. Kraus, "Antenna and Wave Propagation", Tata McGraw-Hill, 5th Edition, 2017
- Balanis, C.A., "Antenna Theory and Design", 4th Ed., John Wiley & Sons., 2021

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- Stutzman, W.L. and Thiele, H.A., "Antenna Theory and Design", 3rd Edition, John Wiley & Sons., 2012
- E.C. Jordan and Balmain, "Electromagnetic waves and Radiating Systems", Pearson Education, 2nd Edition, 2015

Microcontrollers and Embedded Systems (ECN14104)

Course Outcomes:
On successful completion of the course, the students will be able to:

- Learn & understand required features and design parameters of Embedded Systems.
- Understand architectural features of AVR microcontrollers and development of application programs in C.
- Understand interfacing of I/O devices with microcontrollers.
- Understand and design small scale embedded system.

UNIT 1: Introduction, categorization of Embedded systems, exemplary systems, selection of processor and memory for Embedded system. 4(L)

UNIT 2: Evolution of AVR family versions and features, AVR architecture, data types, stack, introduction to assembly language, AVR programming in C. 8(L)

UNIT 3: AVR (Atmega32) I/O ports and their configuration, introduction to timer/counter operation, AVR timer programming in C, interrupts in AVR, Atmega32 programming in C, AVR serial port, programming Atmega32 serial port in C, interrupt driven data transfer through serial port of Atmega32. 8(L)

UNIT 4: ADC, DAC and sensor interfacing in AVR, PWM programming, DC motor control, stepper motor interfacing, RTC interfacing. 8(L)

UNIT 5: Introduction to Arduino UNO R3 (Atmega328P), working with Arduino IDE, configuring digital and analog pins, introduction to Raspberry Pi 4, uses of Raspberry Pi 4 in word processing, internet browsing etc. 8(L)

Text Books:

- Muhammad Ali Mazidi, Sarmad Naimi, Sepehr Naimi, The AVR Microcontroller and Embedded Systems using Assembly and C, Pearson Education.

Reference Books:

- Raj Kamal, Embedded System Architecture, Programming and Design, 2nd Ed, Tata McGraw Hill.
- Myke Predko, Handbook of Microcontrollers –Tab Books/McGraw Hill.
- L. B. Das, Embedded Systems: An Integrated Approach, Pearson Education.

MICROCONTROLLER AND EMBEDDED SYSTEMS LAB

Outcomes:
On successful completion of the experiments in this Lab, the students will be able to:

- Learn and understand simulation with Verilog.
- Simulate a variety of digital devices.
- Understand Microcontrollers programming.
- Understand and design small scale applications using microcontroller kit.

Experiment 1: Verification of various addressing modes

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Experiment 2: Manipulating register banks

Experiment 3: data transfer between internal RAM and code memory.

Experiment 4: Different basic application programs like sorting, code conversion etc.

Experiment 5: Interfacing key boards and displays.

Experiment 6: Interfacing ADC and DAC.

Experiment 7: Interrupt driven serial port communication.

Experiment 8: Mini Project using Arduino.

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Courses offered by ECED in Fifth Semester B Tech ECE

Course Code	Course name	L	T	P	Credit
ECN15101	Digital Signal Processing*	3	1	2	5
ECN15102	Computer Architecture	3	0	0	3
ECN15103	Data Communication Networks	3	0	0	3
ECN15104	Electronic Circuit Design*	3	1	2	5
ECN15105	Optical Communication	3	0	0	3
ECN15106	VLSI Design*	3	0	2	4
ECN15250,15251,15252,15253, 15254, 15255	Elective-I	3	0	0	3
	Total	21	2	6	26

*** Theory and Lab Course**

Details of all Elective Courses (Elective I, II, III, IV and V) are available at one place.

DIGITAL SIGNAL PROCESSING (ECN15101)

Course outcomes:

On successful completion of the course, the students will be able to:

- Analyze the discrete-time systems in both time and frequency domains.
- Analyze the discrete-time signals and systems using DFT and FFT.
- Design and implement IIR and FIR filters.
- Implement digital filter structures and analyze the effects of finite wordlength.
- Understand and develop Multirate digital signal processing systems.
- Understand the concept of Adaptive signal processing.

UNIT 1: Introduction, Overview of Digital signal processing, review of signals and systems, review of Z-transforms, Inverse Z-transform, pole zero plot, Power series expansion and partial fraction expansion, one sided Z-transform and its properties, initial value and final value theorems, analysis and characterization of LTI systems using Z-Transforms. 6(L)

UNIT 2: DISCRETE FOURIER TRANSFORM: Review of Discrete Fourier Series (DFS) and Discrete-time Fourier Transform (DTFT), Discrete Fourier Transform (DFT) and its properties, relationship with other transforms, Computation of DFT of long data sequences (Overlap and Add method, Overlap and Save method), Fast Fourier Transform (DIT FFT and DIF FFT) algorithms, linear filtering using DFT, applications of DFT. 6(L)

UNIT 3: REALIZATION OF DIGITAL LINEAR SYSTEMS: Introduction, basic realization, block diagram representation and signal flow graph, different structures for IIR and FIR systems. 4(L)

UNIT 4: INFINITE IMPULSE RESPONSE (IIR) AND FINITE IMPULSE RESPONSE (FIR) FILTERS: Introduction to IIR filters, filter design by approximation of derivatives, impulse invariance method, bilinear transformation, design of Butterworth, Chebyshev filters, frequency transformation, Introduction to FIR filters, frequency response of linear phase FIR filters, various design techniques of FIR filters. 10(L)

UNIT 5: EFFECT OF FINITE WORDLENGTH IN DIGITAL FILTERS: Introduction, rounding and truncation errors, quantization effects in analog to digital conversion of signals, limit cycle oscillations. 4(L)

UNIT 6: INTRODUCTION TO MULTIRATE DSP AND ADAPTIVE SIGNAL PROCESSING: Introduction, sampling rate conversion, filter structures, polyphase decomposition, introduction to adaptive signal processing, adaptive filter structures, minimum MSE criterion, application examples. 6(L)

Text Books:

- A.V. Oppenheim and R.W. Schafer, Digital Signal Processing, Pearson.
- J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, 3rd edition, PHI.
- R. E. Crochiere and L. R. Rabiner, Multirate Digital Signal Processing, 1st edition, Pearson.
- B. Widrow and S. D. Sterns, Adaptive Signal Processing, Pearson Education, 2nd Indian reprint.

Reference Books:

- A.V. Oppenheim and R.W. Schafer, Discrete-time Signal Processing, 3rd edition, Pearson.
- A.V. Oppenheim, A.S. Willsky, and I.T. Young, Signals and Systems, PHI.

DIGITAL SIGNAL PROCESSING LAB

Outcomes:

On successful completion of the experiments in this lab, the students will be able to:

- Understand the experimental concepts of DSP and their implementation using MATLAB software.
- Learn the generation of basic signals and calculation of response of DSP systems.
- Carry out the simulation of multiple numerical transforms relating time and frequency in DSP.
- To learn DSP Processor-based implementation of different DSP systems.

Experiment 1: Plot the following sequences:
(a) Unit sample (b) Unit step (c) Ramp (d) Exponential (e) Sine (f) Cosine.
Also, down sample each of the above sequences and plot.

Experiment 2: Write a MATLAB program to perform linear convolution of two sequences x(n) and h(n). Also verify the result using inbuilt functions.

Experiment 3: Write a MATLAB program to perform circular convolution of two sequences x(n) and h(n). Also verify the result using inbuilt functions.

Experiment 4: Write a MATLAB program to perform cross correlation between two sequences x(n) and h(n). Also verify the result using inbuilt functions.

Experiment 5: Write a MATLAB program to obtain the Pole-Zero plot of a given system transfer function.

Experiment 6: To study the effect of frequency-domain aliasing and reconstruction.

Experiment 7: To study the effect of time-domain aliasing and reconstruction.

Experiment 8: Write a MATLAB program to compute DFT and IDFT of a given sequence.

Experiment 9: Write a MATLAB program to generate Gaussian numbers with given mean and variance. Plot the PDF of the generated numbers.

Experiment 10: Design a FIR low-pass filter with given specifications and verify the magnitude, phase and impulse responses using FDA toolbox.

Experiment 11: Design a IIR low-pass Butterworth filter with following specifications and verify themagnitude, phase and impulse responses using FDA toolbox.

Experiment 12: Write a MATLAB program to perform linear convolution of two sequences using overlap and add method.

Experiment 13: Experiments on TMS320C6713 DSK DSP Kit
(a) Design and conduct IIR low-pass and high-pass filters
(b) Design and conduct FIR low-pass and high-pass filters
(c) Generation of different wave forms (Square, Saw tooth and Sinusoidal)

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COMPUTER ARCHITECTURE (ECN15102)

Course Outcomes:

On successful completion of the course, the students will be able to:

- Design processing unit and control unit of a computer system.
- Analyze the addressing mode concepts and design the instruction set architecture.
- Design high speed fixed-point and floating-point arithmetic circuits.
- Understand memory hierarchy and memory management.
- Understand basic concepts of pipeline and parallel processing.

UNIT 1: CENTRAL PROCESSING UNIT: Fundamental concepts, ALU, CPU architecture, design of arithmetic logic circuits, bus architecture, instruction format, instruction set architecture, addressing modes, instruction cycles. 8(L)

UNIT 2: CONTROL UNIT: Design methodology (processor level, register level and gate level design), register transfer and micro-operations, hardwired and micro-programmed control unit design concept, microprogramming. 6(L)

UNIT 3: MEMORY: Memory hierarchy, performance characteristics, main memory organization, cache memory organization, mapping, and replacement algorithms, associative memory, concept of virtual memory, address Translation. 8(L)

UNIT 4: COMPUTER ARITHMETIC: Fixed point arithmetic, Design and implementation of fast adders and multipliers, division algorithms, IEEE standard for floating point numbers, floating point arithmetic. 4(L)

UNIT 5: I/O ORGANIZATION: Accessing I/O devices, interrupts, DMA, I/O interfaces- serial port, parallel port, PCI bus, SCSI bus, USB bus, firewall. 4(L)

UNIT 6: Introduction of parallel processing and pipeline processing. 4(L)

Text Books:

- Mano Morris, "Computer system Architecture", PHI.
- John P. Hayes, "Computer Architecture and Organization", McGraw Hill.

Reference Books:

- Hamacher, "Computer Organization", McGraw Hill.
- Tennenbaum, "Structured Computer Organization", PHI.
- B. Ram, "Computer Fundamentals architecture and organization", New age international.
- Gear C. W., "Computer Organization and Programming", McGraw Hill.
- William Stalling, "Computer Organization and Architecture", PHI fourth edition.

DATA COMMUNICATION AND NETWORKS (ECN15103)

Course Outcomes:

On successful completion of the course, the students will be able:

- To learn OSI and TCP/IP models and review of Physical Layer concepts.
- To understand the basic concepts of framing, flow and error control.
- To learn different MAC protocols and IEEE standards for LAN, MAN and WAN.
- To comprehend the basic concepts of IP addressing and routing.
- To understand the basic concepts of process to process delivery and Quality of Service.
- To explore some of the recent trends in data communication and networks.

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UNIT 1:	Introduction to Data Communication And Networking Concepts, Networks Topologies, Layered Network Protocol Architectures, Network Types, Performance Parameters; Wired and Wireless media, Basic Concept of Switching and Switching Architecture, Introduction to ATM Reference Model and ATM Networks.	6(L)
UNIT 2:	Data Link Control: Framing, Flow and Error Control, Reliable transmission and Automatic Repeat Request (ARQ) protocols including Stop-and-Wait, Go-back-N, and Selective Repeat. Performance analysis of ARQ protocols. Example protocols such as HDLC and PPP	6(L)
UNIT 3:	Medium Access Control: Random Access and Controlled Access Protocols, Aloha, CSMA, CSMA/CD, CSMA/CA, Hidden and Exposed Terminal Problem, Ethernet (IEEE 802.3), Wireless LAN (IEEE 802.11), DCF and PCF, MAC Frame, Introduction to IEEE 802.15 (WPAN) and IEEE 802.16 (WMAN).	8(L)
UNIT 4:	Networks Layer: Logical Addressing, Ipv4 and Ipv6, ARP, DHCP, ICMP, Subnetting, Classless addressing, Network Address Translation, Routing Protocols: Distance-Vector and Link-State, Interior and Exterior Gateway Protocol concepts, Dijkstra's algorithm, Bellman-Ford algorithm, Example protocols: OSPF, RIP, BGP.	8(L)
UNIT 5:	Transport Layer: Process to Process Delivery, UDP and TCP, Connection Establishment and Termination, Sliding Window, Flow and Congestion Control, Timers, Retransmission, Quality of Service.	4(L)
UNIT 6:	Introduction to latest protocols and standards.	4(L)

Text/Reference Books:

- Kurose and Ross, "Computer Networking – A top-down approach", Seventh Edition, Pearson, 2017.
- Andrew S. Tanenbaum, "Computer Networks", Fifth Edition, Pearson Education India, 2013.
- Peterson and Davie, "Computer Networks, A Systems Approach'', 5th ed., Elsevier, 2011.
- Behrouza A. Forouzan, "Data Communications and Networking", Fourth Edition, TMH, 2017.
- William Stallings, Data and Computer Communications, Tenth Edition, Prentice Hall, 2017.
- Web resources

ELECTRONIC CIRCUIT DESIGN (ECN15104)

Course Outcomes:

On successful completion of the course students will be able to understand:

- Quantitative and Qualitative Analysis of signal stage amplifier and their frequency responses, IC biasing and current mirrors circuits.
- Quantitative and Qualitative Analysis of differential amplifiers circuits and multistage amplifier.
- Internal architecture of Operational amplifiers and its application in signal generation and processing,
- Basic operation and analysis of active filters.
- Operation and application of PLL.

UNIT 1: Single Stage Integrated Circuit Amplifiers: IC Biasing (Current Source, Current Mirrors and Current– Steering circuit), Common source and Common Emitter Amplifier with active load, Common Gate and Common Base amplifier with active load, Cascade amplifier. CMOS Current mirror, CS, CD & CG Amplifier & their frequency response, Bipolar Current mirrors. 10(L)

UNIT 2: Differential and Multistage Amplifier: BJT Differential Pair, Block diagram of MOS Differential Pair, Differential Amplifier with active load, Multistage Amplifier 5(L)

UNIT 3: Operational Amplifier and its Applications: Internal Architecture, Bipolar Op-Amp circuit, CMOS operational amplifier circuit, Stability and Frequency compensation of op-amp, Measurement of OP Amp parameter, Frequency response and compensation, MOS based Inverting and Non inverting amplifier, Difference amplifier. 10(L)

UNIT 4: Active Filter Circuit: Comparison of active and passive filter, Design of Low pass, High pass, Band pass, band stop and all pass active filter, Switched Capacitor Circuits: Basic building blocks, Basic operation and analysis, Bi-quad filter, Switched capacitor filter. 8(L)

UNIT 5: D/A and A/D Converters, Phase Locked Loop: Basic architecture, PLL operation, and application. 3(L)

Text/Reference Books:

- Design of Analog CMOS Integrated circuits- Behzad Razavi-TMH.
- Digital Integrated circuits- J.M Rabaey- PHI.
- CMOS Analog Circuit Design- 2nd Edition – Phillip E. Allen, Douglas R. Holberg – Oxford Uni. Press.
- Analysis and Design of Analog Integrated Circuits- 4th Edition – Gray, Hurst, Lewis, Mayer- Wiley.
- Microelectronic Circuits Theory and Applications- 5th Edition- Adel S. Sedra, Kenneth C. Smith- Oxford

ELECTRONIC CIRCUIT DESIGN (LAB)

Experiment 1: To design a comparator circuit and study the non-linear applications of Op-Amp.

Experiment 2: To design and test the Schmitt Trigger for the given UTP and LTP using IC 741 Op-Amp

Experiment 3: To design a circuit and study the following waveform generators using IC 741 Op-Amp.
(a) Sine wave generator.
(b) Square wave generator.
(c) Triangular wave generator. (d) Sawtooth wave Generator.

Experiment 4: To design and test the following circuits using IC-555
(a) Astable Multivibrator
(b) Monostable Multivibrator
(c) Voltage to Frequency converter
(d) Schmitt Trigger

Experiment 5: To design Voltage Limiter circuit and Precision rectifier using IC741 Op-Amp

Experiment 6: To design and study the circuit of a voltage to frequency converter using IC741Op-Amp

Experiment 7: To design and study the performance of an Instrumentation amplifier

Experiment 8: To design an integrator and differentiator using IC 741 Op-Amp

Experiment 9: To design a band pass filter and notch filter using IC 741 Op-Amp

Experiment 10: To design and test a Second order low pass filter and high pass filter using IC 741 Op-Amp

OPTICAL COMMUNICATION (ECN15105)

Course Outcomes:

On completion of the course students will be able to:

- Learn about the basic concepts of Optical Communication
- Learn about the fiber types and their suitability or choice for any application
- Understand the characterization of Optical Sources and Detectors
- Learn about coherent and incoherent optical communication
- Learn about optical losses and Link- design
- Learn about the concepts of Free Space Optical (FSO) communications

UNIT 1: Optical evolution, advantages of optical communication, its representations, Optical waveguides, basic optical laws, acceptance angle, numerical aperture Skewed rays, Rays and Modes, Step- index, Graded-index fibers, phase and group velocities, Signal degradation in optical fibers, absorption, scattering Dispersions, Optical amplifiers. 10(L)

UNIT 2: Optical sources, modulators, transmitted optical fields, optical field expansion, Photo detection processes, count statistics, photo counting with receiver fields, photo counting with random photo multiplication, shot noise processes, PSD of shot noise, Coherent and Non-coherent detection, system model, single mode and multi-mode detection, SNR performance, AM/IM, FM/IM systems, Multiplexed FM/IM systems, heterodyne SNR. 12(L)

UNIT 3: Optical digital communications, heterodyne ASK, FSK, PSK, Systems, PLL Loop receiver and their noise performance, Optical Link Design 6(L)

UNIT 4: Introduction to Free Space Optical Communication Systems, FSO-OFDM Transmission and Reception, Atmospheric Turbulence Channel Modeling, Temporal Correlation FSO Channel Model, LDPC-Coded IM/DD OFDM for FSO communication, Applications of FSO communications 8(L)

Text/Reference Books:

- Optical Fiber Communications, 5th Edition, 2017, McGraw Hill Education- Gerd Keiser
- Optical Fiber Communications, 3rd Edition,2009, Prentice Hall -John M Senior, Yousif Jamro
- Optical Fiber Communications Principles and Practice -Robert. Gagliardi, Sherman Karp
- OFDM for Optical Communications, 2010 Elsevier Inc. Academic Press, by William Shieh, Ivan Djordjevic
- An Introduction to Fiber Optics, Cambridge University Press, 2017 – Ajoy Ghatak.

VLSI DESIGN (ECN15106)

Course Outcomes:

On successful completion of the course students will be able to:

- Understand the fundamental of MOSFET scaling and short channel effects.
- Introduce the basic of physical VLSI Design and design rules.
- Understand the basic operation of MOS Inverter and their static characteristic.
- Analyse the switching characteristic of the MOS Inverter and the effect of interconnects.
- Understand the Qualitative study of Combinational and Sequential MOS Logic circuits.
- Understand the concept of dynamic logic circuits.
- Understand the fundamental of test and testability for VLSI.

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UNIT 1: Scaling: constant voltage and constant field scaling, scaling factors for device parameter, short channel effects. 2(L)

UNIT 2: Physical VLSI Design: Y-chart, Design rules, stick diagram, layout design strategies and Methods, Design Capture & Verification tool, DRC, LVS, Parasitic extraction. 3(L)

UNIT 3: MOS Inverters: static characteristics – Resistive load inverters, inverters with n type MOSFET load, CMOS inverter. Switching characteristic of MOS inverters and interconnect effect: delay time, inverter design with delay constraints, CMOS ring oscillator, interconnect parasitic and delay, switching power dissipation of CMOS inverter. 10(L)

UNIT 4: **Combinational MOS Logic Circuits**: Two-input NOR, NAND gate, structure of multiple input NOR gate, NAND gate, CMOS based 2 input NAND and NOR gate, Complex logic circuit using NMOS and CMOS, CMOS transmission gate, complementary pass- transistor logic.
Sequential MOS logic circuit: SR latch circuit, clock SR latch, clock JK, Master Slave JK, D flip flop 10(L)

UNIT 5: Dynamic Logic Circuit: Pass Transistor circuit, charge storage and charge leakage, voltage Bootstrapping, CMOS transmission gate logic, Dynamic CMOS logic, Domino CMOS logic, NORA CMOS logic. 6(L)

UNIT 6: **Memories:** – DRAM, SRAM, Advanced RAM techniques, Applications.
Testability: Test principle, DFT principle, design strategies, IDDQ testing. 5(L)

Text/Reference Books:

- Principles of CMOS VLSI Design – By 'Neil H.E Weste & Kamran Eshraghian'
- Essentials of VLSI circuits and systems- By 'Kamran Eshraghian, D.A. Pucknell & S. Eshraghian".
- CMOS Digital IC's analysis and design- By 'Sung-Mo-Kang & Yusuf Leblebici", TMH

VLSI DESIGN LAB

Experiment 1: To write a hardware description of 4-bit adder and subtractor and test its operation

Experiment 2: To write a hardware description of Degree to radian converter

Experiment 3: To write a hardware description of 4-bit mod 13 counter and test its operation

Experiment 4: To write a hardware description of 8-bit register with shift left and shift right operationand test its operation

Experiment 5: To write a hardware description of 4-bit array Multiplier

Experiment 6: To write a hardware description of Booth Multiplier

Experiment 7: To Design NOT, NOR, NAND gates using MENTOR GRAPHICS and compute thedelay between input and output waveforms

Experiment 8: To Design 2:1 MUX using MENTOR GRAPHICS and compute the delay betweeninput and output waveforms

Experiment 9: To Design XOR, NOR, NAND gates using MENTOR GRAPHICS and compute the delay between input and output waveforms and compare the difference between CMOS and pseudo technique.

Experiment 10: To Design XOR gate using CMOS and pseudo NMOS technique using MENTOR GRAPHICS and compute the delay between input and output waveforms and compare them.

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Experiment 11: To Design and simulate D-FLIP FLOP as a MASTER-SLAVE configuration using MENTOR GRAPHICS

Experiment 12: To Design Ring Oscillator using MENTOR GRAPHICS and compute the delaybetween input and output waveforms.

PROFESSIONAL ELECTIVE-I

MODERN RADAR SYSTEMS (ECN15250)

Course Outcomes:

After the completion of the course, the students will be able to:

- Understand radar System principle and fundamentals
- Explain the basic concepts of RCS and radar wave propagation
- Analyze and differentiate between different radar types
- Understand target detection and tracking using radar systems
- Analyze the imaging radar concepts and its applications

UNIT 1: Basics of Radar detection and estimation: Radar frequencies and bands, Radar Applications, Radar block diagram. Radar Range Equation: Range prediction, Maximum Unambiguous Range, Pulse Repetition frequency and Range Ambiguities, Radar Waveforms, Minimum detectable signal. 6(L)

UNIT 2: Radar signals in noise: Threshold detection of radar signals, Receiver noise, SNR, Integration of radar pulse, CFAR detection, Radar cross section of targets, RCS fluctuations, Transmitter Power, System losses, Propagation of Radar Waves, Atmospheric Refraction, Standard propagation, Nonstandard Propagation, Radar clutter 6(L)

UNIT 3: MTI and Pulse doppler Radar: MTI delay lines, Doppler frequency shift, Delay Line Cancellers, Coherent and Non -Coherent MTI, Staggered Pulse Repetition Frequencies, Doppler Filter Banks, Moving Target Detector, Digital MTI Processing 6(L)

UNIT 4: CW FM Radar: Doppler effect, CW Radar, Frequency-modulated CW Radar, Multiple-frequency CW Radar. Tracking radar: Monopulse-amplitude & phase comparison, Sequential Lobing, Conical Scan, Limitations to Tracking Accuracy, Low-Angle Tracking, Tracking in Range. 6(L)

UNIT 5: Phased array and Imaging Radar: Phase array working and feed systems, beamforming, Synthetic Aperture Processing, Resolution Concept, Pulse Compression, ISAR Imaging, Radar based Microwave & millimeter wave Imaging: Ground penetrating radar, Through wall imaging, standoff target detection and identification 6(L)

UNIT 6: Radar Topography: Passive radar, active radar, SDR, MIMO, UWB, drone detection radar, LiDAR, Advanced Radar Systems for Meteorology and Remote sensing applications 6(L)

Text/Reference Books:

- Introduction to Radar Systems – Merrill. I. Skolnik, Publisher: McGraw Hill Education; 3rd edition (2017)
- Radar – principles, technology, applications – Byron Edde, Publisher: Prentice Hall; 1st edition (1992)
- Microwave Imaging – Matteo Pastorino, Publisher: John Wiley & Sons, First edition (2010)
- Radar Foundations for Imaging and Advanced Concepts – R. J. Sullivan, Publisher: SciTech Publishing Inc; Revised ed. Edition (2004)
- Fundamental of Radar Signal Processing – M. A. Richards, Publisher: McGraw-Hill Education; 2nd edition (2014)
- Modern Radar System -Meikle Hamish, Second Edition, Publisher: Artech House, (2001).

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MULTIMEDIA COMMUNICATION (ECN15251)

Course Outcomes:

- To understand the types and representations of multimedia information.
- To learn compression techniques for multimedia contents (Text, audio, video)
- To study and understand the standards and types of multimedia networks
- To learn about tools and devices for multimedia content development
- To understand the technical and operational aspects of emerging and futuristic multimedia applications

UNIT 1: Multimedia Communications- Introduction, information representation, networks, Applications and networking terminology, multimedia Information Representation-text, images, audio, video 4(L)

UNIT 2: Text compression – Huffman coding, Arithmetic coding, LZ coding. Image compression- JPEG, Wavelet based image compression. 4(L)

UNIT 3: Audio and Video compression- Linear predictive coding, perceptual coding, MPEG audio coder. – Video Compression Video compression principle, H.261, H.263, MPEG video coders. 8(L)

UNIT 4: Standards for Multimedia Communications- reference models, network services and protocols, interpersonal communication. Interactive applications over internet. Multimedia conferencing, streaming, and interactive broadcasting, multimedia communication over next generation wireless network. 8(L)

UNIT 5: Interactive Multimedia devices & content development– video, animation, infographic , interactive multimedia devices – interactive smart board, video conferencing system, video streaming devices, etc. 6(L)

UNIT 6: Emerging Multimedia applications- digital classrooms, telemedicine, e-governance, social networks, video-on-demand, OTT (Over The Top) platform, interactive television, etc. 6(L)

Text/Reference Books:

- Fred Halsall/ Multimedia communications: Applications, Networks, Protocols and standards/ Pearson Education, Asi Fourth Impression, 2009
- Jean Walrand & Pravin Varaiya/ High Performance communication Networks, Morgan Kaufmann Publisher, 2nd Editio
- Krishna Kumar D.N. / Multimedia Communication/ Pearson Education, 1st Edition
- Ashok Banerji and Anand Mohan Ghosh, *Multimedia Technologies*, TMH, 2010, 1st Edition.
- Wireless Multimedia Communication Systems: Design, Analysis, and Implementation 1st Edition (2014), by K.R. Rao , Zoran S. Bojkovic, CRC Press.

ADVANCED MICROCONTROLLERS (ECN15252)

Course outcomes:

On successful completion of the course, the students will be able to:

- Understand architectural features of ARM Architecture and development of application programs in Assembly language & C language.
- Understand interfacing of I/O devices with ARM.

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- Understand and design small-scale embedded systems.

UNIT 1: ARM ARCHITECTURE: Evolution of ARM Architecture, 32-Bit Cortex-M Architecture, CPU architecture, memory model, MPU, registers, modes, exceptions, interrupts and vector table, core extensions, architecture revisions, exception handlers, interrupt controllers, power modes, hardware features and optimizations, advanced bus standards like AMBA, The NVIC on ARM Cortex-M, LPC2148 Microcontroller architecture. 12(L)

UNIT 2: ARM INSTRUCTION SET: Syntax, addressing modes and operands, memory access instructions, operations, shift operations, arithmetic operations, stack logical, functions and control flow, assembler directives, thumb and arm instruction differences. 8(L)

UNIT 3: PERIPHERALS PROGRAMMING: Assembly language and C programming of timers, interrupts, serial port. UART, I2C, PWM, DAC, ADC and other important on-chip peripherals. 8(L)

UNIT 4: INTERFACING: Interfacing sensors, actuators, GPIO, LED, 7 segment display, stepper motor, keyboard, push button switch, data Conversions (ADC, DAC), timer. 8(L)

Text Books:

- Mazidi, Muhammad Ali, Sarmad Naimi, Sepehr Naimi, and Shujen Chen. "ARM Assembly Language Programming & Architecture (Volume 1)", 2016.

Reference Books:

- Yiu J. The definitive guide to the ARM Cortex-M3/M4 Processors. Newnes; 2009 Nov 19.
- Valvano, Jonathan W. Embedded Systems: Real-Time Interfacing to Arm® Cortex (TM)-M Microcontrollers. Jonathan W. Valvano, 2012.

ADVANCED ANALOG DESIGN (ECN15253)

UNIT-1: Noise

Statistical characteristics of Noise, Types of Noise, Representation of Noise in circuits, Noise in single-stage amplifiers, Noise in differential pairs, Noise bandwidth 5(L)

UNIT-2: Feedback

Introduction and Properties of Feedback circuits, Types of Amplifiers, Feedback Topologies- Voltage-Voltage Feedback, Current-Voltage Feedback, Voltage-Current Feedback, Current-Current Feedback, Effect of Loading, Effect of feedback on noise 7(L)

UNIT-3: Operational Amplifiers

Introduction and Performance parameters, One-stage Op Amps, Two-stage Op Amps, Gain Boosting, Common mode feedback, Slew Rate, Power supply rejection, Noise in Op Amps 6(L)

UNIT-4: Stability and Frequency Compensation

General considerations, Multipole systems, Phase margin, Frequency compensation, Compensation of two-stage Op Amps, Other compensation techniques 6(L)

UNIT-5: Introduction to Switched-Capacitor Circuits

General considerations, Sampling switches, Switched-capacitor Amplifiers, Switched-capacitor Integrator, Switched-capacitor common mode feedback 6(L)

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UNIT-6: Oscillators

Ring Oscillators, LC Oscillators, Voltage-Controlled Oscillators, Mathematical Model of VCOs, Phase-locked loop 6(L)

Text/Reference Books:

- Design of Analog CMOS Integrated Circuits- by 'Behzad Razavi', TMH
- CMOS Analog Circuit Design- By 'Douglas R. Holberg and Phillip E. Allen', Oxford University Press

MEMS AND INTEGRATED SENSORS (ECN15254)

Course Outcomes:

On successful completion of the course students will be able to:

- Apply the principles behind the operation of MEMS devices
- Select micro manufacturing methods and identify key variables to improve quality of MEMS.
- Design and fabricate MEMS devices or a microsystem
- Understand traditional and recent advancements in the field of MEMS sensors and devices
- Choose appropriate industrially viable process, equipment and tools for a specific product.
- Understand the need of interface electronics and different measurement techniques for sensorsystem.

UNIT 1: Introduction to MEMS; MEMS technologies; Applications. 6(L)

UNIT 2: Microelectronic technologies for MEMS, Micromachining- surface and bulk; MEMS processes 10(L)

UNIT 3: MEMS based sensors, thermal sensors, chemo sensors, optical sensors, pressure sensors, biosensors, accelerometer, gyroscope, Flow sensor 12(L)

UNIT 4: Interface electronics and measurement techniques for smart sensor systems, Object orientedDesign of Sensor Systems, Sensing Elements and their Parasitic Effects, Future Trends 8(L)

Text/ Reference Books:

- Smart Sensor Systems, Gerard C. M. Meijer, John Wiley and Sons, 2008
- Microsystem Design, Stephen D. Senturia, Kluwer Academic Publishers, 2001
- Microsensors, MEMS, and Smart Devices, Julian W. Gardner, V. K. Varadan, Osama O.Awadelkarim John Wiley and Sons

Emerging Technologies, Devices and Applications (ECN15255)

Pre-requisite(s): Electronic Devices, Physics of MOS Transistor
Co- requisite(s): CMOS Digital Integrated Circuits

Course Outcomes:

After the completion of this course, students will be able to:

CO1	Understand the emerging technologies to fabricate novel devices
CO2	Analyse and understand the basics of HEMT and advanced memory devices and their integration
CO3	Analyse the challenges involved in scaling device beyond sub-5 nm and integration of diverse and heterogeneous materials with improved electronic properties

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CO4	Understand the basic principles involved in solar photovoltaics and related challenges in storing the solar energy and available storage technologies
CO5	Understand the basics if of neuromorphic devices which can be further related to fabricate devices and intelligent ICs

UNIT -1:
Emerging Technologies:
Printed electronics, Printed-micro-devices, Sensors, spintronics, flexible electronics, wearable electronics, photodetectors based on 2D materials, Magnetic materials-based devices. 4(L)

UNIT -2:
HEMT and Novel Memory Devices: Basic structure and fabrication process of a HEMT device, Energy-band diagram analysis of HEMT devices, metal-oxide RRAM, magneto resistive random-access memory (MRAM). 8(L)

UNIT -3:
New generation device engineering for sub-5 nm scaling and non-silicon electronics:
Finfets, Vertical MOSFETs, 3D heterogeneous integration, GAA MOSFETs, Nanowire Based MOSFETs, Carbon nanotube electronics: band structure, transport, and applications, Single electron transistors. 8(L)

UNIT -4:
Solar Photovoltaics (PV):
Need and Prospects of PV, Basics of solar energy conversion: Basic optoelectronic properties of materials, Device configurations for solar cell design: PN (c-Si), PIN (Organic, perovskite), Carrier-selective, Tandem; Grid connected PV, challenges in storage of solar energy, printed and flexible solar cells. 8(L)

UNIT -5:
Neuromorphic Engineering
Introduction to Neuromorphic Engineering; Signalling and operation of biological neurons, neuron models, signal encoding and statistics; biological neural circuits; Neuromorphic design principles; Analog and digital electronic neuron design; Electronic synapses. 8(L)

Text Books:

- Phaedon Avouris, Tony Heinz and Tony Low, "2D Materials: Properties and Devices", 1st edition (July 31, 2017), Cambridge University Press.
- The Physics of Low-Dimensional Semiconductors, John H. Davies, Cambridge University Press, 1998.
- Quantum Transport: Atom to Transistor, Supriyo Datta, Cambridge, (2005).
- Nanoelectronics and Information Technology (Advanced Electronic Materials and Novel Devices), Waser Ranier, Wiley-VCH (2003).
- Photovoltaics Fundamentals, Technology, and Practice, Konrad Mertens, Wiley, 2018, ISBN No. 13: 978-1119401049.
- Introduction to Nanotechnology, C.P. Poole Jr., F.J. Owens, Wiley (2003).
- Eric Kandel, James Schwartz, Thomas Jessell, Steven Siegelbaum, A.J. Hudspeth, Principles of neural science, McGraw Hill 2012, ISBN 007139011.

Reference Book:

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- Michel Houssa, Athanasios Dimoulas, Alessandro Molle, "2D Materials for Nanoelectronics", 1st edition (April 5, 2016), CRC Press.
- Electronic transport in mesoscopic systems, Supriyo Datta, Cambridge, (1995).
- Nanosystems, K.E. Drexler, Wiley (1992).
- Solar Cells: Operating Principles, Technology and System Applications, Martin A. Green, Prentice-Hall, 1986, ISBN No. 13: 978-0138222703.
- Dale Purves, Neuroscience, Sinauer, 2008, ISBN 0878936971.
- Carver Mead, Analog VLSI and neural systems, Addison-Wesley, 1989, ISBN0201059924.
- Research Papers

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Courses offered by ECED in Sixth Semester ECE

Course Code	Course name	L	T	P	Credit
ECN16101	Digital Image Processing	3	0	2	4
ECN16102	RF and Microwave Engineering	3	0	2	4
ECN16103	Semiconductor Devices and Modeling	3	0	0	3
HSN16XXX	Soft Skills and Personality Development	3	0	0	3
ECN16250,16251, 16252, 16253,16254,16255, 16256, 16257	Elective-II	3	0	0	3
ECN16275,16276,16277,16278, 16279, 16280, 16281, 16282	Elective-III	3	0	0	3
	Total	18	0	4	20

DIGITAL IMAGE PROCESSING (ECN16101)

Course outcomes:

On successful completion of the course, the students will be able to:

- Introduce the concepts of image processing and basic analytical methods to be used in image processing.
- Understand image transforms and their applications.
- Understand the concept of time-frequency transforms and their applications.
- Explain different image compression techniques.
- Familiarize students with image enhancement and restoration techniques.
- Introduce segmentation techniques.

UNIT 1: INTRODUCTION: Introduction to Digital image processing, fundamental steps, 2-D signals and systems, Mathematical preliminaries, 2-D sampling theorem, sampling with different geometries, some basic relationship between pixels. 5(L)

UNIT 2: IMAGE TRANSFORMS: 2-D orthogonal and unitary transforms, basis image, properties of unitary transforms, 1-D and 2-D discrete Fourier transform and its properties, DCT, DST and their properties, Walsh Hadamard transform, Harr & Slant transform, KL transform. 6(L)

UNIT 3: WAVELET TRANSFORM AND ITS APPLICATIONS: Review of Multirate signal processing, short-time Fourier transform, fundamentals of wavelet transform and its application, image analysis using multi-resolution techniques. 5(L)

UNIT 4: IMAGE DATA COMPRESSION: Image redundancies, lossy and lossless compression, pixel coding, predictive coding, fidelity criteria, DCT and wavelet-based transform coding schemes, Huffman, run-length and arithmetic coding, JPEG and JPEG 2000 standards. 6(L)

UNIT 5: IMAGE ENHANCEMENT TECHNIQUES: Spatial domain and frequency domain methods, Gray scale transformation, histogram matching and equalization, Smoothening: noise removal, averaging, median, min/max filtering, sharpening of images using differentiation, Laplacian and high emphasis filtering, edge detection. Image restoration: degradation model, averaging, inverse and Wiener filtering. 8(L)

UNIT 6: IMAGE SEGMENTATION: Line and edge detection, detection of discontinuities, edge labelling and boundary detection, edge linking using Hough transform, thresholding techniques, image segmentation using similarities: region growing, split and merge. 6(L)

Text Books:

- R. C. Gonzalez & Richard E. Woods, Digital Image Processing, 3rd edition, Pearson.
- A. K. Jain, Fundamentals of Digital Image Processing, Pearson.

Reference Books:

- Sanjit K. Mitra, Digital Signal Processing: A Computer Based Approach, 3e, McGraw Hill.
- J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms, and Applications, 3rd edition, PHI.
- R. C. Gonzalez & Paul Wintz, Digital Image Processing, Longman Higher Education.

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- A. Rosenfield & A.C. Kak, Digital Picture Processing, Morgan Kaufmann.
- N. Ahmad & K.R. Rao, Orthogonal Transform for Digital Signal Processing, Springer.
- A.M. Tekalp, Digital Video Processing, Prentice-Hall.

DIGITAL IMAGE PROCESSING LAB

Course outcomes:

On successful completion of the course, the students will be able to:

- Learn the use of various simulation tools for digital image processing operations.
- Implement various conventional image processing operations.
- Implement the gained knowledge in solving practical image processing related problems.
- Learn hardware implementation of signal/image processing algorithms.

Experiment 1: Write a program to read an RGB image and perform various operations on the image.

Experiment 2: Write a program to perform zoom in and zoom out operation on an image by 200% and 50 % respectively.

Experiment 3: Write a program to construct 5*5 Gaussian and Median filter and apply on an image corrupted by salt and pepper noise.

Experiment 4: Write a program to detect the edges of a coloured image using Sobel operators and verify the results using the inbuilt commands.

Experiment 5: Write a program to detect the edges of a coloured image using Prewitt operators and verify the results using the inbuilt commands.

Experiment 6: Write a program to detect an edge of an image using second order derivative Laplacian operator.

Experiment 7: Convert a colour image into a grayscale image. Write a program to perform histogram equalization of a gray scale image and compute the PSNR of the output image.

Experiment 8: Develop an efficient program to scan the elements, of any given 8X8 matrix, in zig–zagorder (i.e., from 0 to 63 in order)

Experiment 9: Write a program to read RGB image and calculate DCT coefficients of the image and recover the original image after applying inverse DCT.

Experiment 10: Add Gaussian noise to a grayscale image and then recover original image by appropriate filter.Calculate the parameter MSE, PSNR of original and recovered image.

Experiment 10: Write a program to perform bit slicing of colour image and plot them.

Experiment 11: Write a program to perform morphological operation on a coloured image and detect edge using the same.

RF AND MICROWAVE ENGINEERING (ECN16102)

Course Outcomes:

On successful completion of the course students will be able to:

- Understand the classification of Microwave frequency bands and their respective applications. Student will also understand the change in circuit behavior at higher frequency
- Understand the design simple microwave passive circuits and devices. Student will also understand the

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microwave propagation in ferrites

- Demonstrate various operating principles of solid-state microwave devices
- Understand the limitations of conventional tubes at microwave frequency and concept of different Microwave tubes
- Have the knowledge regarding handling microwave instrument as well as measurement of different parameter at microwave frequency

UNIT 1: Introduction- Microwave frequencies, Standard Frequency bands, Behavior of circuits at Conventional and microwave frequencies, Microwave applications. 4 (L)

UNIT 2: Microwave Passive Components- Scattering matrix- Concept of N port Scattering matrix representation, Properties of S matrix- S matrix formulation of two-port junction. Microwave junctions- Tee junctions E-Plane Tee, H- Plane Tee and Magic Tee, Rat-race, Corners, bends and twists, Directional couplers- two-hole directional couplers- Ferrites –important microwave properties and applications, Isolator, Circulator, Attenuator, Phase shifter. 10 (L)

UNIT 3: Microwave Sources, Microwave Semiconductor Devices- Principles of operation – characteristics and application of tunnel diodes, PIN diode and LSA. Transferred Electron Devices – Gunn Diode-Avalanche Transit time devices IMPATT and TRAPAT, Parametric devices - Principles of operation - applications of parametric amplifier. 8(L)

UNIT 4: Microwave measurements: Microwave test bench, Measurement of power, wavelength, frequency, impedance, SWR, attenuation and phase shift, Microwave measurement and applications. 6(L)

UNIT 5: Microwave Link Design of Wireless System: Microwave Networks, Noise and Distortion in Microwave System, Antenna Design, Filter and Amplifier Design, Receiver Design 8(L)

Text/Reference Books:

- Samuel Y. Liao "Microwave Devices and Circuits" PHI, 3rd Edition, 2005
- D.M. Pozar, "Microwave Engineering.", John Wiley & sons, Inc.,4th Edition, 2013
- Robert. E. Collin- Foundation of Microwave Engineering–Tata Mc Graw Hill.
- Annapurna Das and Sisir K Das, "Microwave Engineering", Tata Mc Graw-Hill Inc., 3rd Edition, 2017
- D M Pozar, "Microwave and RF Design of Wireless Systems", Wiley Publication, 2nd Edition, 2017

RF AND MICROWAVE ENGINEERING LAB

Experiment 1: To Study the Characteristics of Reflex Klystron and to determine its electronic tuning range.

Experiment 2: To determine the frequency and wavelength in a rectangular waveguide working in TE10 mode.

Experiment 3: To Measure the Standing Wave Ratio (SWR) and Reflection Coefficient.
(a) Low VSWR (b) High VSWR

Experiment 4: To measure an unknown impedance with smith chart.

Experiment 5: To study V-I characteristics of GUNN diode.

Experiment 6: Study the function of directional coupler by measuring the following parameters

Experiment 7: To measure main line and main line VSWR

Experiment 8: To measure the coupling factor and directivity.

Experiment 9: Study of Attenuator and Isolator

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Experiment 10: Study of Magic Tee. E-plane Tee and H-plane Tee

Experiment 11: Low power Microwave measurement using Microwave power Sensor.

Experiment 12: Simulation of basic microwave components

SEMICONDUCTOR DEVICES AND MODELING (ECN16103)

UNIT 1: Contact Potential, Two terminal MOS, Concept of Flat band Voltage, Potential Balance and Charge Balance, Effect of Gate-Body Voltage on Surface Condition, Accumulation Depletion and Inversion - Regions of Inversion - Strong Inversion, Weak Inversion and Moderate Inversion, Small-Signal Capacitance. 10(L)

UNIT 2: Three Terminal MOS, Contacting the Inversion Layer, The Body Effect, Strong Inversion, Weak Inversion and Moderate Inversion, Approximate Limits of Strong Inversion, Weak Inversion and Moderate Inversion, Pinchoff voltage, Uses for Three-Terminal MOS Structures References Problems. 7(L)

UNIT3: Four Terminal MOS, Transistor regions of Operations, Complete All-Region Model, Simplified All-Region Models, Models Based on Quasi-Fermi Potentials, Regions of Inversion in Terms of Terminal Voltages, Complete Strong-Inversion Model, Body-Referenced Simplified Strong-Inversion Model, Source-Referenced Simplified Strong-Inversion Model, Special Conditions in Weak Inversion Body and source Referenced Model for weak inversion Moderate-Inversion Models, Source-Referenced vs. Body-Referenced Modeling, Effective Mobility, Effect of Extrinsic Source and Drain Series Resistances, Temperature Effects, Breakdown. 13(L)

UNIT 4: Carrier Velocity Saturation, Channel Length Modulation, Charge Sharing, Limitations of Charge-Sharing Models, Drain-Induced Bather Lowering, Punch through, Hot Carrier Effects; Impact Ionization, Velocity Overshoot and Ballistic Operation. 6(L)

Text/ Reference Books:

- Donald A Neamen, "Semiconductor physics and devices: basic principles McGraw-Hill, 2003.
- Yannis Tsividis, Colin McAndrew "*Operation and Modeling of the MOS Transistor*", Oxford University Press, 2011.

Professional Elective-II

ADVANCED DIGITAL TRANSMISSION (ECN16250)

Course Outcomes:

On successful completion of the course students will be able to:

- Understand basics of communication system and different channel models.
- Understand optimum receiver, synchronization and equalization.
- Learn the basic concepts of channel fading.
- Understand diversity techniques and multiuser communication.
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UNIT 1: Multipath fading environment: Rayleigh Fading and Statistical Characterization, Properties of Rayleigh Distribution, Narrowband vs Wideband Channels, Characterization of Multipath Fading Channels, BER performance in fading channels. 6(L)

UNIT 2: Diversity techniques for fading multipath channels, Statistical Characterization of Antenna Diversity, Optimal Diversity Combining, Capacity of fading Channels, Capacity with Outage, Channel State Information, Optimum Power Allocation, Receiver Synchronization. 6(L)

UNIT 3: Foundation for SDR, Components of SDR, SDR architecture, Non-linear distortion parameters, Behavioral models for representing nonlinear distortions, Linearization Techniques for nonlinear distortion. 6(L)

UNIT 4: Introduction to cognitive radio, CR architecture, Dynamic spectrum access, Introduction to spectrum sensing, spectrum sensing technique. 6(L)

UNIT 5: Details of beam forming in mm Wave, Hybrid beam forming concept, MIMO-OFDM with mm Wave beam forming, Parameter estimation in mm Wave system, Introduction of impairments and a basic analysis in mm Wave system. 6(L)

UNIT 6: Free space optical communication, Magnetic induction communication, Introductions to Reconfigurable Intelligent surface for 5G and 6G technologies. 6(L)

Text/Reference Books:

- John J. Proakis, "Digital communication" 5th edition MGH, 2008
- Fundamental of Wireless Communication By David Tse, Pramod Viswanathan, Cambridge University Press, 2005
- Millimeter Wave communication Systems By Kao-Cheng Huang, Zhaocheng Wang, Wiley-IEEE Press, 1st edition, 2011.
- Y. S. Cho, J. Kim, W. Y. Yang, and C. G. Kang, MIMO-OFDM Wireless Communications with MATLAB. Hoboken, NJ, USA: Wiley, 2010.

SATELLITE COMMUNICATION (ECN16251)

Course Outcomes:

On successful completion of the course students will be able:

- To learn the Satellite Communication Overview and Orbital Mechanics
- To understand the different subsystem of satellite Communication
- To learn the satellite link design and suggest the methods to improve the link performance
- To learn the different Multiple Access and Multiplexing Techniques used for satellite links
- To understand the designing and testing of different satellite communication systems as per given specifications.
- To understand the satellite launch mechanism and different launch vehicles

UNIT 1: Fundamental of Satellite Communications: Different Frequency bands and their applications in satellite Communication, Satellite orbit and orbital equations, Kepler's laws of planetary motion, Locating satellite in the orbit, Locating satellite with respect to earth, Look angle calculation, coverage angle and slant range, orbital perturbations, satellite launching, orbital effects in communication subsystem performance, Mechanism of Satellite launching, Launch Vehicles, Advanced launching tech like Space X 10 (L)

UNIT 2: Satellite link Design: Design Parameters, Link Budget Design, Path Loss Calculations, Look Angles: Elevation and Azimuth Angle, Transponder: Antenna, LNA, BPF, Down-Converter, HPA, Adjacent Channel Interference, Input and Output Back Off, Uplink Power Control (UPC), Noise Figure, Figure of Merit (G/T) and Energy per Bit (Eb/No) 8 (L)

UNIT 3: Satellite Communication Applications: VSAT, Direct broadcast satellite television and radio, Satellite navigation and the Global positioning systems, GPS position location principle, GPS receivers and codes, Satellite Signal Acquisition, GPS navigation Message, GPS Signal Levels, Timing Accuracy, GPS Receiver Operation 8 (L)

Unit 4: Satellite Solutions for 5G: Role of satellite communications in 5G ecosystem, Satellite use cases and scenarios for 5G eMBB, Next-generation non-geostationary satellite communication systems, Enabling 5G using MEO satellites

5(L)

Unit 5: Emerging Trends in Satellite Communication: IoT via Satellite, Beam Hopping and Docking, 2nd Generation Galileo Navigation Satellites, Anti-Satellite (ASAT) and Direct Ascent Anti-Satellite (DA-ASAT) technologies, Next-generation interceptor

5(L)

Text/Reference Books:

- Timothy Pratt and Jeremy Allnutt, "Satellite Communications", Wiley India, 3rd Edition, 2021
- Shree Krishna Sharma, Symeon Chatzinotas and Pantelis-Daniel Arapoglou, "Satellite Communications in the 5G Era" IET, 1st Edition, 2021
- D. Roddy, "Satellite Communications", McGraw-Hill Education, 4th Edition, 2010.
- M. Karimi, "Advances In Satellite Communications", 1st Edition, ;2016

OPTICAL WIRELESS COMMUNICATION (ECN16252)

Course Outcomes:

On successful completion of the course students will be able:

- To understand the techniques of Wireless Optical Communication in the near-Infrared and visible bands.
- To understand the principles of Directed and Non-Directed LOS Systems
- To understand the different channel modelling schemes.
- To find the performance of OWC systems under different modulation schemes.
- To learn the versatile applications of OWC

UNIT-1: Introduction to Optical Wireless Communication Systems

Wireless Access Schemes, A Brief History of OWC, OWC/Radio Comparison Link Configuration, OWC Application Areas, Safety and Regulations: Maximum Permissible Exposures, OWC Challenges, Review of Light Sources including LED and Laser, Review of Photodetectors, Direct Detection, Coherent Detection: Heterodyne Detection, Homodyne Detection, Photodetection Noise: Photon Fluctuation Noise, Dark Current and Excess Noise, Background, Signal-to-Noise Ratio, Optical Detection Statistics.

7(L)

Unit-2: Channel modelling

Indoor Optical Wireless Communication Channel: LOS Propagation Model ,Non-LOS Propagation Model, Ceiling Bounce Model, Hayasaka–Ito Model ,Spherical Model, Artificial Light Interference: Incandescent Lamp, Fluorescent Lamp Driven by Conventional Ballast ,Fluorescent Lamp Model, Outdoor Channel: Atmospheric Channel Loss ,Fog and Visibility ,Beam Divergence ,Optical and Window Loss ,Pointing Loss, The Atmospheric Turbulence Models: Log-Normal Turbulence Model ,Spatial Coherence in Weak Turbulence ,Limit of Log-Normal Turbulence Model, The Gamma–Gamma Turbulence Model, The Negative Exponential Turbulence Model, Atmospheric Effects on OWC Test Bed: Demonstration of Scintillation Effect on Data Carrying Optical Radiation.

8(L)

Unit-3: Modulation Techniques

Introduction, Analogue Intensity Modulation, Error Performance on Gaussian Channels, Digital Baseband Modulations and Error Probability Analysis, Passband Modulations, Comparisons of Baseband Modulation Schemes: Power Efficiency, Transmission Bandwidth Requirements, Transmission Capacity, Transmission Rate, Peak-to-Average Power Ratio, Subcarrier Intensity Modulation.

5(L)

Unit-4: FSO link Performance Under the effect of Atmospheric Turbulence

On–Off Keying:OOK in a Poisson Atmospheric Optical Channel, OOK in a Gaussian Atmospheric Optical Channel, Pulse Position Modulation, Subcarrier Intensity Modulation: SIM Generation and Detection, SIM-FSO Performance in Log-Normal Atmospheric Channel, Bit Error Probability Analysis of SIM-FSO:BPSK-Modulated Subcarrier ,M-Ary PSK-Modulated Subcarrier ,DPSK-Modulated Subcarrier , Multiple SIM Performance Analysis ,Outage Probability in Log-Normal

Atmospheric Channels, SIM-FSO Performance in Gamma–Gamma and Negative Exponential Atmospheric Channels, Outage Probability in Negative Exponential Model Atmospheric Channels. 8(L)

Unit-5: Outdoor OWC Links with Diversity Techniques
Atmospheric Turbulence Mitigation Techniques, Receiver Diversity in Log-Normal Atmospheric Channels: Maximum Ratio Combining, Equal Gain Combining, Selection Combining, Effect of Received Signal Correlation on Error Performance, Outage Probability with Receiver Diversity in a Log-Normal Atmospheric Channel, Transmitter Diversity in a Log-Normal Atmospheric Channel, Transmitter–Receiver Diversity in a Log-Normal Atmospheric Channel. 8(L)

Text Book:

- Ghassemlooy Z, Popoola W, Rajbhandari S. Optical wireless communications: system and channel modelling with MATLAB®. CRC press; 2019.

Reference Book:

- Majumdar AK, Ricklin JC, editors. Free-space laser communications: principles and advances. Springer Science & Business Media; 2010.

VLSI FOR SIGNAL PROCESSING (ECN16253)

Course outcomes:
On successful completion of the course, the students will be able to:

- Understand VLSI design methodology for signal processing systems.
- Be familiar with VLSI algorithms and architectures for DSP.
- Be able to implement basic architectures for DSP.
- Provide fundamental of circuit concept and VLSI optimization
- Qualitative study of VLSI implementation for DFT, digital filters etc. and issue related to VLSI forsignal processing.

UNIT 1: Introduction to Digital Signal Processing, Review of DFT-FFT, Filter structures, errors in digital filter implementation. Design of FIR and IIR filters. 6(L)

UNIT 2: NUMBER SYSTEMS AND DSP ARCHITECTURES: Number systems, Bit-parallel and Bit-Serial arithmetic, Basic shift accumulator, Reducing the memory size, Complex multipliers, Improved shift-accumulator, FFT processor. Programmable Digital Signal Processors, DSP system architectures. 6(L)

UNIT 3: Graphical representation of DSP algorithms, signal flow graph (SFG), data flow graph (DFG) and dependence graph (DG), high level transformation, critical path, Iteration bound –Retiming of DFG, critical path minimization by retiming, loop retiming and iteration bound, Cutset retiming, Unfolding – Folding: idea of unfolding, unfolding theorem, loop unfolding, Parallel realization of DSP algorithms. 8(L)

UNIT 4: Pipelining and Parallel Processing, Pipelining digital filters, look ahead techniques, combining parallel processing with pipelining in digital filters, Polyphase decomposition of transfer functions, hardware efficient parallel realization of FIR filters, Hardware minimization by folding, folding formula, examples from digital filters. 8(L)

UNIT 5: Systolic Architecture Design – Fast Convolution – Algorithmic Strength Reduction in Filters and Transforms – Pipelined and Parallel Recursive and Adaptive Filters. 4(L)

UNIT 6: Scaling and Round off Noise – Digital Lattice Filter Structures – Bit-Level Arithmetic Architectures - Redundant Arithmetic – Numerical Strength Reduction – Low- Power Design. 4(L)

Text Books:

- Digital Signal Processing: Principles, Algorithms and Applications, J. G. Proakis and D.G.

Manolakis, Pearson Education.

- K. K. Parhi, "VLSI Digital Signal Processing Systems- Design and Implementation", John Wiley & Sons

Reference Books:

- Sanjit K. Mitra, "Digital Signal Processing: A Computer based approach", McCraw Hill, 1998.
- Sen M. Kuo and Woon-SengGan, "Digital Signal Processors, architectures, implementations and applications", Prentice-Hall, ISBN 0130352144.
- V. Madisetti, "The Digital Signal Processing Handbook", IEEE press, ISBN 0849385725.
- Lawrence R. Rabiner and Bernard Gold, "Theory and application of Digital signal Processing", Prentice-Hall of India, 2006.
- R. E. Crochiere and L. R. Rabiner, Multirate Digital Signal Processing, Prentice-Hall, 1983, ISBN 0-13-605162-6.
- S. M. Kay, Modern Spectral Estimation: Theory and Application, Prentice Hall, 1988, ISBN 0-13-598582-X.
- Applications of Digital Signal Processing, A. V. Oppenheim.

ADAPTIVE SIGNAL PROCESSING (ECN16254)

Course outcomes:

On successful completion of the course, the students will be able to:

- Understand the concept of adaptive filtering, design criteria, modeling & performance evaluation.
- Acquire knowledge on various adaptive algorithms, convergence issues & computational complexity.
- Apply mathematical models for error performance and stability.
- Ability to develop adaptive systems for various applications.

UNIT I: INTRODUCTION TO ADAPTIVE FILTERS: Definitions, characteristics, adaptive filter structures, applications, examples of adaptive systems. Adaptive linear combiner: General description, desired response and error, the performance function, gradient and minimum mean square error (MMSE) and alternative expression of gradient. 6(L)

UNIT II: WIENER FILTER, SEARCH METHODS AND THE LMS ALGORITHM: Wiener FIR filter (Real case), Newton's type algorithm, steepest descent search and the LMS algorithm, extension of optimal filtering to complex valued input, complex LMS algorithm (FxLMS), sign-LMS and the normalized LMS algorithm. 8(L)

UNIT III: CONVERGENCE AND STABILITY ANALYSIS: Convergence analysis of the gradient search algorithms, learning curve and mean square error behavior, weight error correlation matrix, dynamics of the steady state mean square error (MSE), Mis-adjustment and stability of excess MSE. 8(L)

UNIT IV: ADAPTIVE RECURSIVE FILTERS AND STRUCTURES: Least square (LS) estimation, pseudo-inverse of a data matrix, optimality of LS estimation, adaptive recursive filters, RLS algorithm, and convergence analysis of RLS algorithm, Application of RLS algorithm, lattice structures and adaptive lattice filters. 8(L)

UNIT V: APPLICATION OF ADAPTIVE FILTERS: Echo cancellation, equalization of data communication channels, linear predictive coding and noise cancellation, Adaptive control systems: Adaptive model control, adaptive inverse control. Introduction of adaptive array and adaptive beam forming, recent advances in adaptive filtering. 6(L)

Text Books:

- B. Widrow and S. D. Sterns, Adaptive Signal Processing, Pearson Education, 2nd Indian reprint, 2002.
- S. Haykin, Adaptive Filter Theory, Fourth Edition, Pearson Education LPE, 2007.

Reference Books:

- Alexander D. Poularikas, Zayed M. Ramadan, Adaptive filtering primer with MATLAB, CRC Press, 2006.
- A. H. Sayed, Adaptive Filters, John Wiley & Sons, NJ, ISBN 978-0-470-25388-5, 2008.

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Professional Elective-III

WIRELESS COMMUNICATION NETWORK (ECN16275)

Course Outcomes:
On successful completion of the course, the students will be able:

- To understand basic concepts, issues and challenges of wireless networks.
- To comprehend about the latest network standards.
- To understand the basic concepts of different types of ad hoc networks.
- To learn the basic concepts of mobility management in heterogeneous networks.
- To understand the basic concepts of SDR and cognitive radio networks.

UNIT 1: **Introduction to Wireless Networks:** Evolution of Wireless Networks, Challenges in Wireless Networks, Overview of various Wireless Networks, Wireless Network Planning and Operation: Design of Wireless Networks, Topologies, Radio Resource and Power Management In Wireless Networks. 6(L)

UNIT 2: **Wireless LANS, PANS, and MANS:** Introduction, IEEE 802.11 (WLAN) - Technical Issues, Network Architecture, Latest Developments – IEEE802.11ac (Wi-Fi 5), and IEEE802.11ax (Wi-Fi 6), Introduction to IEEE 802.15 (WPAN) and IEEE 802.16 (WMAN), WLL - Generic WLL Architecture. 8(L)

UNIT 3: **Ad Hoc Wireless Networks:** Introduction and Applications of Wireless Ad Hoc Networks, Medium Access and Routing for Wireless Ad Hoc Networks, Introduction to Vehicular Ad Hoc Networks (VANETs), IEEE 802.11p and IEEE 802.11bd, Introduction to Wireless Sensor Networks (WSN), Applications and Issues in WSNs. 8(L)

UNIT 4: **Mobility Management for Wireless Networks:** Introduction, Mobility Management in Next Generation Wireless Networks, Mobility Management for Mobile Networks (Vehicular Networks), Route Optimization and Handover Techniques in Mobile Wireless Networks. 8(L)

UNIT 5: **Cognitive Radio Networks:** Introduction, Architecture, Software Defined Radio (SDR), Spectrum Sensing and Handoff in Cognitive Radio Networks, UWB Cognitive Radio, Applications of Cognitive Radio, Issues and Challenges. 6(L)

Text/Reference Books:

- P. Nicopolitidis, M.S. Obaidat, G.I. Papadimitriou, A.S. Pomportsis, "Wireless Networks," John Wiley & Sons, Ltd. 2003.
- C. Siva Ram Murthy and B.S. Manoj, "Ad-hoc Wireless Networks - Architecture and Protocols," Pearson Education, 2005.
- Kaveh Pahlavan and Prashant Krishnamurthy, "Principle of Wireless Networks - A Unified Approach," Prentice Hall, 2006.
- Huseyin Arslan, "Cognitive Radio, Software Defined Radio and Adaptive Wireless Systems," Springer, 2007.
- Research Papers from Journals (provided by the course instructor)

INTELLIGENT COMMUNICATION SYSTEMS (ECN16276)

Course Outcomes:
On successful completion of the course students will be able to

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- Understand the fundamentals of machine learning and deep learning
- To apply learning algorithms to communication and networking problems
- Understand the communication aspects involved in ML-empowered wireless communication systems
- To follow recent developments and emerging directions in ML theory and applications towards the developments of Intelligent Communication Systems

UNIT 1: Machine Learning Techniques: Preliminaries & ML basics, Supervised (regression, classification) and unsupervised learning, Deep learning, Convolution Neural Networks, Generative models (VAEs and GANs) 6(L)

UNIT 2: Applications to Communication Systems: PHY- layer: modulation, coding, channel estimation, detection, MIMO Autoencoders and End-to-End Communication Systems, Multiple access and Resource allocation (power control, scheduling, spectrum management), Autonomous networks, Internet-of-Things (IoT) 7(L)

UNIT 3: Automatic Modulation Classification: Modulation Classification and its Features, Likelihood based Classifiers, Distribution Test-based Classifiers, Machine Learning Models for modulation Classifications 7(L)

UNIT 4: Distributed Machine Learning in Networks: Distributed optimization & SGD in resource-constrained systems, Communication-Efficient Distributed Learning, Low-latency ML, Edge and On-device Artificial Intelligence, Federated learning, Decentralized learning 7(L)

UNIT 5: Reinforcement Learning (RL): Markov decision processes, Q-learning and Policy Optimization methods, Deep Reinforcement Learning (DRL), Multi-agent systems 6(L)

UNIT 6: Artificial Intelligence tools for different communication applications 3(L)

Text/Reference Books:

- Zhechen Zhu, Ashoke K Nandi, Automatic Modulation Classification: Principles, Algorithms and Applications
- Luo F. L., (2020), Machine Learning for Future Wireless Communications, Wiley Publication.
- S. Shalev-Shwartz and S. Ben-David, "Understanding Machine Learning", Cambridge University Press
- M. Mohri, A. Rostamizadeh, and A. Talwalkar, "Foundations of Machine Learning", MIT Press
- J. Friedman, R. Tobshirani, T. Hastie, "The Elements of Statistical Learning", Springer

Self Learning Course Material:

Jagannatham, A. K. Principles of Communication II, NPTEL Course Material, Department of Electrical Engineering, IIT Kanpur, https://nptel.ac.in/courses/108104094

TWO-DIMENSIONAL SIGNALS AND SYSTEMS (ECN16277)

Course outcomes:

On successful completion of the course, the students will be able to:

- Understand various 2-D discrete signals and systems, 2-D DFT and FFT.
- Understand 2-D Z-transforms, realize 2-D LSI system and study its stability properties.
- Acquire knowledge of 2-D digital filters and their design & implementation.
- Acquire knowledge of finite word length effects in 2-D discrete systems.
- Test the stability of 2-D systems employing parameter uncertainties and delays.
- Understand various 2-D filtering techniques.

UNIT 1: Introduction to two-dimensional (2-D) discrete signals and systems, 2-D impulse, step, exponential, separable and periodic sequences, 2-D LSI systems, convolution, BIBO stable systems and special support systems, sampling of 2-D signals. 6(L)

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TESTING AND VERIFICATION OF VLSI CIRCUITS (ECN16255)

Unit-1: Logic Simulation: Functional Modeling, Simulation for Design Verification, Compiled simulation, Event driven simulation, Delay models, Element evaluation, Hazard Detection. 6(L)

Unit-2: Fault Modeling and Fault Simulation: Logical fault models, Fault detection and redundancy, Fault equivalence and dominance, Single stuck and multiple stuck fault model, Fault Simulation technique, Fault Simulation for combinational circuits. 8(L)

Unit-3: Testing: Role of Testing, Digital and Analog VLSI Testing, Testing for single stuck faults in combinational and sequential circuits, Testing for bridging fault, functional testing. 6(L)

Unit-4: Design for Testability: Controllability and Observability, Ad-Hoc design, Generic scan-based design, Digital DFT Design, Partial-Scan Design, Boundary Scan Standard. 8(L)

Unit-5: Built-In Self-Test: Introduction to BIST, Random Logic BIST: Definitions, BIST Process, Pattern Generation, BIST Architecture: CSBL, BEST, RTS, LOCST, STUMPS, RTD, SST etc., Test-Per-Scan BIST Systems, Circular Self-Test Path System, Memory BIST, Delay Fault BIST. 8(L)

Text/Reference Books:

- M. Abramovici, M.A. Breuer and A.D Friedman, "Digital Systems and Testable Design", Jaico Publishing House.
- M.L. Bushnell, V. D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits", Kluwer Academic Publishers.
- P.K. Lala, "Digital Circuits Testing and Testability", Academic Press.

VLSI INTERCONNECTS (ECN16256)

Unit-1: Introduction: Moore's law, Technological trends, Interconnect scaling, 3D-interconnect view; 2(L)

Unit-2: Interconnect delay modeling: Typical interconnect structure, Extraction of interconnect parameters, modeling interconnect drivers, switch-level RC model, effective capacitance modeling; 4(L)

Unit-3: Interconnection Length Prediction: Rents rule and parameter, Technology extrapolation, performance prediction, Interconnect-power and power modeling; 5(L)

Unit-4: Inductance of Interconnects: Increasing the effects of inductance, skin effect and its influence on resistance and inductance, Partial element equivalent circuit (PEEC) method; 5(L)

Unit-5: Driving interconnect for circuit speed optimization and Crosstalk: Evolution of the speed optimization problem, logical effort method, Wire sizing, spacing. Driving RC trees, Crosstalk configuration, DC noise margins, Reasons for high delay uncertainty, switch factor modeling of delay uncertainty, Buffer insertion for noise 10(L)

Unit-6: Routing topology generation for speed optimization: New approaches in routing topology generation. Width optimization based on separability / monotonicity properties. Advanced interconnect techniques: reduced-swing circuits, current mode transmission techniques. Electro migration in interconnects, Mitigation of electro migration 10(L)

Text Books/References

- Analysis and Design of Digital Integrated Circuits – A Design Perspective by Jan M. Rabaey, Tata Mc-Graw Hill.

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- Interconnection Noise in VLSI Circuits by F. Moll and M. Roca, Kluwer Academic Publishers.
- Introduction to VLSI Circuits and Systems by J. P. Uymera, Wiley Student Edition
- Interconnects in VLSI Design by Hartmut Grabinski, Springer-Verlag New York Inc. Publications

DESIGN OF CURRENT MODE CIRCUITS (ECN16257)

Pre-requisite: Semiconductor Devices and Circuits

Course Outcomes:

After the completion of this course, students will be able to:

CO1	Have a basic understanding of analog electronics.
CO2	Have a basic understanding of the concepts and design analog circuits.
CO3	Understand and investigate the fundamental of different analog circuits.
CO4	Have a rigorous study of the various current mode building blocks
CO5	Understand the practical aspects of current mode building blocks

UNIT -1:
INTRODUCTION & REVIEW:
Differential amplifier - single-ended and differential operation, basic differential pair: quantitative and qualitative analysis, common-mode response differential pair. Current mirrors and references, basic current mirrors, cascade current mirrors, advanced current mirrors, active current mirrors: large-signal and small-signal analysis, basic voltage and current references. Operational amplifiers: performance parameters, one-stage Op-amps, two-stage Op-amps. 10(L)

UNIT -2:
ANALOG CIRCUITS:
Current mode approach, Translinear circuits, vector difference circuit, Translinear one quadrant squarer/divider, current mode four quadrant CMOS analog multiplier with low power. 8(L)

UNIT -3:
CURRENT MODE BUILDING BLOCKS:
Current conveyors, Classification of Current Conveyor, Operational Transresistance Amplifier Current Differencing Buffered Amplifier, Operational Transconductance Amplifier, Differential Difference Current Conveyor, Differential Voltage Current Conveyor, Current Differencing Transconductance Amplifier, Differential Voltage Current Conveyor Transconductance Amplifier. 10(L)

UNIT -4:
APPLICATIONS:
Current Mode Building Blocks based Amplifiers, Integrator, Differentiator, Filters, Oscillator, Inductor. 8(L)

Text Books:

- C. Toumazou, F. J. Lidgey, David Haigh, Analogue IC Design: The current-mode approach, Institution of Engineering and Technology (IET), 1993.

Reference Book:

- Massimo Alioto, Gaetano Palumbo, Model and Design of Bipolar and MOS Current-Mode Logic, Springer New York.
- P. V. Ananda Mohan, Current-Mode VLSI Analog Filters, Birkhäuser Boston, MA.
- Research and review papers in specific area.

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UNIT 2: 2-D Discrete Fourier Transform (DFT), definition and properties, Calculation of DFT, FFT. 4(L)

UNIT 3: Finite order difference equations, 2-D Z-transforms, realization of 2-D LSI systems using difference equations, recursive computability, boundary conditions, stability of 2-D recursive systems. 6(L)

UNIT 4: 2-D digital filters, periodic shift-variant digital filters, state variable realizations, design and implementation of 2-D digital filters. 6(L)

UNIT 5: 2-D systems with parameter uncertainties, finite word length effects in fixed-point 2-D discrete systems, 2-D delayed systems. 7(L)

UNIT 6: Stability of 2-D systems, convergence analysis of various 2-D state-space models, 2-D filtering techniques and their performances, applications of 2-D signal processing. 7(L)

Text Books:

- N. K. Bose, Multidimensional systems theory and applications, 2nd edition, Springer.
- J. S. Lim, Two dimensional signal and Image Processing, Prentice Hall.

Reference Books:

- Dan E Dudgeon and R M Mersereau, Multidimensional Digital Signal Processing, Prentice Hall.
- Tamal Bose, Digital Signal and Image Processing, John Wiley publishers.

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MATHEMATICS FOR SIGNAL PROCESSING (ECN16278)

Course outcomes:

On successful completion of the course, the students will be able to:

- Understand the fundamental mathematical concepts related to the machine learning.
- Develop skills in the techniques of linear algebra, optimization and their applications
- Analyze the behaviour of various practical systems.
- Apply the acquired knowledge in various mathematical problems in engineering.

UNIT 1: Vector spaces and their properties, linear dependence, basis and dimension, column space, row space, null space, vector subspaces, inner product spaces, orthogonal basis and Gram-Schmidt process of orthogonalization. 6(L)

UNIT 2: Linear transformations and their properties, basics of matrix algebra, eigenvalues, eigenvectors, spectral radius, diagonalization, matrix norms, induced matrix norms, equivalent norms, sensitivity analysis and condition numbers, special matrices and properties. Gerschgorin theorem. 7(L)

UNIT 3: Quadratic forms with applications, positive definite matrices and their properties, Sylvester's criterion for positive definiteness, Schur complements, applications of Schur complements in reducing computational complexity of matrix inequalities, Rayleigh quotient, evaluation of matrix functions, spectral decomposition, singular value decomposition and its applications, Moore-Penrose invers 8(L)

UNIT 4: Principal component analysis, least square approximation and minimum normed solution, Jordan canonical form, convex sets and convex functions, properties of convex functions, convex optimization problems. 7(L)

UNIT 5: State-space models for 1-D systems, stability triangle, systems with parameter uncertainties, systems with delays, systems with nonlinearities, state trajectory and convergence analysis, state-space models for 2-D systems, introduction to theory and applications of positive systems. 8(L)

Text Books:

- G. Strang, "Linear Algebra and its Applications", 4th Edition, Thomson, (2006).
- Marc Peter Deisenroth, A. Aldo Faisal , Cheng Soon Ong, "Mathematics for Machine Learning ", Cambridge University Press (2020).
- B.N. Datta, "Numerical Linear Algebra and applications", Society for Industrial and Applied Mathematics; 2nd edition (2010).

Reference Books:

- K. Hoffman and R. Kunze, "Linear Algebra", Prentice Hall, (2008).
- K. B. Datta, "Matrix and Linear Algebra, Third Edition, PHI Learning Pvt. Ltd. (2017).
- S. Boyd, L. El Ghaoui, E. Feron, V. Balakrishnan, Linear Matrix Inequalities in System and Control Theory, SIAM, Philadelphia, (1994).
- T. Kaczorek, Positive 1-D and 2-D Systems, Springer-Verlag, London 2002.

SWITCHING CIRCUITS AND FINITE AUTOMATA THEORY (ECN16279)

Course outcomes:
On successful completion of the course, the students will be able to:

- Understand the principles of threshold logic, the effects of hazards on digital circuits and faultdetection strategies.
- Be familiar with the concepts of finite state model and finite automata theory.
- Understand the structure, behavior, and limitations of logic machines.
- Design for testability and built-in self-test for combinational and sequential circuits.
- Analyze and synthesize digital circuits.

UNIT 1: STRUCTURAL PROPERTIES OF SWITCHING FUNCTIONS: Functional decomposition, symmetric networks, identification of symmetric functions, threshold logic, analysis, and synthesis of threshold networks. 6(L)

UNIT 2: RELIABLE DESIGN AND FAULT DIAGNOSIS IN COMBINATIONAL CIRCUITS: Hazards, fault models, fault detection and location in combinational circuits, fault detection by fault-table, path sensitizing, and Boolean difference methods, D- algorithm, delay fault testing, detection of multiple faults, failure-tolerant design, Quadded logic. 6(L)

UNIT 3: SYNCHRONOUS SEQUENTIAL CIRCUITS: Finite-state model, capabilities and limitations of finite-state machines, Mealy and Moore machines, state equivalence and machine minimization, analysis and synthesis of synchronous sequential circuits, simplification of incompletely specified machines. 6(L)

UNIT 4: ASYNCHRONOUS SEQUENTIAL CIRCUITS: Fundamental-mode circuits, analysis and synthesis of asynchronous sequential circuits, state assignment in asynchronous sequential circuits, Hazard-free asynchronous circuits. 6(L)

UNIT 5: FAULT-DETECTION AND LOCATION IN SEQUENTIAL CIRCUITS: Homing experiments, distinguishing experiments, machine identification, fault-detection experiments, design for testability, scan design, Built- in Self-Test (BIST). 6(L)

UNIT 6: MEMORY, DEFINITENESS AND INFORMATION LOSSLESSNESS OF FINITE AUTOMATA: Properties of finite- memory machines, definite machines, tests for definiteness, finite output memory machines,information lossless machines, inverse machines. 6(L)

Text Books:

- Z. Kohavi and N. K. Jha, Switching and Finite Automata Theory, Tata McGraw-Hill, Third Edition.

Reference Books:

- M. Abramovici, M. A. Breuer, and A. D. Friedman, Digital Systems Testing and Testable Design,Wiley-IEEE
- press, 1994.
- R. D. Adams, High Performance Memory Testing, Kluwer Academic Publishers, 2002.
- J. Altet and A. Rubio, Thermal Testing of Integrated Circuits, Kluwer Academic Publishers, 2002.
- Parag K Lala, Fault Tolerant And Fault Testable Hardware Design, Prentice Hall Inc. 1985.
- Charles Roth Jr, Larry L. Kinney, Digital Circuits and Logic Design, Cengage Learning, 2014.

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VLSI PHYSICAL DESIGN AND AUTOMATION (ECN16280)

UNIT1: VLSI Physic Design: New trends in VLSI design cycle and physical design cycle, Design Styles: Full-custom, standard cell, FPGA, sea of Gates, comparison; System Packaging Styles, **Fabrication Process and its impact on Physical Design:** scaling methods, issues related to fabrication process, future of fabrication process, solutions for interconnect issues. 6(L)

UNIT2: Layout-Layout design rules, symbolic layout, process, floor-planning, ESD and I/O pad layout, analog circuit layout techniques, digital circuit layout techniques. 6(L)

UNIT 3: Basic Algorithms- Basic terminology, complexity issues and NP-hardness, graph algorithms, computational geometry algorithms, graph algorithms for physical design.
Partitioning: problem formulation, partitioning algorithms, Kernighan-Lin algorithm, simulated annealing and evolution, other partitioning algorithms, performance driven partitioning. 8(L)

UNIT 4: Floor planning and Pin Assignment: Floor planning, floor planning algorithms, chip planning, Pin assignment, integrated approach; **Placement:** problem formulation, simulation-based placement algorithms, partitioning based placement algorithms, other placement algorithms, performance driven placement, recent trends. 8(L)

UNIT 5: Routing-Global routing, detailed routing, over-the-cell routing and via minimization, clock and power routing, **Compaction:** problem formulation, compaction algorithms, 1-D compaction, 1.5-D compaction, 2-D compaction, hierarchical compaction, recent trends in compaction. 8(L)

Text/ Reference Books:

- Algorithms for VLSI Physical Design Automation by Naveed Sherwani, Springer, 4th edition, 2009.
- CMOS Analog and Mixed Signal Circuit Design by Arjuna Marzuki, CRC Press, 2020.
- Introduction to VLSI Physical Design by M. Sarraf zadeh, McGraw Hill (I.E.), 1996.
- VLSI Physical Design Automation by S. M. Sait, H. Youssef, World Scientific Publication

LOW POWER VLSI DESIGN (ECN16281)

Course Outcomes:

On successful completion of the course students will be able to:

- Familiarize with the power dissipation in ICs, its limitations, and low power methodologies.
- Acquire broad knowledge of power consumption in CMOS digital circuit designs.
- Understand the effect of voltage scaling approaches in low power applications.
- Understand the role of adiabatic logic circuits approach in low power VLSI design.
- Understand the sources of leakage power and its mitigation techniques.

UNIT 1: Introduction- IC Power consumption concerns. Limits of Power in Microelectronics. Low-power design methodologies. 2(L)

UNIT 2: Power Consumption in CMOS Digital Designs- Switching component of power. Switching energy per transition. Conventional CMOS circuits with rail-to-rail swing. Charge sharing. Components of node capacitance. Definition of transition activity factor. Influence of logic level statistic and circuit topologies on the node transition activity factor. Word level signal statistics influencing activity. Influence of voltage scaling. Short-circuit component of power. Leakage component of power. Diode Leakage. Sub-threshold leakage. Static Power. Reduced voltage levels feeding CMOS gates. Pseudo-NMOS logic style. 12(L)

UNIT 3: Voltage Scaling Approaches- Reliability-driven voltage scaling. Technology-driven voltage scaling, Energy x delay minimum based voltage scaling. Voltage scaling through optimal transistor sizing. Voltage scaling using threshold reduction. Architecture-driven voltage scaling. Trading area for lower power through hardware duplication. Optimal supply voltage for architecture driven voltage scaling. Trading area for lower power through hardware pipelining. Noise Considerations at reduced supply voltage. Digital design with multiple supplies. 10(L)

UNIT 4: Adiabatic Switching- Adiabatic charging. Adiabatic amplification. One-stage adiabatic buffer in conventional system. Two-stage adiabatic buffer in conventional system. Fully adiabatic system. Comparison with conventional buffer. Supply voltage influence. Adiabatic logic gates. Fully adiabatic sequential circuits. Partially-adiabatic sequential circuits. Stepwise charging. Pulsed-power supplies. Optimization algorithms. 8(L)

UNIT 5: Leakage Power Reduction- Leakage current in deep submicron ICs. Gate oxide tunneling. Supply power control. Bulk-source biasing. Bias voltage generator. Logic gate optimization for leakage power. Input vector selection for standby mode. 4(L)

Text/Reference Books:

- Low Power CMOS VLSI circuit design By Kaushik Roy and S.C Prasad, Publisher: John Wiley & Sons.
- CMOS/BiCMOS VLSI: Low Voltage Low Power by K.S. Yeo, S.S. Rofail, W.L. Goh Publisher: Prentice Hall.
- Low Power Digital CMOS Design By A.P. Chandraksen, R.W. Brodersen Publisher: Kluwer Academics

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OPTOELECTRONIC DEVICES AND APPLICATIONS (ECN16282)
Pre-requisite: Semiconductor Devices and Circuits

Course Outcomes:

After the completion of this course, students will be able to:

CO1	Understand the fundamental electrical properties of materials
CO2	Analyse and understand the basics of optoelectronic device physics and their integration
CO3	Analyse and understand the fabrication of various optoelectronic devices
CO4	Understand the various applications of optoelectronic devices

UNIT -1:
Electrical Properties of Materials:
Band structure of metals and semiconductors, Semiconductors - band diagrams, direct and indirect bandgap, degenerate and non-degenerate semiconductors, intrinsic and extrinsic semiconductors, determination of dopant levels and mobility measurements; Dielectric materials - dielectric constants and polarization, linear dielectric materials, capacitors and insulators, C-V characterization; Electronic structure of interfaces: metal-semiconductor, insulator-semiconductor, semiconductor heterostructures.
9(L)

UNIT -2:
Optoelectronic Device Physics:
Optical materials - electron-hole recombination, bandgap engineering, Light interaction with materials-transparency, translucency and opacity, refraction and refractive index, reflection, absorption and transmission; Carrier generation processes, recombination processes, R-G statistics, surface R-G processes; Carrier transport, drift, diffusion, equation of state.
8(L)

UNIT -3:
Fabrication of Optoelectronic Devices:
PN junction and their application in solar cells and light emitting diodes; MOS devices and Transistors; Organic electronics - Thin Film Transistors, Light Emitting Diodes, Solar cells.
9(L)

UNIT -4:
Applications of Optoelectronic Devices:
Photodetector, Schottky diode; Photoresistor; Phototransistor; Solar cells; Supercapacitor. 8(L)

Text Books:

- Electronic Properties of Materials: An Introduction for Engineers, Rolf E. Hummel, Springer Verlag, 1985
- Solid State Electronic Device, Streetman, Ben, G, Streetman, Prentice-Hall, inc., N.J. USA, 1980
- The Physics of Low-Dimensional Semiconductors, John H. Davies, Cambridge University Press, 1998.
- Photovoltaics Fundamentals, Technology, and Practice, Konrad Mertens, Wiley, 2018, ISBN No. 13: 978-1119401049.

Reference Book:

- Introduction to Nanotechnology, C.P. Poole Jr., F.J. Owens, Wiley (2003).
- Physical Properties of Semiconductors, Charles M. Wolfe, Nick Holonyak and Gregory E. Stillman, Prentice Hall, 1989

- Phaedon Avouris, Tony Heinz and Tony Low, "2D Materials: Properties and Devices", 1st edition (July 31, 2017), Cambridge University Press.
- Electronic transport in mesoscopic systems, Supriyo Datta, Cambridge, (1995).
- Research Papers

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Courses offered by ECED in Seventh Semester B Tech ECE

Course Code	Course name	L	T	P	Credit
ECN17101	Mobile and Wireless Communication	3	1	0	4
ECN17102	Nanoelectronics and its Applications	3	0	0	3
ECN17250,17251,17252,17253,17254,17255, 17256	Elective – IV	3	0	0	3
ECN17275,17276,17277,17278,17279, 17280, 17281	Elective-V	3	0	0	3
ECN17351	Project	0	0	4	4
	Total	12	1	4	17

MOBILE AND WIRELESS COMMUNICATION (ECN17101)

Course Outcomes:

On successful completion of the course students will be able to:

- Understand mobile communication systems and wireless standards.
- Comprehend the basic concepts of cellular system design.
- Learn the basic concepts of Mobile radio propagation.
- Understand the basic concepts of diversity and multiple access techniques.
- Learn the basic techniques and concepts of 5G.

UNIT 1:	Introduction to Mobile Communication Systems, Characterization of Wireless Channel, Wireless Communication Standards, Comparison of Wireless Systems and Trends.	6(L)
UNIT 2:	Cellular concept and system design fundamentals, channel assignment strategies, Hand -off strategies, Interference and system capacity, Improving capacity in cellular systems, Trunking Theory and Grade of Service.	8(L)
UNIT 3:	Large Scale Path Loss, Ground reflection model, diffraction scattering, Indoor propagation models, outdoor propagation models, ray tracing and site specific signaling	5(L)
UNIT 4:	Small Scale Fading and Multipath, Envelope fading, Doppler Spread, Time delay spread, Coherence time and coherence bandwidth, types of small-scale fading, Multipath fading using Rayleigh and Rician PDF	6(L)
UNIT 5:	Diversity techniques: space, angle, frequency, time and polarization. Spread Spectrum Systems, CDMA, OFDM, Capacity of FDMA, TDMA and CDMA.	3(L)
UNIT 6:	5G Use Cases and Standardization, Spectrum Requirements and System Concept, Architecture and deployment, Radio Access Techniques, Radio access techniques for NGNs like RIS and NOMA, Mobility Management.	4(L)

Text/Reference Books:

- T. S. Rappaport, "Wireless Communication - Principle and practice," Pearson Education, 2nd Edition, 2010.
- Andreas F. Molisch, "Wireless Communication," IEEE Press, 2010.
- Simon Haykin, "Modern Wireless Communication," Pearson Education, 2011.
- Andrea Goldsmith, "Wireless Communication," Cambridge University Press, 2005.
- Afif Osseiran, Jose F. Monserrat, "5G Mobile and Wireless Communication Technology," Cambridge University Press, 2016.

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NANOELECTRONICS AND ITS APPLICATIONS (ECN17102)

Course Outcomes:

On successful completion of the course students will be able to

- Understand the concepts and growth of various Nanostructures
- Understand the methods of fabrication of Nano layers
- Understand the applications of Carbon Nanotubes
- Understand the concepts of Nano sensors and their applications

Unit-1

Introduction to nanoelectronics, Classification of Nanostructures, Electronic properties of atoms and solids: Isolated atom, Bonding between atoms, Giant molecular solids, Free electron models and energy bands, crystalline solids, Periodicity of crystal lattices, Electronic conduction, effects of nanometer length scale, Fabrication methods: Top-down processes, Bottom up processes methods for templating the growth of nanomaterials, ordering of Nano systems. 10(L)

Unit-2

Microscopic & Mesoscopic physics, trends in microelectronics and optoelectronics, characteristic lengths in mesoscopic systems, Quantum mechanical coherence, Schrodinger's Equation, wave function, Low dimensional structures Quantum wells, Basic properties of two-dimensional semiconductor nanostructures, Quantum wires and quantum dots, carbon nano tube, grapheme, Introduction to methods of fabrication of nano-layers 10(L)

Unit-3

Carbon Nanostructures: Carbon molecules, Carbon Clusters, Carbon Nanotubes, application of Carbon Nanotubes. 6(L)

Unit-4

Nano sensors: Introduction, Sensor and Nano sensors, Chaotic response analysis, Characterization, Perception, Nano sensor-Based On Quantum Size Effects, Electrochemical Sensors, Sensors Based On Physical Properties, Nano biosensors, Smart dust Sensor for the future. Applications: Injection lasers, quantum cascade lasers, single-photon sources, biological tagging, optical memories, coulomb blockade devices, photonic structures, QWIP's, NEMS, MEMS 10(L)

Text/ Reference Books:

- Ed Robert Kelsall, Ian Hamley, Mark Geoghegan, Nanoscale Science and Technology, John Wiley, 2007.
- Charles P Poole, Jr, Frank J Owens, Introduction to Nanotechnology, John Wiley, Copyright 2006, Reprint 2011.
- T Pradeep, Nano: The Essentials-Understanding Nanoscience and Nanotechnology, TMH.

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Professional Elective-IV

WDM OPTICAL NETWORKS (ECN17250)

Course Outcomes:
On successful completion of the course students will be able to:

- Recognize and evaluate the performance of various enabling technologies used in modern optical networks.
- Evaluate several WDM network topologies, including wavelength routing networks.
- Illustrate the important aspects involved in WDM network planning, such as power budget, dispersion correction, OSNR calculation, and nonlinearity.

Unit I: Introduction to Optical Networks- Principles and Challenges and its Generation, Optical Transmission systems, Wavelength Division Multiplexing, Optical layer, Optical components such as Isolators and Circulators, Wavelength Add/Drop Multiplexer, Transmitter & Detectors, Optical Filters, Optical Amplifiers, Wavelength cross connect, Evolution of WDM Optical Network, WDM Point-to-point Link. 10(L)

Unit II: Client Layers of the Optical Layer like SONET/SDH, Optical Transport Network, WDM Network Elements, Enabling technologies for WDM optical networks, WDM optical networks architecture, Broadcast-and-select network, Wavelength routed network, linear light wave network. 8(L)

Unit III: Issues in wavelength routed network, Routing and wavelength assignment, Wavelength convertible networks, Network Control and Management, Network Survivability, Virtual topology design, Virtual topology reconfiguration, Survivable networks, Optical multicast routing, Network control and management. 10(L)

Unit IV: Transmission impairment, Ring networks and traffic grooming, VPN over WDM Optical network, Access network and Next generation optical Internet Networks, Introduction of All Optical Network. 8(L)

Text/Reference Books

- R. Ramaswami, & K. N. Sivarajan, "Optical Networks a Practical perspective", Morgan Kaufmann Publishers, 3rd Ed.
- B. Mukherjee, Optical Communication Networks, New York, NY: McGraw-Hill, July 1997.
- U. Black, "Optical Networks: Third Generation Transport Systems"/ Pearson Educations

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ADVANCED WIRELESS COMMUNICATION (ECN17251)

Course Outcomes:

On successful Completion of the course students will be able to

- Distinguish and understand the major cellular communication standards (1G/2G/3G/4G/5G/6G systems) and wireless communications networks.
- Understand the 5G techniques e.g. massive MIMO. mmWave etc. for the design of communication systems.
- Characterize and analyze various modulation and multiplexing techniques e.g. OFDM, NOMA etc.
- Applications of Machine Learning in 5G Wireless Communications.

Unit 1: Introduction and fundamentals of wireless communications: Cellular systems, non-cellular wireless systems. 4(L)

Unit 2: 5G Key Technologies: Small cells, massive MIMO, mm Wave, RSMA
Small cells: Past, present, and future trends of cellular networks coverage and capacity of small cell networks Interference management, D2D architecture Towards IoT Spectrum sharing.
Massive MIMO: Point-to-point MIMO, Virtual MIMO (relaying), multiuse MIMO, Massive MIMO, propagation channel model, channel estimation, uplink and downlink data transmission capacity bounds, achievable rate, energy and spectral efficiency trade-off.
Mm Wave: Applications, radio wave propagation Physical layer design and algorithms mm Wave MIMO challenges channel modeling channel estimation
Beamforming. Multiple access techniques: OFDM, filter banks, GFDM, OTFS, NOMA. 14(L)

Unit 3: 6G Key Enablers: Wireless energy harvesting, machine learning, visible light communication, Intelligent reflecting surface (IRS), Extremely Large Aperture Massive MIMO.
Wireless energy harvesting: Energy-rate trade-off Simultaneous wireless information and power transfer (SWIPT), time-switching, power splitting Wireless powered communication networks Outage probability and throughput. 10(L)

Unit 4: Machine learning applications: Channel modeling and estimation, Spectrum sensing and sharing, Resource allocation (NOMA, mmWave massive MIMO). 8(L)

Text Books:

- R. Vannithamby and S. Talwar, *Towards 5G: Applications, Requirements and Candidate Technologies.*, John Willey & Sons, West Sussex, 2017.
- Manish, M., Devendra, G., Pattanayak, P., Ha, N., *5G and Beyond Wireless Systems PHY Layer Perspective*, Springer Series in Wireless Technology

Reference Books"

- T. S. Rappaport, R. W. Heath Jr., R. C. Daniels, and J. M. Murdock,, *Millimeter Wave Wireless Communication.*, Pearson Education, 2015.
- M. Vaezi, Z. Ding, and H. V. Poor, *Multiple Access techniques for 5G Wireless Networks and Beyond.*, Springer Nature, Switzerland, 2019

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ADVANCED DSP ARCHITECTURE (ECN17252)

Course outcomes:

On successful completion of the course, the students will be able to:

- Understand various DSP architectures.
- Gain knowledge in addressing modes, interrupts, peripherals and pipelining structure of TMS320C54xx processor.
- Develop basic DSP algorithms using DSP processors.
- Implement DSP techniques in different practical applications.

UNIT 1: Introduction in concepts and architectures used in digital signal processing, parallel architecturesspecialized in digital signal processing. 5(L)

UNIT 2: DIGITAL SIGNAL PROCESSORS, PROCESSING ARCHITECTURES: Von Neuman (SISD), Harvard, SIMD, MIMD. Comparison: CISC-RISC versus Transputers. DSP types: fixed point, floating point.TI DSP family. 6(L)

UNIT 3: Other DSP structures (Enhanced fixed point-TMS320C54x, floating point- 3x, 4x families, high performance 8x, 6x), Internal architecture- improvements compared with C2x. Hardware implementation of loops. memory organization, interrupts, addressing modes, instruction set. MVP TMS320C80-internal architecture, TMS320C54x architecture. Improvements. TMS320C6x, VLIW Architecture - VelociTI.C6201 chip. 12(L)

UNIT 4: Implementation of DSP algorithms on DSP processor. 5(L)

UNIT 5: Interconnection in DSP systems (high performance buses), testing of DSP based systems (JTAGinterfaces), practical applications using DSP. 8(L)

Text Books:

- D Liu, Embedded DSP processor design: Application specific instruction set processors, Illustratededition, Morgan Kaufmann, 2008.
- Chassaing, Rulph, Digital Signal Processing: Laboratory Experiments Using C and the TMS320C31DSK. John Wiley & Sons, Inc., New York, 1999.

Reference Books:

- Phil Lapsley, Jeff Bier, Amit Shoham, "DSP Processor Fundamentals, Architectures and Features",IEEE Press.
- Michael J. Flynn, "Computer Architecture. Pipelined and parallel processor design", Jones andBartlett, 1995.
- Kehtarnavaz, Nasser; Simsek, Burc, C6x-Based Digital Signal Processing. Prentice Hall, New Jersey,2000.
- Gomaa, Hassan, Software Design Methods for Concurrent and Real-Time Systems. Addison-WesleyPublishing Company, Inc., 1993.

ADVANCED COMPUTER ARCHITECTURE (ECN17253)

Course outcomes:

On successful completion of the course, the students will be able to:

- Measure performance parameter for computer design and system attributes.
- Learn about conditions for parallelism, hardware and software parallelism, different type of data, resourceand control dependencies.
- Understand classification of parallel computer, multiprocessor system like distributed and shared memoryarchitecture, different types of interconnection networks.
- Understand the concepts of pipelining, different types of pipelined architecture, optimization andmechanism of instruction pipelining, Hazard and its avoidance.
- Understand the concepts of memory hierarchy and managements, concepts of shared memory inmultiprocessor system.
- Understand the basic concepts of RISC, CISC, super scalar and vector processing.

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UNIT 1: PARALLEL PROCESSING: Necessity of high performance, constraints of conventional architecture, parallelism in uniprocessor system, evolution of parallel processors, future trends, architectural classification, applications of parallel processing, principles of scalable performance, conditions of parallelism, data and resource dependences, hardware and software parallelism, program partitioning and scheduling, grain size and latency, program flow mechanisms, control flow versus data flow, data flow architecture. 8(L)

UNIT 2: PIPELINING: Linear pipeline processor, nonlinear pipeline processor, instruction pipeline design, mechanisms for instruction pipelining, pipeline hazards, dynamic instruction scheduling, branch handling techniques, arithmetic pipeline design, static arithmetic pipeline, multifunctional arithmetic pipelines. 8(L)

UNIT 3: PROCESSORS TECHNOLOGY: Advanced processor technology, instruction-set architectures, CISCscalar processors, RISC scalar processors, superscalar processors, VLIW architectures, vector processing principles, vector instruction types, vector-access memory schemes, CRY-1 architecture. 8(L)

UNIT 4: MEMORY TECHNOLOGY: Hierarchical memory technology, inclusion, coherence and locality, memory capacity planning, virtual memory technology, memory interleaving. 6(L)

UNIT 5: SYSTEM INTERCONNECT ARCHITECTURES: Network properties and routing, static interconnection networks, dynamic interconnection Networks, multiprocessor system interconnects, hierarchical bus systems, crossbar switch and multiport memory, multistage and combining network. 6(L)

Text Books:

- Kai Hwang, "Advanced computer architecture", TMH.
- Hwan and Briggs, "Computer Architecture and Parallel Processing", MGH.

Reference Books:

- Hennessy and Patterson, "Computer Architecture: A Quantitative Approach", 3rd edition,Morgan Kauffmann
- Harvey G. Cragon, "Memory System and Pipelined processors", Narosa Publication.
- V. Rajaranam & C.S.R. Murthy, "Parallel computer", PHI.
- R K Ghose, Rajan Moona & Phalguni Gupta, "Foundation of Parallel Processing", NarosaPublications.
- Kai Hwang and Zu, "Scalable Parallel Computers Architecture", MGH

MIXED MODE VLSI DESIGN (ECN17254)

Course Outcome:

On successful completion of this course students will be able to:

- Understand the fundamentals of active and passive elements with their state variables, sensitivity analysis, pole positions etc.
- Analyze the basic CMOS circuits applicable in Mixed-signal VLSI and techniques for continuous time signal processing blocks.
- Basic operation and analysis of mixed-signal circuits such as nonlinear and dynamic analog circuits, analog filters/sensors, A/D and D/A converters etc.
- Qualitative study of digitally programmable features of analog building blocks for realization of high-speed mixed signal circuits.

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UNIT 1: Nonlinear Analog Circuits: Basic CMOS comparator design and its characterizing parameters, adaptive biasing, analog multipliers, level shifting circuits; Dynamic Analog Circuits: MOSFET switch, sample and hold circuits, **Switched-Capacitor Circuits:** basic building blocks, operation and its analysis, resistor equivalence, noise in switched capacitor circuits, switched-capacitor integrator, other switched capacitor circuits. 10[L]

UNIT 2: DAC Architectures: digital-to-analog converter specifications, digital input code, resistor string, R-2R ladder networks, current steering, charge scaling DACs, cyclic DAC, pipeline DAC. 8[L]

UNIT 3: ADC Architectures: Analog-to-digital converter specifications, flash ADC, two-step flash ADC, pipeline ADC, integrating ADC, successive approximation ADC, oversampling ADC. 10[L]

UNIT 4: Digital Tuning/Digital Programmability: SPRA/SPCA (switched programmable resistor array & switched programmable capacitor array), m-DAC (Multiplier-DA converter) and their interfacing to microcontroller/micro computer system, digitally programmable active RC network using high speed analog/mixed -signal building block. 8[L]

Text/ Reference Books:

- CMOS Circuit Design, Layout, and Simulation by R. Jacob Baker et.al., Prentice Hall of India, 2010.
- Advanced data converters by Gabriele Manganaro, Cambridge University Press, 2012.
- Randall L Geiger, Phillip E. Allen, "Noel K. Strader, VLSI Design Techniques for Analog and Digital Circuits", Mc Graw Hill International Company, 1990.
- Jose E. France, Yannis Tsividis, Design of Analog-Digital VLSI Circuits for Telecommunication and Signal Processing, Prentice Hall, 1994.
- C. Toumazou, F. J. Lidgey& D. G. Haigh, Analog IC Design: The Current-Mode Approach, Peter Peregrinus Ltd.

RF IC DESIGN (ECN17255)

Unit-1: Introduction to RF and Wireless Technology:
Complexity, design and applications. Choice of Technology, path loss, and transmitter output power, Nonlinearly and Time Variance, intersymbol Interference, random processes and Noise. Definitions of sensitivity and dynamic range, conversion Gains and Distortion. 6(L)

Unit-2: Analog and Digital Modulation for RF circuits:
Comparison of various techniques for power efficiency. Coherent and Non coherent detection. Mobile RF Communication systems and basics of Multiple Access techniques. Receiver and Transmitter Architectures and Testing heterodyne, Homodyne, Image-reject, Direct-IF and sub-sampled receivers. Direct Conversion and two steps transmitters. 6(L)

Unit-3: Low Noise Amplifiers

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Basic blocks in RF systems and their VLSI implementation: Basic concepts of amplifiers, Low Noise Amplifiers design in various technologies, Design of Mixers at GHz frequency range. Various Mixers, their working and implementations 6(L)

Unit-4: Mixers
RF mixers and their basic concepts, active and passive mixers, balanced and unbalanced mixers, mixer's noise performance, design of up and down-conversion mixers, Design issues in integrated RF filters. 4(L)

Unit-5: Oscillators
Working principles of frequency oscillators and their basic concepts, topologies of oscillators, tune oscillators, impact of noise in the oscillator's signal, Voltage Controlled Oscillator (VCO), phase noise, Quadrature oscillators. 6(L)

Unit-6: Synthesizers
Working principles of frequency synthesizers and their basic concepts. Phase-Locked Loop types I and II, All-Digital PLL, and the impact of the PLL frequency synthesizer on the signal's noise performance. fractional-N PLL frequency synthesizers, design of a frequency divider and a phase detector.

Power Amplifiers
Classification, types of power amplifiers and their design. Linearization technique, polar modulation. 8(L)

Text/References

- B. Razavi, RF Microelectronics, Prentice-Hall PTR,1998.
- T.H. Lee, The Design of CMOS Radio-Frequency Integrated Circuits", Press, 1998.
- R. Jacob Baker, H.W.Li, and D.E. Boyce, CMOS Circuit Design Layout and Simulation, Prentice-Hall of ,1998.
- Y.P. Tsividis Mixed Analog and Digital VLSI Devices and Technology, McGraw Hill,1996.

MEMORY DESIGN AND TESTING (ECN17256)
Pre-requisite(s): VLSI Design

Course Outcomes:

After the completion of this course, students will be able to:

CO1	Get complete knowledge regarding different types of memories, their architectural and different packing techniques of memories.
CO2	Design and optimize semiconductor memory cell for a given specification.
CO3	Design SRAMs, DRAMs, NVRAMs, and Flash Memories.
CO4	Understand different memory testing and design for testability
CO5	Contribute to the development of high-performance memory subsystems and use advanced memory technologies

UNIT -1:
Voltaile Memory (RAMs):
STATIC RANDOM ACCESS MEMORY(SRAM) TECHNOLOGIES: SRAM cell structure, MOS SRAM, Architecture-MOS SRAM cell and peripheral circuit operation, bipolar SRAM technologies-silicon on insulator (SOI) technology, advanced SRAM architectures and application specific SRAMs. DRAM technology development CMOS, DRAM cell theory and advanced cell structures, BiCMOS, DRAMs-soft error failures in

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DRAMs-Advanced DRAM designs and architecture-application, Specific DRAMs.

9(L)

UNIT -2:

Non Voltaile Memory (ROMs):

Read-only memories (ROMs)-High density, ROMs-programmable read only memories (PROMs)- bipolar PROMs-CMOS PROMs, Erasable (UV) – Programmable road-only memories (EPROMs)- floating-gate EPROM cell-one- time programmable (OTP) EPROMs-Electrically Erasable PROMs (EEPROMs)-EEPROM technology and architecture, nonvolatile SRAM-flash memories (EPROMs or EEPROM), advanced flash memory architecture.

9(L)

UNIT -3:

Memory Testing:

General Fault Modeling – Read Disturb Fault Model – Precharge Faults – False Write Through Data Retention Faults – Decoder Faults. Megabit DRAM Testing Nonvolatile Memory Modeling and Testing-IDDQ Fault Modeling and Testing Application Specific Memory Testing.

9(L)

UNIT -4:

Advanced Memory Technologies:

Low-power memory circuits: sources and reduction of power dissipation in a ram subsystem and chip, low-power dram circuits, low power SRAM circuits. Content Addressable Memories (CAMs) Ferroelectric RAMs (FRAMs), GaAs FRAMs, Analog memories, magneto resistive RAMs (MRAMs), Experimental memory devices, Memory Hybrids and MCMs (2D), Memory stacks and MCMs (3D), Memory MCM testing and reliability issues, memory cards, high density memory packaging future directions.

9(L)

Text Books:

- Ashok K.Sharma," Semiconductor Memories Technology, Testing and Reliability", Prentice-Hall of India Private Limited, New Delhi.
- Tegze P . Haraszti, "CMOS Memory Circuits", Kluwer Academic Publishers.
- Betty Prince, "Emerging Memories: Technologies and Trends", Kluwer Academic publishers.

Reference Book:

- Alberto Bosio, Luigi Dilillo, Patrick Girard, Serge Pravossoudovitch, Arnaud Virazel, Advanced Test Methods for SRAMs: Effective Solutions for Dynamic Fault Detection in Nanoscaled Technologies, Springer, 2010.
- Hao Yu and Yuhao Wang, Design Exploration of Emerging Nano-scale Non-volatile Memory, Springer, 2014.
- Takayuki Kawahara (Editor), Hiroyuki Mizuno (Editor), Green Computing with Emerging Memory: Low-Power Computation for Social Innovation, Springer, 2012.
- Research and review papers in specific area.

<u>**Professional Elective- V**</u>

ADAPTIVE AND SMART ANTENNA (ECN17275)

Course Outcomes:

On successful completion of the course students will be able to

- Understand antenna theory and application of signa processing in it.
- Learn techniques of developing MIMO antennas, beam forming.
- Design practical antennas for Radar applications.

UNIT 1: Adaptive Array Concept: Motivation of using Adaptive Arrays, Adaptive Array problem statement, Signal Environment, Array Element Spacing considerations, Array Performance, Nulling Limitations due to miscellaneous array effects, Narrow band and broad band signal processing considerations 8(L)

UNIT 2: Optimum Array Processing: Steady state performance limits and the Wiener solution, Mathematical Preliminaries, Signal Description for conventional and signal aligned arrays, Optimum Array Processing for narrowband applications, Optimum Array Processing for broadband applications, Optimum Array Processing for perturbed propagation conditions 8(L)

UNIT 3: Adaptive Algorithms: The least mean square error (LMS) algorithm, the Differential Steepest descent algorithm, the accelerated gradient approach, Gradient algorithm with constraints, Simulation studies. 5(L)

UNIT 4: Recursive Methods for Adaptive Error Processing: The weighted Least Square Error Processor, Updated Covariance Matrix Inverse, Kalman Filter methods for Adaptive Array Processing, the minimum variance processor, Simulation studies. 7(L)

UNIT 5: Effect of Mutual Coupling on Adaptive Antennas: Accounting for mutual effects for dipole array-compensation using open-circuit voltages, compensation using the minimum norm formulation, Effect of mutual coupling- Constant Jammers, Constant Signal, Compensation of mutual coupling- Constant Jammers, Constant Signal, Result of different elevation angle. 8(L)

Text Books:

- C. A. Balanis & P. I. Ioannides, *Introduction to Smart Antennas*, Morgan & Claypool Publication , 2014
- Frank Gross, *Smart Antennas with MATLAB*, McGraw-Hill Professional , 2015

Reference Books

- T.S. Rappaport, *Smart Antennas Adaptive Arrays Algorithms and Wireless Position Location*, IEEE Press, PTR – PH publishers
- Lal Chand Godara, *Smart Antennas*, CRC Press

ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY (ECN17276)

Course Outcomes:

On successful completion of the course students will be able to:

- Familiarize with the fundamentals of EMIC which is essential for electronic industry.
- Understand the source, types, and conduction principles of Electromagnetic Interference.
- Understand the specifications, standards, and limits of Electromagnetic compatibility.
- Acquire broad knowledge of various EMI radiation measurement instruments and the measurement techniques.
- Understand the Electromagnetic Interference Compatible for PCB design.

UNIT 1: EMI ENVIRONMENT-Sources of EMI, conducted and radiated EMI, Transient EMI, EMI- EMC Definitions and units of parameters.
6(L)

UNIT 2: EMI COUPLING PRINCIPLES- Conducted, Radiated and Transient Coupling , Common Impedance Ground Coupling, Radiated Common Mode and Ground Loop Coupling, Radiated Differential Mode Coupling, Near Field Cable to Cable Coupling, Power Mains and Power Supply Coupling.
6(L)

UNIT 3: EMI SPECIFICATIONS/STANDARDS/ LIMITS - Units of specifications, Civilian standards, Military standards
6(L)

UNIT 4: EMI MEASUREMENTS- EMI Test Instruments/Systems, EMI Test, EMI Shielded Chamber, Open Area Test Site, TEM Cell Antennas, Conductors Sensors/Injectors/Couplers, Military Test Method and Procedures, Calibration Procedures.
6(L)

UNIT 5: EMI CONTROL TECHNIQUES -Shielding, Filtering, Grounding, Bonding, Isolation Transformer, Transient Suppressors, Cable Routing, Signal Control, Component Selection and Mounting.
6(L)

UNIT 6: EMC DESIGN OF PCBS-PCB Traces Cross Talk, Impedance Control, Power Distribution Decoupling, Zoning, Motherboard Designs and Propagation Delay Performance Models.
6(L)

Text/Reference Books:

- Bernhard Keiser, "Principles of Electromagnetic Compatibility ", Artech house, 3rd Ed, 1986.
- Henry W. Ott, "Noise Reduction Techniques in Electronic Systems ", John Wiley and Sons, 1988.
- V P Kodali, "Engineering EMC Principles, Measurements and Technologies ", IEEE Press, 1996.
- Learning Materials on Electromagnetic Interference and Compatibility, prepared by IIT, New Delhi, for the project IMPACT, DoE, Government of India, 1997.

PATTERN RECOGNITION AND ANALYSIS (ECN17277)

Course outcomes:

On successful completion of the course, the students will be able to:

- Identify the basic structure of pattern recognition systems.
- Be familiar with the concepts of execution of a pattern recognition system
- Understand the supervised and unsupervised pattern recognition approaches.
- Explain the pattern classifiers.
- Understand the feature extraction and selection approaches for different pattern recognition applications.

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UNIT 1: Introduction to Pattern Recognition, Data sets for Pattern recognition, Review of Probability Theory, Random Vectors, Review of Linear Algebra, Linear Transformations, Decision Theory, ROC Curves, Likelihood Ratio Test. 6(L)

UNIT 2: Linear and Quadratic Discriminants, Fisher Discriminant, Sufficient Statistics, Coping with Missing or Noisy Features, Template-based Recognition, Feature Extraction, Different approaches to Feature Selections. 6(L)

UNIT3: Eigenvector and Multilinear Analysis, Training Methods, Maximum Likelihood and Bayesian Parameter Estimation, Perceptron Learning, Gradient Descent optimization. 6(L)

UNIT4: Support Vector Machines, Nearest-Neighbor Classification, Non-parametric Classification, Decision Trees, Density Estimation, Parzen Estimation. 6(L)

UNIT 5: Unsupervised Learning, Clustering, Vector Quantization, K-means, Hidden Markov Models, Viterbi Algorithm. 6(L)

UNIT 6: Linear Dynamical Systems, Kalman Filtering, Bayesian Networks, Combination of Multiple Classifiers "Committee Machines", Applications for Document Recognition. 6(L)

Text Books:

- R O Duda, P E Hart and D G Stork, Pattern Classification, John Wiley and Sons 2002

Reference Books:

- C M Bishop, Neural Networks for Pattern Recognition, Oxford University Press, 1995
- V N Vapnik, The Nature of Statistical Learning Theory, Springer 2000.
- N Cristianini and J Shawe-Taylor, An Introduction to Support Vector Machines, Cambridge University Press 2000.

SIGNAL COMPRESSION TECHNIQUES (ECN17278)

Course outcomes:

On successful completion of the course, the students will be able to:

- Learn the fundamental signal compression techniques.
- Apply compression techniques such as lossless and lossy techniques for different types of signals.
- Understand the computational and implementational issues.
- Understand machine learning based signal compression methods.

UNIT 1: Introduction to Signal Compression, Distortion Measures PSNR, mutual-information, divergence, and Kullback-Liebler number. 4(L)

UNIT 2: LOSSLESS AND LOSSY CODING: Run Length Encoding, Lempel-Ziv-Welch, Huffman Coding, Arithmetic Coding, adaptive and predictive, Subband Coding, QMF bank. 8(L)

UNIT 3: Review of uniform and non-uniform Quantization, Vector Quantization, Structured Vector Quantization, Product Vector Quantization, Differential Coding, Delta Modulation. 5(L)

UNIT 4: TRANSFORM CODING: Wavelets, Multi Resolution Analysis, Compression using DCT, DWT, KLT. 6(L)

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UNIT 5: COMPRESSION STANDARDS: TIFF, PNG, JPEG, JPEG 2000, H264, MPEG, HEVC 2013 same bit rate of HS264.
8(L)

UNIT 6: Sparse Representation, Dictionary Learning Based Approaches, Machine Learning based compression and its modern applications.
5(L)

Text books:

- Introduction to data compression, 5th Edition, 2017. Morgan Kaufmann Series in Multimedia Information and Systems.
- Gersho, Allen, and Robert M. Gray, (2012). Vector quantization and signal compression. Vol.159, Springer Science & Business Media.

Reference Books/Material:

- Salomon, David, and Giovanni Motta (2010). Handbook of data compression. Springer Science & Business Media. Prof. Ajit Rajwade, Digital Image Processing, Department of Electrical Engineering, Indian Institute of Technology Bombay, https://www.cse.iitb.ac.in/~ajitvr/CS663_Fall2018/
- Prof. S.C. Dutta Roy, Digital Signal Processing, NPTEL Course Material, Department of Electrical Engineering, Indian Institute of Technology, Delhi, https://nptel.ac.in/courses/117/102/117102060/

VLSI for IoT (ECN17279)

UNIT 1: Introduction to Internet of Things (IoT): Evolution of Internet of Things, Enabling Technologies, IoT Architectures, Edge and Cloud in IoT, Functional blocks of an IoT ecosystem, Sensors, Actuators, Smart Objects and Connecting Smart Objects;
IoT Platform overview: Overview of IoT supported Hardware platforms such as: Arduino, Raspberry pi, ARM Cortex Processors and Intel Galileo boards; Internal block diagram of Ardno board. 10(L)

UNIT 2: IoT Devices (Sensors, Actuators, and Microcontrollers): Introduction, basic block diagram, and their interfacing; Ultra-low power VLSI design for IoT; Mixed Signal VLSI Circuits for IoT: data converters, Integrated Sensors; Smart Sensors and their interfacing circuit.
10(L)

UNIT3: VLSI for IoT Application: Opportunity and Challenges, System on Chips, IoT system building blocks, Tools for IoT-oriented circuit and system design, Low-cost design approach; Reliability of IoT VLSI, VLSI Dimension to Create Secure IoT
10(L)

UNIT4: Case Studies/Applications Studies: IoT applications in home, infrastructures, buildings, security, Industries, Home appliances, other IoT electronic equipment, Sensors interfacing using Raspberry-pi/Arduino board.
6(L)

Text/Reference Books:

- Principles of CMOS VLSI Design–By 'Neil H.E Weste & Kamran Eshraghian.
- CMOS Mixed-Signal Circuit Design - R. Jacob Baker, Wiley Interscience,2009
- IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, Cisco Press, 2017.
- Internet of Things – A hands-on approach, Arshdeep Bahga, Vijay Madisetti, Universities Press,2015
- Smart sensor systems: Emerging technologies and applications. Meijer, G., Makinwa, K., &Pertijs, M. (Eds.). (2014), John Wiley & Sons.
- Raspberry Pi IoT Projects- Prototyping Experiments for Makers. John C. Shovic (2016). Apress

ORGANIC ELECTRONICS (ECN17280)
Pre-requisite: Semiconductor Devices and Circuits, VLSI Technology

Course Outcomes:

After the completion of this course, students will be able to:

CO1	Understand the fundamentals of organic electronics.
CO2	appreciate importance of structural property relationship of molecules in devices like OPV, OLED, and transistors.
CO3	Understand the fabrication of organic devices.
CO4	Understand the transport mechanism of organic electronic devices
CO5	Understand and appreciate organic electronics for futuristic device application

UNIT -1:
Fundamental physics and electronic properties:
Introduction, Atomic and Molecular Orbitals, Potential Energy Curve, Particle in a Box, Schrodinger's equation. 6(L)

UNIT -2:
Fundamentals of Semiconductors:
Semiconductors and their uses, Junctions --> Ohmic and Schottky Junction, Introduction to I/V curve, General Devices -> Diode, PV, Transistor, Sensor. 6(L)

UNIT -3:
Charge Transport:
Generation of the charged species, Conduction of the charges such as Species Present, Mechanism of Transport, Charge trapping effect at the electrode. 6(L)

UNIT -4:
Chemistry of Conducting Polymers and Processing and Fabrication:
Synthesis of conducting polymer, Type of conducting polymer (AB and AA type), General synthesis methods for each type, Characterisation the basic properties of the polymer. Spin coating, Evaporation, Sputtering, Electrospinning, Drop casting, Templating. 10(L)

UNIT -5:
Organic Devices and Modern devices
Conduction in Organic devices, Conduction at the junction and electrode, Space charge limited current, Specific Organic devices such as Transistors, OPV, OLED, Sensors. Flexible Glass material, Advance 2D and 3D materials. 8(L)

Text Books:

- Handbook of Conducting Polymers Third Edition CONJUGATED POLYMERS THEORY, SYNTHESIS, PROPERTIES, AND CHARACTERIZATION Edited by Terje A. Skotheim and John R. Reynolds, CRC Press.
- Handbook of Conducting Polymers Third Edition CONJUGATED POLYMERS PROCESSING AND APPLICATIONS Edited by Terje A. Skotheim and John R. Reynolds, CRC Press

Reference Book:

- Organic Photovoltaics Mechanisms, Materials, and Devices by Sam-Shajing Sun Niyazi Serdar Sariciftci. CRC Press.
- Semiconductor Physics and Devices Basic Principles Donald A. Neamen, McGraw Hill publications.
- Research and review papers in specific area.

WEARABLE ELECTRONIC DEVICES (ECN17281)
Pre-requisite(s): VLSI Technology, Semiconductor Devices and Circuits

Course Outcomes:

After the completion of this course, students will be able to:

CO1	Understand the role of wearable devices for measure physiological/ environmental parameters.
CO2	Understand the fabrication of wearable devices.
CO3	Understand the Energy harvesting for wearable devices.
CO4	Provide a clear understanding of the state-of –the-art wearable devices available in the market for various applications.
CO5	Explore the latest research trends in development of wearable and flexible sensors and its applications in the healthcare industry in particular.

UNIT -1:
Introduction to Wearable Devices:
Role of Wearables, Attributes of Wearables, Meta Wearables, Challenges and Opportunities, Future of Wearables, Social Aspects, Wearable Haptics, Intelligent clothing, Industry sectors' overview – sports, healthcare, Fashion and entertainment, military, environment monitoring, mining industry, public sector, and safety.
10(L)

UNIT -2:
Fabrication of Wearable Sensors:
Working principles of wearable sensors, Characteristics of wearable sensors; Thick-film processing, Thin film processing, overview of Photolithography; Issues in the fabrication of wearable sensors, Substrate selection, Substrate pre-processing, Fabrication of electrodes. Fabrication of wearable sensors using electrical properties.
8(L)

UNIT -3:
Energy harvesting for wearable devices:
Energy Expenditure of Body-Worn Devices, Energy and Power Consumption Issues, Design Considerations and need for Energy Harvesting Systems, Energy Harvesting from Temperature Gradient at the Human Body, Foot Motion and Light, Wireless Energy Transmission, Energy.
10(L)

UNIT -4:
Wearable Devices for Healthcare:
Wearable ECG devices, Wearable EEG devices, Wearable Blood Pressure (BP) Measurement, Wearable sensors for Body Temperature measurement: Intermittent and Continuous temperature monitoring.
8(L)

Text Books:

- "Seamless Healthcare Monitoring", Toshiyo Tamura and Wenxi Chen, Springer 2018.
- "Wearable Sensors -Fundamentals, Implementation and Applications", by Edward Sazonov and Michael R. Neuman, Elsevier Inc., 2014.
- "Wearable and Autonomous Biomedical Devices and Systems for Smart Environment", by Aimé Lay-Ekuakille and Subhas Chandra Mukhopadhyay, Springer 2010

Reference Book:

- "Flexible Electronics: Materials and Applications", William S. Wong and Alberto Salleo, Springer 2009.
- "Wearable Electronics Sensors - For Safe and Healthy Living", Subhas Chandra Mukhopadhyay, Springer 2015.
- Research and review papers in specific area.

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8th Semester (Electronics and Communication Engineering)

Course Code	Course name	L	T	P	Credit
ECN18351	Project/ Internship	0	0	14	14
	Total	0	0	14	14

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MINOR BASKETS

The following Undergraduate Programs (with Sl. No. 2, 3, 4 and 5) are exclusively applicable for the students of other Disciplines other than ECE.

2. PROGRAM: B Tech (XXXX) Minor in VLSI Design

Minor courses in VLSI Design will be offered for B.Tech students of other branches in 5th, 6th, and 7th semesters.

MINOR in VLSI Design

Sl. No.	Course Code	Course	Credit	Core/Elective
1.	ECN13104	Solid State Devices and Circuits	4	Core
2.	ECN14101	VLSI Technology	3	Core
3.	ECN15104/ ECN15106	Electronic Circuit Design/ VLSI Design	4	Core
4.	ECN15253-15255/ECN16255-16257	Elective-I/Elective-II	3	Elective
5.	ECN16280-16282	Elective-III	3	Elective
		Total	17	

N.B. Course contents and other details of this Program are available in the respective regular semester courses in B Tech ECE Program. Elective courses are of VLSI wing.

3. PROGRAM: B Tech (XXXX) Minor in Signal Processing

Minor courses in Signal Processing will be offered for B.Tech students of other branches in 5th, 6th, and 7th semesters.

Minor in Signal Processing

Sl. No.	Course Code	Course	Credit	Core/Elective
1.	ECN13102	Signals & Systems	3	Core
2.	ECN15101	Digital Signal Processing	5	Core
3.	ECN16104	Digital Image Processing	5	Core
4.	ECN15252,15256/ECN16253-16254	Elective-I/Elective-II	3	Elective
		Total	16	

N.B. Course contents and other details of this Program are available in the respective regular semester courses in B Tech ECE Program. Elective courses are of Signal Processing wing.

4. PROGRAM: B Tech (XXXX) Minor in Digital Systems

Minor courses in Digital Systems will be offered for B.Tech students of other branches in 5th, 6th, and 7th semesters.

Minor in Digital Systems

Sl. No.	Subject Code	Subject	Credit	Core/Elective
1.	ECN11102	Digital Electronics	4	Core
2.	ECN15107	Microprocessors	4	Core
3.	ECN15102	Computer Architecture	4	Core
4.	ECN15252,15256/ECN16253-16254	Elective-I/Elective-II	4	Elective
		Total	16	

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N.B. Course contents and other details of this Program are available in the respective semester courses in B Tech ECE Program. Elective courses are of Signal Processing wing.

MICROPROCESSORS (ECN15107) (MINOR Course)

Course objectives:

After the completion of the course, the students will be able to:

- To understand the basic concepts of microprocessors.
- To understand the concepts of writing variety of Assembly Language Programs.
- To learn the CPU module preparations and timing constraints for practical applications.
- To understand the interfacing of various devices, their uses in real system designs.

Unit 1: (a) Introduction: Evolution of Microprocessors and Microcomputers, Bus Organization, Bus Contention, Standard Bus Drivers & Transceivers, 3-State Buffers & Latches. 2(L)

(b) Architecture of a 8-bit Microprocessor: Internal organization of 8085, Signal descriptions, Machine Cycles & Timing diagrams, CPU Module Organization 4(L)

Unit 2: Assembly Language Programming: Data Addressing modes, Instruction Set of 8085, Assembly Language Programming. 8(L)

Unit 3: Basic Interfacing: Memory interfacing, Programmable Peripheral Interface (8255), Programmable Interval Timer (8253/8254) and Operating Modes, Minimum 8085 System Configuration with 8355/8755. 6(L)

Unit 4: (a) Special Architectural Features: Organization of Stack, Interrupts Structure, INTE Flip-Flop, Interrupt Programming. 4(L)

(b) Direct Memory Access: Basic DMA operations and timings, 8257 Programmable DMA Controller and its interfacing. 2(L)

Unit 5: Exemplary System Design: Interfacing A/D and D/A converters and Measurement of Physical & Electrical Quantities, Waveform Generators, Design of Digital IC Tester, Process Monitoring/Control System etc. 6(L)

Text books/Reference books:

- Ramesh S. Gaonkar, Microprocessors: Architecture Programming and applications with 8085, Penram International Publishing.
- N. Senthil Kumar, M Saravanan & S Jeevananthan, Microprocessors and Microcontrollers, Oxford University Press.
- B. Ram, Fundamentals of Microprocessors and Microcontrollers, Dhanpat Rai Publications.
- The Intel Microprocessors 8086/8088, 80186/80188, 80286, 80386, Pentium, and Pentium Pro Processor – B. B. Brey.

Elective-I

EMBEDDED SYSTEMS (ECN15256)

Course objectives:

After the completion of the course, the students will be able to:

- To understand the basic concepts of Embedded Systems.
- To understand the basic concepts of microcontrollers.
- To understand and program 8051 microcontrollers in C.
- To learn the interfacing of real-world devices and their control.

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Unit 1: Introduction to Embedded systems: Introduction, Categorization of Embedded Systems, CISC & RISC, Harvard & Princeton Architecture, Selection of Processor and Memory for Embedded Systems, I/O Devices, Memory Optimization, Power Saving and Embedded Software design. (7)

Unit 2: 8-bit Microcontrollers: Introduction to MCS-51 Family, Programming model of 8051, Addressing modes, Programming in C. (7)

Unit 3: Architectural Features: SFRs, Power Saving Modes, 8051 I/O Ports and its programming in C, On-Chip Timers, Operating Modes and Programming in C, 8051 Interrupts, Writing ISRs in C, UART. (8)

Unit 4: Interfacing & Applications: Interfacing of Serial Switches, LEDS, LCDs Modules, RTC Interfacing, Motor Interfacing, Interfacing of Temperature Sensors, Light Sensors etc. (8)

Unit 5: Example of Application Development: Development of Temperature Monitor, Development of Digital Watch etc. (4)

Text/Reference Books:

- Raj Kamal, Embedded System Architecture, Programming and Design, 2nd Ed, Tata McGraw Hill.
- M.A. Mazidi, J.G. Mazidi, R.D. McKinlay, The 8051 Microcontrollers and Embedded Systems: Using Assembly and C, 2nd Ed, Pearson Education.
- K. J. Ayala, The 8051 Microcontrollers Architecture Programming & Applications, 2nd Ed, Penram International.

5. PROGRAM: B Tech (XXXX) Minor in Communication Systems

Minor courses in Communication Systems will be offered for B.Tech students of other branches in 5th, 6th, and 7th semesters.

Minor in Communication Systems

Sl. No.	Subject Code	Subject	Credit	Core/Elective
1.	ECN13102	Signals & Systems	03	Core
2.	ECN14102	Digital Communication	04	Core
3.	ECN16102	RF and Microwave Engineering	04	Core
4.	ECN17101	Mobile & Wireless Communication	03	Core
5.	ECN15250-15251/ECN16250-16252	Elective-I/Elective-II	03	Elective
		Total	17	

N.B. Course contents and other details of this Program are available in the respective semester courses in B Tech ECE Program. Elective courses are of Communication Systems wing.

6. PROGRAM: B Tech Honours (Electronics and Communication Engineering)

Honours Programme courses will be offered in 5th, 6th, and 7th semesters

This Undergraduate Program is applicable to ECE students only.

Sl. No.	Subject Code	Subject	Credit	Core/Elective
1.	ECN15108	VLSI Circuits and Systems	4	Core
2.	ECN16104	Advanced Communication Systems	4	Core
3.	ECN16105	Multidimensional Digital Signal Processing	4	Core
4.	ECN17260, 17261,17262	Statistical Signal Processing/Advanced Analog IC Design/Information theory and coding	4	Elective VI
5.	ECN17290,17291, 17292	Speech Signal Processing/ Nanoelectronic Devices and Engineering /Antenna Design and MIMO Systems	4	Elective VII
		Total	20	

N.B. Course contents and other details of this Honours Program are available in the respective semester courses in M Tech Communication Systems, M Tech Signal Processing and M Tech Micro Electronics and VLSI Design Programs.

Professional Electives for B Tech (Honours)

Elective VI

1. ECN17260 Statistical Signal Processing
2. ECN17261 Advanced Analog IC Design
3. ECN17262 Information theory and coding

Elective VII

1. ECN17290 Speech Signal Processing
2. ECN17291 Nanoelectronic Devices and Engineering
3. ECN17292 Antenna Design and MIMO Systems

MULTIDIMENSIONAL DIGITAL SIGNAL PROCESSING (ECN16105)

Course Outcomes:
On successful completion of the course, the students will be able to:

- To expand the knowledge within digital signal processing to multidimensional signals and systems
- To design and implement two-dimensional FIR and IIR filters.
- To understand the spectral analysis of multidimensional signals
- To understand various applications of multidimensional signal processing

UNIT 1 Introduction to Multidimensional Discrete signals and systems: Frequency domain characterization of multidimensional signals and systems, sampling two dimensional signals, processing continuous signals with discrete systems. 6(L)

UNIT 2 Discrete Fourier analysis of Multidimensional signals: Discrete Fourier series representation

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of rectangular periodic sequences, Multidimensional DFT, definition and properties, Calculation of DFT, Vector radix FFT, Discrete Fourier transforms for general periodically sampled signals, relationship between m-dimensional ($m > 1$) and one-dimensional DFTs. 6(L)

UNIT 3 Design and implementation of Two-dimensional FIR filters: Implementation, Design using windows,Optimal FIR filter design- least squares design, Design of cascaded and parallel 2-DFIR filters, Design and implementation of FIR filters using transformations. 6(L)

UNIT 4 Multidimensional Recursive systems: Finite order difference equations- realizing LSI systems using difference equations, recursive computability, boundary conditions, ordering the computation of output samples, Multidimensional Z-Transforms, stability of 2-D recursive systems, stability theorems, Two- dimensional complex Spectrum. 8(L)

UNIT 5 Design and implementation of Two-dimensional IIR filters: Classical 2-D IIR filter implementations,Iterative implementation of 2-D IIR filters, signal flow graphs- circuit elements and their realizations, state variable realizations, Space domain Design techniques- Shank's method, Descent methods, Iterative pre-filtering design method, Frequency domain design techniques, stabilization techniques. 8(L)

UNIT 6 Multidimensional Spectral Estimation, Two-Dimensional Kalman Filtering. Applications: Applications of Multidimensional Signal Processing in Radar, Seismology and Image Processing etc. 6(L)

Text books/Reference books:

- Dan E Dudgeon and R M Mersereau, *Multidimensional Digital Signal Processing*, Prentice Hall
- Tamal Bose, *Digital Signal and Image Processing*, John Wiley publishers.
- J S Lim, *Two dimensional signal and Image Processing*, Prentice Hall.

STATISTICAL SIGNAL PROCESSING (ECN17260)

Review of random variables: distribution and density functions, moments, independent, uncorrelated and orthogonal random variables, Vector-space representation of Random variables, Schwarz Inequality Orthogonality principle in estimation, Central Limit theorem, Random process, stationary process, autocorrelation and autocovariance functions, Spectral representation of random signals,Wiener Khinchin theorem, properties of power spectral density, Gaussian Process and White noise process.

Linear System with random input, Spectral factorization theorem and its importance, innovation processand whitening filter.

Random signal modelling: MA(q), AR(p), ARMA(p,q) models. Parameter Estimation Theory: Principle of estimation and applications, properties of estimates,unbiased and consistent estimators, MVUE, CR bound, Efficient estimators, Criteria of estimation: the methods of maximum likelihood and its properties,Bayesian estimation: MeanSquare error and MMSE, Mean Absolute error, Hit and Miss cost function andMAP estimation.

Estimation of signal in presence of White Gaussian Noise (WGN) Linear Minimum MeanSquare Error(LMMSE) Filtering: Wiener Hoff Equation FIR Wiener filter, Causal IIR Wiener filter, Non-causal IIRWiener filter Linear Prediction of Signals, Forward and Backward Predictions, Levinson Durbin Algorithm, Lattice filter realization of prediction errorfilters.

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Spectral analysis: Estimated autocorrelation function, periodogram, Averaging the periodogram (Bartlett Method), Welch modification, Blackman and Tukey method of smoothing periodogram, Parametric method, AR(p) spectral estimation and detection ofHarmonic signals, MUSIC algorithm.

Textbooks/Reference Books:

- M. Hays, *Statistical Digital Signal Processing and Modelling*, John Willey and Sons,1996.
- M. D. Srinath, P. K. Rajasekaran and R. Viswanathan, *Statistical Signal Processing withApplications*, PHI, 1996.
- D. G. Manolakis, V. K. Ingle and S. M. Kogon, *Statistical and Adaptive SignalProcessing*, McGraw Hill, 2000.
- S. M. Kay, *Modern Spectral Estimation*, Prentice Hall, 1987.
- S. J. Orfanidis, *Optimum Signal Processing*, Second Edition, MacMillan Publishing,1989.
- H. Stark and J.W. Woods, *Probability and Random Processes with Applications toSignalProcessing*, Prentice Hall 2002.
- A. Papoulis and S.U. Pillai, *Probability, Random Variables and Stochastic Processes*,4thEdition, McGraw-Hill, 2002

SPEECH SIGNAL PROCESSING (ECN17290)

Course Objectives:

- To introduce the models for speech production
- To develop time and frequency domain techniques for estimating speech parameters
- To introduce a predictive technique for speech compression
- To understand speech recognition, synthesis and speaker identification.

UNIT I Introduction: Speech production mechanism, Classification of speech, sounds, nature of speech signal, models of speech production. Speech signal processing: purpose of speech processing, digital models for speech signal, Digital processing of speech signals, Significance, short time analysis.

8(L)

UNIT II Time domain methods for speech processing: Time domain parameters of speech, methods for extracting the parameters, zero crossings, auto correlation function, pitch estimation.

6(L)

UNIT III Frequency domain methods for speech processing: Short time Fourier analysis, filter bank analysis, spectrographic analysis, Format extraction, pitch extraction, Analysis - synthesis systems.

6(L)

UNIT IV Linear predictive coding of speech: Formulation of linear prediction problem in time domain, solution of normal equations, Interpretation of linear prediction in auto correlation and spectral domains.

6(L)

UNIT V Homomorphic speech analysis: Central analysis of speech, format and pitch estimation, Applications of speech processing - Speech recognition, Speech synthesis and speaker verification.

8(L)

TEXT BOOK:

- L.R. Rabiner and R.E Schafer: Digital processing of speech signals, Prentice Hall, 1978.

REFERENCE BOOKS:

- J.L Flanagan : Speech Analysis Synthesis and Perception - 2nd Edition - Sprenger Vertag, 1972.
- I.H.Witten :Principles of Computer Speech , Academic press, 1983.

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RESEARCH BASKET

The following Undergraduate Programs (with Sl. No. 7, 8 and 9) are applicable to students of ECE Discipline only.

7. PROGRAM: B Tech (Electronics and Communication Engineering) with Research (in VLSI Design)

The Research courses in VLSI Design will be offered in 5th,6th, and 7th semesters.

Sl. No.	Course Code	Course	L	T	P	Credits	Core/Elective
1.	ECN15108	VLSI Circuits and Systems	3	1	0	04	Core
2.	ECN16106/ECN17291	Nanoelectronic Devices and Engineering	3	1	0	04	Core
3.	ECN16260-16264	Elective VIII	3	1	0	04	Elective
4.	ECN16260-16264	Elective VIII	3	1	0	04	Elective
5.	ECN17352	Research Project				04	Elective
		Total				20	

N.B. These specialization courses in B Tech Research (Electronics and Communication Engineering, VLSI Design) Program are of M Tech Microelectronics and VLSI design Program.

Professional Electives for B Tech (Research) VLSI Design

Elective VIII

1. ECN16260 VLSI CAD
2. ECN16261 System on Chip
3. ECN16262 VLSI for Telecommunications
4. ECN16263 Reconfigurable Hardware Design
5. ECN16264 Architectural Design of ICs

VLSI CIRCUITS AND SYSTEMS (ECN15108)

Designing High-Speed CMOS Logic Networks: Gate delays, driving large capacitive loads, logical effort, optimizing number of stages, branching, BiCMOS drivers.

Advanced Techniques in CMOS Logic Circuits: Mirror circuits, Pseudo-nMOS, domino logic, adiabatic logic, tri-state circuits, clocked CMOS, dynamic CMOS logic Circuits, dualrail logic networks.

System Specifications using Verilog Codes: Basic concepts, structural, gate level modeling, switch level modeling, design hierarchies, behavioral, dataflow modeling and RTL.

General VLSI System Components using Verilog Codes: Multiplexers, binary decoders, equality detectors and comparators, priority encoder, shift and rotation operations, latches, D flip-flop, registers and their structural description using Verilog.

Arithmetic Circuits in CMOS VLSI using Verilog Codes: Bit adder circuits, ripple-carry adders, carry look-ahead adders, other high-speed adders, and their Verilog implementation, Booth algorithm and Booth encoded digit operations and array multipliers.

Reliability and Testing of VLSI Circuits: General concepts, reliability modeling and performance metrices, CMOS testing, test generation methods: logical effects of faults, the D-Algorithm, path sensitization and basic networks for deriving the boolean difference.

References:

1. Neil H. E. Weste and David M. Harris, *CMOS VLSI Design: A Circuits and Systems Perspective*, Addison-Wesley
2. John P. Uyemura, *Introduction to VLSI Circuits and Systems*, John Wiley & Sons, INC.
3. Neil H. E. Weste and Kamran Eshraghian, *Principles of CMOS VLSI Design*, Addison-Wesley, MA

ADVANCED ANALOG IC DESIGN (ECN17261)

Basic MOS Device Physics: A review, single-stage amplifiers, basic concepts, common sourcestage, types of load source follower, common-gate stage, cascode stage folded cascode. Differential amplifier - single-ended and differential operation, basic differential pair: quantitative and qualitative analysis, common-mode response differential pair with MOS loads, Gilbert cell.

Current mirrors and references, basic current mirrors, cascode current mirrors, advanced current mirrors, active current mirrors: large-signal and small-signal analysis, basic voltage and current references.

Operational amplifiers: performance parameters, one-stage Op-amps, two-stage Op-amps, current conveyer.

Operational transconductance amplifier, current feedback amplifier.

Textbooks/Reference Books:

1. Behzad Razavi, *Design of Analog CMOS Integrated Circuits*
2. Allen and Holberg, *CMOS Analog Circuit design*
3. Gray, Hurst, Lewis and Meyer, *Analysis and Design of Analog CMOS IntegratedCircuits*

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VLSI CAD (ECN16260)

Hierarchical view of VLSI design, architectural design, high level synthesis, scheduling, data path synthesis, logic synthesis, minimization techniques, circuit design and simulation, layoutsynthesis, placement and routing, DRC, silicon compiler, array processors.

Textbooks/Reference Books:

1. M. Sarrafzadeh and C. K. Wong, *An introduction to physical design*, McGrew Hill
2. Naveed Sherwani, *Algorithm for VLSI Design Automation*, Springer
3. S. M. Sait and H. Youssef, *VLSI Physical design automation: theory and practice*,World Scientific Pub. Co.

SYSTEM ON CHIP (ECN16261)

Introduction to digital system and VLSI design, design techniques, fabrication processes and steps, wires and vias, design rules and layout. Logic gates, static complementary gates, nonconventional logic circuits, low power gate circuits, delay through interconnect. Combinational logic network, network delay, logic and interconnect design, power optimization and logic testing. Sequential machines, latches and flip-flops, clocking techniques, sequential system design, optimization, validation and testing.
Chip design: design methodologies, timing specifications, architecture design layout with validation, data paths.

Textbooks/Reference Books:

1. Wayne Wolf, *Modern VLSI Design*, Third Edition
2. Neil Weste, *Principles of CMOS VLSI Design*

VLSI FOR TELECOMMUNICATIONS (ECN16262)

Building blocks of signal processing systems, dedicated architectures, architecture of a transceiver, front end ICs for wireless systems, direct conversion receivers, processors for cellular telephony, chip sets for GSM and CDMA for various protocols, chipsets for satellite TV receiver, ICs for digital TV and image compression, ICs for fibre optic communication, ATM switching, ICs for error correction and detection.

Textbooks/Reference Books:

1. Y. Tsividis, P. Antognetti, *Design of MOS VLSI Circuits for Telecommunications,* Prentice-Hall
2. Bosco Leung, *VLSI for Wireless Communication,* 2nd Edition, Springer

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NANOELECTRONIC DEVICES AND ENGINEERING (ECN17291/ECN16106)

Shrinking of device dimensions from micrometres to nanometres, limitations of conventional devices, quantum mechanics of nanometric structures, concept of quantum wells, quantum wires and quantum dots, fundamentals of carrier transport in quantum structures, temperatureeffects, MODFETs, HBTs and other ultra-high-performance devices for future ULSI, super lattices, resonant tunneling phenomena, opto-electronic interactions in quantum structures, quantum lasers, single-carrier devices, formation of quantum structures, elements of nanoelectronic device processing.

Textbooks/Reference Books:

1. Paul Harrison, *Quantum wells, wires and dots: Theoretical and ComputationalPhysics of Semiconductor Nanostructures*, Second Edition, Wiley-Interscience
2. Y. Taur and T. H. Ning, *Fundamentals of Modern VLSI Devices*, Oxford
3. S. M. Sze, *Physics of Semiconductor Devices*, Wiley
4. Yannis Tsividis, Colin McAndrew, *Operation and Modelling of the MOS Transistor*,Oxford, Third Edition
5. B. G. Streetman, *Solid State Electronics Devices*, Prentice Hall
6. Mark Lundstrom, Jing Guo, *Nanoscale Transistor Device Physics, Modeling andSimulation*, Springer
7. Mark Lundstrom, *Fundamentals of carrier transport*, Cambridge
8. Jean-Pierre Colinge, *FinFETs and Other Multi-Gate Transistors*, Springer 2007

RECONFIGURABLE HARDWARE DESIGN (ECN16263)

Introduction to reconfigurable design, objectives, advantages and performance issues, classification/types of reconfigurability, details of logic reconfiguration, instruction set reconfiguration, static vs dynamic reconfiguration, full or partial reconfiguration, fine grained, medium grained and coarse grained reconfiguration. Hardware vs software configurability andreconfigurability. Flow of reconfigurable design including synthesis, program execution and reconfigurable processor, reconfigurable instruction cell array. Algorithms related to differentdesign steps of reconfigurable architecture. Fault covering problem in reconfigurable VLSI, fault covers in heterogeneous and general arrays. Fault diagnosis in reconfigurable VLSI and WSI processors arrays. Reconfigurable architecture design for different applications including DSP and Communication. Testability for reconfigurable VLSI architecture. Network on Chips(NOC).

Textbooks/Reference Books:

1. P. -E. Gaillardon, *Reconfigurable Logic: Architecture, Tools, and Applications,* CRCPress
2. John V. Oldfield and Richard C. Dorf, *Field-Programmable Gate Arrays: Reconfigurable Logic for Rapid Prototyping and Implementation of Digital Systems,*

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Wiley Pub

3. Scott Hauck and André DeHon, *Reconfigurable Computing: The Theory andPractice of FPGA-Based Computation*

ARCHITECTURAL DESIGN OF ICS (ECN16264)

Introduction, general design methodologies, Datapath synthesis, mapping algorithms intoarchitectures, control strategies, concepts of system analysis, hardware implementation of various control structures, microprogram control techniques, implementation of simple and nested subroutine calls, timing considerations, worst case system speed calculation, pipelined and parallel architectures, latency and throughput, dependency and dataflow, fault tolerance, fault-tolerant architectures.

Textbooks/Reference Books:

1. Sajjan G. Shiva, *Computer Organization, Design and Architecture*, 5th edition, CRCPress Taylor and Fransis group
2. Sung Kyu Lim, *Design for High Performance Low Power and Reliable 3D IntegratedCircuits*, Springer

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8. **PROGRAM: B Tech (Electronics and Communication Engineering) with Research (in Signal Processing)**

The Research courses in Signal Processing will be offered in 5th,6th, and 7th semesters.

Sl. No.	Course Code	Course	L	T	P	Credit	Core/Elective
1.	ECN15109	Advances in Digital Signal Processing	3	1	0	04	Core
2.	ECN16107	DSP Processors and Architecture	3	1	0	04	Core
3.	ECN16105	Multidimensional Digital Signal Processing	3	1	0	04	Core
4.	ECN17293-17298	Elective IX	3	1	0	04	Elective
5	ECN17353	Research Project				04	Elective
					Total	20	

N.B. The specialization courses in B Tech Research (Electronics and Communication Engineering, Signal Processing) Program are of M Tech Signal Processing Program.

ADVANCES IN DIGITAL SIGNAL PROCESSING (ECN15109)

Course outcomes:

On successful completion of the course, the students will be able to:

- Comprehend multirate digital signal processing and demonstrate its applications
- Demonstrate an understanding of the power spectral density and apply to discrete random signals and systems
- Apply linear prediction and filtering techniques to discrete random signals for signal detection and estimation.
- Apply power spectrum estimation techniques to random signals.

UNIT 1: Multirate Digital Signal Processing: Introduction, decimation by a factor D, interpolation by a factor I, sampling rate conversion by a rational factor I/D, filter design and implementation for sampling rate conversion, multistage implementation of sampling rate conversion, sampling rate conversion of band-pass signals, sampling rate conversion by an arbitrary factor, applications. 10(L)

UNIT 2: Linear Prediction and Optimum Linear Filters: Representation of a random process, forward and backward linear prediction, solution of normal equations, properties of the linear error-prediction filters, AR lattice and ARMA lattice-ladder filters, Wiener filters for filtering and prediction.

10(L)

UNIT 3: Power Spectrum Estimation: Estimation of spectra from finite-duration observations of signals, the Periodogram, use of DFT in power spectral estimation.

(a) Non parametric methods for power spectrum estimation: Bartlett, Welch and Blackman, Tukey methods, Comparison of performance of non-parameric power estimation methods.

(b)Parametric methods for power spectrum estimation: Relationship between the auto-Correlation and model parameters, Methods for AR model parameters: Yule-Walker, Burg and Unconstrained Least Squares methods, Sequential Estimation methods, Moving Average (MA) and ARMA Models for power spectrum estimation.

(c) Minimum variance spectral estimation, eigenanalysis algorithms for spectral estimation. 16(L)

Textbooks/Reference Books:

- John G. Proakis and Dimitris G. Manolakis, *Digital Signal Processing*, 3rd Edition, Pearson, 2003.

- Li Tan, *Digital Signal Processing – Fundamentals and applications*, Elsevier, 2008.
- Paulo S. R. Diniz, Eduardo A. B. da Silva and Sergio L. Netto, *Digital Signal Processing: System Analysis and Design*, Cambridge University Press, 2002.
- Sanjit K. Mitra, *Digital Signal Processing - A Computer Based Approach*, TataMcGraw Hill, 2001.

DSP PROCESSORS AND ARCHITECTURE (ECN16107)

Course outcomes:
On successful completion of the course, the students will be able to:

- Understand architectural features of DSP Processors
- Understand various on-chip devices required for DSP algorithm.
- Understand and realize various DSP Filters and Algorithm.
- Understand the interfacing of external devices with DSP Processors.

UNIT 1: INTRODUCTION TO DIGITAL SIGNAL PROCESSING: A Digital Signal Processing System, the Sampling process, the convolution theorem, the DFT and FFT, decimation and interpolation, number formats forsignals and coefficients in DSP systems, dynamic range and precision, sources of error in DSP implementations,A/D conversion errors, DSP computational errors, D/A conversion errors.
6(L)

UNIT 2: INTRODUCTION OF DSP PROCESSORS: Need for DSP processors, MAC, modified bus structures,memory access schemes, Harvard architecture, VLIW architecture, on-chip peripherals, addressing modes, concept of pipelining. Issues in real time DSP applications, fixed point and floating point processors.
6(L)

UNIT 3: PROGRAMMABLE DIGITAL SIGNAL PROCESSORS : TMS320C50x architecture, interrupts and interrupt vector, TMS320C50x peripherals, external memory interface, direct memory access, multi-channel buffered serial ports, clock generator and timers, general purpose input/output port, TMS320C50x addressing modes, direct addressing modes, pipeline, instruction set, assembly language programming, assembly code generation by C compiler, mixed C-and-assembly language programming, phase-locked loop and timers, Direct Memory Access (DMA).
10(L)

UNIT 4: IMPLEMENTATION OF BASIC DSP ALGORITHMS: Introduction, the Q-notation, interpolation and decimation filters. An FFT Algorithm for DFT computation, overflow and scaling, Bit-reversed index generation & implementation on the TMS32OC50x. 8(L)

UNIT 5: INTERFACING OF MEMORY AND PARALLEL I/O PERIPHERALS TO DSP DEVICE: Introduction, memory space organization, external bus interfacing signals, memory interface, parallel I/O interface, programmed I/O, interrupts and DMA interface. 6(L)

Text Book:

- B. Venkataramani & M. Bhaskar, Digital Signal Processor, Architecture, Programming and Applications, (2/e), McGraw- Hill, 2010.

Reference Books:

- K Padmanabhan, R. Vijayarajeswaran, A Practical Approach to Digital Signal Processing, New Age International.

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- Sen M. Kuo & Woon-Seng S. Gan, Digital Signal Processors: Architectures, Implementations, and Applications, Prentice Hall.
- C. Marven & G. Ewers: A Simple approach to digital signal processing, Wiley Inter science.
- TMS320C5x User's Guide.

Elective IX

1.	ECN17293	Microprocessor based System Design
2.	ECN17294	Optimization Techniques
3.	ECN17295	Random Theory, Stochastic Process and Queuing Theory
4.	ECN17296	Detection and Estimation Theory
5.	ECN17297	Expert Systems
6.	ECN17298	Digital Control
7.	ECN17260	Statistical Signal Processing
8.	ECN17290	Speech Signal Processing
9.	ECN17262	Information Theory and Coding

MICROPROCESSOR BASED SYSTEM DESIGN (ECN17293)

Review of 8086 & Programming through PC: BIU & EU, addressing modes & programming and CPU module design: Bus buffering and latching, fully buffered systems, bus timings, read & wait etc. Use of memory models, realization of array structures, display screen & keyboard processing with INT and BIOS functions calls, .COM and .EXE programs, use of macros, LOCAL, EXTRN and PUBLIC.

Interfacing with 8086: Memory Interfacing: physical memory organization, memory interfacing, parity error detection & correction, DRAM interfacing.
I/O Interfacing & Interrupts: Interfacing of 8255 PPI, interfacing of 8253/8254 timer devices, The 8279 controller, keyboard formats & display modes, interfacing keypad and alphanumeric displays, interruptresponse of 8086, interfacing 8259 priority interrupt controller, interrupt modes, Master/Slave configuration.

DMA & Serial Communication Interface: DMA data transfer, interfacing 8237 DMA controller and DMA modes, serial communication formats and protocols, interfacing 8251 USART operating modes,modem control, serial transfer between two 8086 single board microcomputers.

Measurement/Instrumentation: Interfacing A/D converters, analog multiplexers, sample and hold, D/A converters, measurement of frequency, measuring KWH, power factor, measurement & display of motor speed, microcomputer based smart scale etc.

Industrial Process Control: Overview, liquid level monitoring & control, microprocessor based protective relays, temperature control in vacuum furnaces, servo motor control etc.

Textbooks/Reference Books:

- D.V. Hall, Microprocessors and Interfacing, 2nd Ed, TMH
- Liu & Gibson, Microcomputer Systems: The 8086/8088 Family Architecture,Programming and Design, 2nd Ed, PHI
- Barry B Brey, The Intel Microprocessors 8086/8088, 80186/80188, 80286, 80386,Pentium, and Pentium Pro Processors, PHI
- Jan Axelson, Serial Port Complete Programming & Circuits for RS-232 and RS-485Linksand

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Networks, Penram International

- Peter Abel, IBM PC Assembly Language and Programming, 3rd Ed, PHI
- The Intel Handbook of peripheral devices

OPTIMIZATION TECHNIQUES (ECN17294)

Introduction and Basic Concepts: Historical development, Engineering applications of optimization, art of modelling, Objective function, constraints and constraint surface; formulation of design problems as mathematical programming problems, classification of optimization problems, Optimization techniques – classical and advanced techniques.

Optimization using Calculus: Stationary points, functions of single and two variables; Global optimumconvexity and concavity of functions of one and two variables, Optimization of function of one variableand multiple variables, Gradient vectors, Examples, Optimization of function of multiple variables subject to equality constraints, Lagrangian function, Optimization of function of multiple variables subject to equality constraints, Hessian matrix formulation, eigenvalues, Kuhn-Tucker Conditions, Examples.

Linear Programming: Standard form of linear programming (LP) problem, Canonical form of LP problem, assumptions in LP Models, elementary operations, graphical method for two variable optimization problem, Examples, motivation of simplex method, simplex algorithm and construction of simplex tableau, simplex criterion, minimization versus maximization problems, revised simplex method; duality in LP, primal-dual relations, dual simplex method, sensitivity or post optimality analysis, other algorithms for solving LP problems – Karmarkar's projective scaling method.

Linear Programming Applications: Use of software for solving linear optimization problems using graphical and simplex methods, Examples for transportation, assignment, water resources, structural and other optimization problems.

Dynamic Programming: Sequential optimization, representation of multistage decision process, types of multistage decision problems, concept of sub optimization and the principle of optimality, recursive equations – forward and backward recursions, computational procedure in dynamic programming (DP). Dynamic Programming Applications: Discrete versus continuous dynamic programming, multiple state variables; curse of dimensionality in DP.

Dynamic Programming Applications: Problem formulation and application in design of continuous beam and optimal geometric layout of a truss.

Integer Programming: Integer linear programming, concept of cutting plane method. Mixed integer programming, solution algorithms, Examples.

Advanced Topics in Optimization: Piecewise linear approximation of a nonlinear function, Multi objective optimization – Weighted and constrained methods, Multi level optimization, Direct and indirect search methods. Evolutionary algorithms for optimization and search.

Textbooks/Reference Books:

- S. S. Rao, *Engineering Optimization: Theory and Practice*, New Age International P Ltd., 2000.
- G. Hadley, *Linear programming*, Narosa Publishing House, New Delhi, 1990.
- H. A. Taha, *Operations Research: An Introduction*, 5th Edition, Macmillan, New York, 1992.
- K. Deb, *Optimization for Engineering Design-Algorithms and Examples*, Prentice Hall of IndiaPvt. Ltd., 1995.

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- K. Srinivasa Raju and D. Nagesh Kumar, *Multicriterion Analysis in Engineering and Management*, PHI Learning Pvt. Ltd.

RANDOM THEORY, STOCHASTIC PROCESS AND QUEUING THEORY (ECN17295)

Introduction to statistical communication theory, Simple binary hypothesis tests: Bayes criteriaand Neyman-Pearson tests, receiver operating characteristic and M hypotheses, Classical estimation theory:Bayes estimation, maximum likelihood estimation, Cramer- Rao Inequalityand multiple parameter estimation.

Representation of random processes: introduction to random variables, sequence of random variables, central limit theorem, transformation of random variables, characterization ofrandom processes.

Gaussian processes and their properties, Wiener process, White noise processes, optimum linear filters,periodic random processes and vector random process. Detection of signals and estimation of signal parameters in white noise.

Matched filters, correlation receivers, linear and nonlinear estimations, nonwhite Gaussian noise, detections and estimations in nonwhite noise estimation of signals with random amplitude and phase, Rayleigh channels, Rician channels, multiple channels.

Queueing theory, Queueing models, Kendall's notation, The M/M/1 Queueing system, Little law, M/M/1/N Queueing systems, The M/G/1, Queueing systems, Network of queues.
Discrete time Queueing systems, Queueing on space division packet switch, Queueing on single-buffered Banyan network.

Textbooks/Reference Books:

- Papoulis & S. U. Pillai, Probability, Random variables and stochastic processes, 4thEdition, McGraw Hill
- K. Sam Shanmugan & A. M. Breipohi, Random Signals, 2nd Edition, Wiley
- John J. Proakis, Digital communication, Fourth Ed., MGH
- Thomas G. Robertazzi, Computer networks and systems: Queueing Theory andPerformance Evaluation, 3rd Edition, Springer.

EXPERT SYSTEMS (ECN17297)

Introduction, expertise and heuristic knowledge, knowledge-based system, structure of knowledge- based systems, logic and automated reasoning, predicate logic, logical inference, Resolution. Truth maintenance systems, rules-based reasoning, forward chaining, backward chaining, rule-based architectures, conflict resolution schemes, associative networks, frames and objects, uncertainty management, Bayesian approaches, certainty factors, Dempster Shafer theory of evidence fuzzy sets and fuzzy logic, knowledge acquisition search strategies and matching techniques.

Textbooks/Reference Books:

- Peter Jackson, Introduction to Expert Systems
- Archino J. Gonzalez, Douglas and Dankel, The Engg. of Knowledge Based Systems
- Dan W. Patterson, An Introduction to Artificial Intelligence

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DETECTION AND ESTIMATION THEORY (ECN17296)

Review of Gaussian variables and processes; problem formulation and objective of signal detection andsignal parameter estimation in discrete-time domain.

Statistical Decision Theory: Bayesian, minimax, and Neyman-Pearson decision rules, likelihood ratio, receiver operating characteristics, composite hypothesis testing, locally optimum tests, detector comparison techniques, asymptotic relative efficiency.

Detection of Deterministic Signals: Matched filter detector and its performance; generalizedmatchedfilter; detection of sinusoid with unknown amplitude, phase, frequency and arrival time, linear model.

Detection of Random Signals: Estimator-correlator, linear model, general Gaussian detection, detection of Gaussian random signal with unknown parameters, weak signal detection.

Nonparametric Detection: Detection in the absence of complete statistical description of observations, sign detector, Wilcoxon detector, detectors based on quantized observations, robustness of detectors.

Estimation of Signal Parameters: Minimum variance unbiased estimation, Fisher information matrix, Cramer-Rao bound, sufficient statistics, minimum statistics, complete statistics; linear models; best linear unbiased estimation; maximum likelihood estimation, invariance principle; estimation efficiency; Bayesian estimation: philosophy, nuisance parameters, risk functions, minimum mean square error estimation, maximum a posteriori estimation.

Signal Estimation in Discrete-Time: Linear Bayesian estimation, Weiner filtering, dynamicalsignal model, discrete Kalman filtering.

Textbooks/Reference Books:

- H. L. Van Trees, Detection, Estimation and Modulation Theory: Part I, II, and III, JohnWiley, NY, 1968.
- H. V. Poor, An Introduction to Signal Detection and Estimation, Springer, 2/e, 1998.
- S. M. Kay, Fundamentals of Statistical Signal Processing: Estimation Theory, Prentice Hall PTR, 1993.
- S. M. Kay, Fundamentals of Statistical Signal Processing: Detection Theory, Prentice Hall PTR, 1998.

INFORMATION THEORY AND CODING (ECN17262)

Information theory: Information, entropy, information rate, classification of codes, Kraft McMillan inequality, sources, memoryless and Markov, source coding theorem, Shannon Fano coding, Huffman coding, Extended Huffman coding - joint and conditional entropies, mutual information, discrete memoryless channels – BSC, BEC – channel capacity, Shannon limit.

Source coding: text, audio and speech: Text: adaptive Huffman coding, arithmetic coding, LZW algorithm – Audio: perceptual coding, masking techniques, psychoacoustic model, MEGaudio layers I,II,III, Dolby AC3 - Speech: channel vocoder, linear predictive coding.

Source coding: Image and Video: Image and video formats – GIF, TIFF, SIF, CIF, QCIF, Image compression: READ, JPEG, Video compression: principles- I,B,P frames, motion estimation, motion compensation, H.261, MPEG standard.

Error control coding - Block codes: Definitions and principles: Hamming weight, Hammingdistance, Hamming Bound, minimum distance decoding, single parity codes, Hamming codes,repetition codes, linear block codes, cyclic codes, syndrome calculation, encoder and decoder,CRC.

Error control coding - Convolutional codes: Convolutional codes, code tree, trellis, state diagram, encoding, decoding: sequential search and Viterbi algorithm, principle of Turbo coding.

Textbooks/Reference Books:

- R Bose, Information Theory, Coding and Crptography, TMH 2007
- Fred Halsall, Multidedia Communications: Applications, Networks, Protocols and Standards, Pearson Education Asia, 2002
- K Sayood, Introduction to Data Compression, 3/e, Elsevier 2006
- S Gravano, Introduction to Error Control Codes, Oxford University Press 2007
- Amitabha Bhattacharya, Digital Communication, TMH 2006
- B. P. Lathi, Modern Digital and Analog Communications Systems, The Oxford Seriesin Electrical and Computer Engineering, Third Edition
- Thamas Cover, Information theory and Coding, 2nd Edition, Prentice Hall

DIGITAL CONTROL (ECN17298)

Introduction: Basic Elements of discrete data control systems, advantages of discrete data control systems, examples.

Signal conversion & processing: Digital signals & coding, data conversion & quantization, sample and hold devices, mathematical modeling of the sampling process, Data reconstructionand filtering of sampledsignals: zero-order hold, first-order Hold and polygonal hold.

Review of Z-transforms, applications of Z-transforms to difference equations and ladder network problem, signal between sampling instants using sub multiple sampling method, modified Z-transforms.

Transfer functions, block diagrams, signal flow graphs: introduction, pulse transfer function, and Z-transfer function, discrete data system with cascaded elements separated by a sampler and not separated by a sampler. Closed loop systems, characteristic equation in discrete domain, causality and physically realizable systems, the sampled signal flow graph, modified Z-transfer function, multirate discrete data systems (slow rate and fast rate), closed loop multirate sampled systems.

Comparison of time response of continuous data and discrete data, steady state error analysis of digital control systems, correlation between time response and root locations in s-plane andz-plane, Root loci fordigital control systems, effects of adding poles and zeros to open loop transfer function, discrete data systems: Stability tests of discrete data systems: Bilinear transformation method, extension of RH criterion, Jury's stability test.

Frequency domain analysis: Polar plot of GH(z), Nyquist stability criterion, Bode plot, gain Margin and phase margin, Nicholas chart, bandwidth considerations, sensitivity analysis.

Review of state space techniques to continuous data systems, state equations of discrete data systems withsample and hold devices, state diagrams of digital systems, decomposition of discrete data transfer function, state variable analysis of response between sampling instants, controllability, observability of LTI discrete data systems.

Design of digital control systems with digital controllers through bilinear transformation. Digital PID controller, design for dead beat response, pole placement design by incomplete feedback or output feedback.

Textbooks/Reference Books:

- Kuo, *Digital control systems,* Second Edition, Oxford University Press
- Ogatta, *Discrete Time control systems,* 2nd ed., PHI 3. M. Gopal,
- *Digital Control Engineering,* New Age Publ.
- Nagrath & Gopal, *Control System Engineering*, Wiley Eastern
- John Dorsey, *Continuous & Discrete Control Systems*, MGH

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9. **PROGRAM: B Tech (Electronics and Communication Engineering) with Research (in Communication Systems)**

The Research Programme courses in Communication Systems will be offered in 5th,6th, and 7th semesters.

Sl. No.	Subject Code	Subject	L	T	P	Credit	Core/Elective
1.	ECN17296/ECN15110	Detection and Estimation Theory	3	1	0	04	Core
2.	ECN16108	Advanced Communication Systems	3	1	0	04	Core
3.	ECN16109	Communication Networks	3	1	0	04	Core
4.	ECN17265-17268/ECN17292, 17294,17295	Elective X	3	1	0	04	Elective
5	ECN17354	Research Project				04	Elective
					Total	20	

N.B. The specialization courses in B Tech Research (Electronics and Communication Engineering, Communication Systems) Program are of M Tech Communication Systems Program.

Elective X

1. ECN17265 Linear Algebra
1. ECN17266 VLSI Design for Communication System
2. ECN17267 Artificial Intelligence and Machine Learning
3. ECN17268 Communication System Design
4. ECN17292 Antenna Design and MIMO Systems
5. ECN17294 Optimization Techniques
6. ECN17295 Random Theory, Stochastic Process and Queueing Theory

ADVANCED COMMUNICATION SYSTEMS (ECN16108)

Introduction to Ultra-Wideband (UWB) Communication Systems: UWB Concepts, Advantage and Challenges, single band vs multiband UWB, FCC emissions and its limits, UWB applications

Pulse Detection and Multiple Access Techniques: Conventional pulse detection technique, pulse modulation and detection techniques, UWB multiple access techniques, Techniques of Spread Spectrum.
Modulation schemes: Channel impairments, and optical transmission system design principles, Advanced modulation formats, OFDM, polarization multiplexing, constrained coding, and coherent detection: Multilevel modulation schemes, Polarization multiplexing, Constrained (line or modulation) coding, and Coherent detection.

Error Correction Techniques: BCH and RS codes, Concatenated codes, Turbo- and turbo-product codes, and LDPC codes. Coded modulation schemes: Multilevel coding. Bit-interleaved coded modulation, and Coded OFDM. Advanced chromatic dispersion compensation, Signal pre-distortion compensation, Postdetection compensation: feed-forward equalizer (FFE), decision feedback equalizer (DFE), turbo equalization (TE).

MIMO wireless communication: Basic MIMO model, MIMO capacity in fading channels, Diversity multiplexing trade off, Space time code for MIMO wireless communication.

Textbooks/Reference Books:

1. K. Siwiak and D. McKeown, Ultra-Wideband Radio Technology, John Wiley and Sons Limited, 2004.
2. Simon Haykin and M. Moher, Modern Wireless Communication, Pearson Education 2005.
3. Faranak Nekoogar, Ultra-Wideband communications: Fundamentals and Aplications, Prentice Hall, 2005.
4. C. Oestages and B. Clerckx, MIMO Wireless Communication, 1st Ed, 2007.

COMMUNICATION NETWORKS (ECN16109)

Introduction to Communication Networks: Introduction, Evolution of Communication Networks, Challenges in Communication Networks, Overview of various Communication Networks, Wireless Communications Principles and Fundamentals, Different Generations of Cellular Systems, Future Trends: 5G Systems and Beyond.

Wireless LANs, PANs and MANs: Introduction, Fundamentals of WLAN - Technical Issues, Network Architecture, WLAN Topologies, IEEE 802.11 Physical Layer, The Medium

Access Control (MAC) Layer, Latest Developments and variants if IEEE802.11, Bluetooth - Specification, Transport Layer, Middleware Protocol Group, Bluetooth Profiles, IEEE 802.16- Differences between IEEE 802.11 and 802.16 PHY and MAC.

Wireless Internet: Introduction –wireless internet, address mobility, inefficiency of transport layer and application layer protocol, mobile IP – simultaneous binding, route optimization, mobile IP variations, handoffs, IPv6 advancements, IP for wireless domain, IP level Mobility Management for Wireless Networks

TCP in wireless domain – TCP over wireless, TCPs -traditional, snoop, indirect, mobile, transaction- oriented, impact of mobility.

Ad Hoc Wireless Networks and Wireless Sensor Networks: Introduction, issues –medium access scheme, routing, multicasting, transport layer protocol, pricing scheme, QoS provisioning, self-organization, security, addressing, service discovery, energy management, deployment consideration, ad-hoc wireless internet.

IoT/WSN: issues and design challenges, architecture – layered and clustered , data dissemination, data gathering, Mac protocols, location discovery, quality of sensor network – coverage and exposure, zigbee standard, IoT/IoX

Textbooks/Reference Books:

1. Aftab Ahmad, *Wireless and Mobile Data Networks*, John Wiley & Sons, Ltd. 2005.
2. P. Nicopolitidis, M. S. Obaidat, G. I. Papadimitriou, A. S. Pomportsis, *Wireless Networks*, John Wiley & Sons, Ltd. 2003.
3. C. Siva Ram Murthy and B.S. Manoj, *Ad-hoc Wireless Networks - Architecture and Protocols*, Pearson Education, 2005.
4. Kaveh Pahlavan and Prashant Krishnamurthy, *Principle of Wireless Networks - A Unified Approach*, Prentice Hall, 2006.
5. Jochen Schiller, *Mobile Communications*, Pearson Education, 2005.
6. William Stallings, *Wireless Communication and Networks*, Prentice Hall, 2005.

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7. T. S. Rappaport, *Wireless Communications: Principles and Practice*, Prentice Hall, 2004.
8. Research Papers from Journals (provided by the course instructor)

LINEAR ALGEBRA (ECN17265)

Algebraic Structures: Sets, functions, Group, homomorphism of groups, Ring, Field, Vector Space, Subspaces, direct sum, metric space, inner product space, Lp space, Banach Space, Hilbert Space. Linear independence, basis, dimension, orthonormal basis, finite dimensional vector spaces, isomorphic vector spaces, Examples of finite and infinite dimensional vector spaces, R^N, C^N.

Linear Transformations: Linear Transformations, four fundamental subspaces of linear transformation, inverse transformation, rank nullity theorem, Matrix representation of linear transformation, square matrices, unitary matrices, Inverse of a square matrix, Change of basis, coordinate transformation, system of liner equations, existence and uniqueness of solutions, projection, least square solution, pseudo inverse.

Matrix Methods and Transforms: Eigen values, Eigen vectors, Generalized Eigen vectors, Diagonalizability, orthogonal diagonalization, Symmetric, Hermitian and Unitary matrices (transformations), Jordan canonical form, Fourier basis, DFT as a linear transformation, Translation invariant linear transformation, wavelet basis, wavelet transforms.

References:

1. G. F. Simmons, *Topology and Modern Analysis*, McGraw Hill
2. Frazier, Michael W. *An Introduction to Wavelets through Linear Algebra*, Springer Publications.
3. Hoffman Kenneth and Kunze Ray, *Linear Algebra*, Prentice Hall of India.

VLSI DESIGN FOR COMMUNICATION SYSTEM (ECN17266)

Review of communication concepts from circuit designer perspective. General VLSI optimization techniques, partitioning and synthesis of different telecommunication blocks. Telecommunication system integration in single chip/ multichip module, high throughput and low delay/latency design requirement for real time communication, critical path analysis for high-speed VLSI design, switched capacitor circuits, high speed A/D and D/A converters. Receiver architectures for different systems. Active and passive mixers. Frequency synthesizer circuits.

VLSI CAD tools, software and languages, low power circuits/architecture design methodologies, high speed switching circuits, high speed memory organization, high speed control & decision circuits, design of analog front ends, impedance matching with bonding pads, Si-Ge devices for RF circuits, interface for optical fibers.

VLSI for generation and detection of PSK, FSK, QAM etc. subscriber line interface circuits, network switching circuits, VLSI systems for modem design, adaptive filters, equalizers, CVSD codecs, PLL, ISDN, UDLT, USART, Viterbi decoding, data encryption, DSPs, audio/video compression, video conferencing, Case studies for implementation of specific protocols currently in vogue.

VLSI design and optimization of switch architecture for next generation networks. Soft switch design and its performance issues.

Textbooks/Reference Books:

1. Jose Epifanio Franca and Yannis Tsividis, *Design of Analog-Digital VLSI Circuits for Telecommunications and Signal Processing,* (2nd Edition) Prentice Hall
2. Keshab K. Parhi, *VLSI Digital Signal Processing Systems: Design and Implementation*, Wiley-Interscience; 1 edition
3. Richard J. Higgins, *Digital signal processing in VLSI*, Prentice Hall

ANTENNA DESIGN AND MIMO SYSTEMS (ECN17292)

Overview of Antennas: Introduction, types of antennas, radiation mechanism of single wire, two wire, dipoles.

Fundamental parameters of antennas: Radiation pattern, radiation power density, radiationintensity, beamwidth, directivity, antenna efficiency, beam efficiency, bandwidth, polarization,input impedance, antenna radiation efficiency, maximum directivity and maximum effective area, antenna temperature, reciprocity, Friis transmission formula.

Wire antennas and Aperture Antennas: Short dipole, Half Wave dipole, monopole, small loop antennas, slot antennas, open ended waveguide radiator, Horn antennas, pyramidal Horn antenna, reflector antenna.

Antenna Arrays and Special Antennas: Linear array and pattern multiplication, two elementarray, uniform array, array with non-uniform excitation.

Special Antennas and Antenna for mobile devices: Monopole and dipole antennas, long wire, V and Rhombic antennas, Yagi-Uda array, Turnstile antenna, Helical antenna, Biconicalantenna, Log-periodical array, spiral antenna, microstrip patch antenna, loop antenna, lens antenna. PIFA, integral IFA, internal folded monopole, ceramic antennas, stubby antennas andwhip stubby antennas.

MIMO antenna systems: Introduction, diversity antennas, key to gigabyte wireless, current issues and challenges of MIMO antenna design, impact of antenna on MIMO performance, MIMO signaling, Reconfigurable MIMO Antenna and Massive MIMO.

Textbooks/Reference Books:

1. C A Balanis, *Antenna Theory: Analysis and Design*, 3rd Edition Wiley, 2009
2. John D Kraus, Ronald J Marhefka and Ahmad S Khan T, *Antennas and WavePropagation*, 4th Edition, Tata McGraw-Hill Education, 2006
3. Constantine A. Balanis, Michael A. Jensen and Jon W. Wallace, *Antenna Design*

Considerations for MIMO and Diversity Systems, WILEY Pub, 2010

4. Mohammad S. Sharawi, *Printed MIMO Antenna Engineering*, Artech House, 2014

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING (ECN17267)

Basic Principles: Introduction, Experimental Evaluation: Over-fitting, Cross-Validation. Sample complexity. VC-dimension, Regularization, Theory of generalization, Bias-Variance trade off, Reinforcement Learning.

Supervised Learning: Linear and Logistic Regression, Decision Tree Learning, k-NN classification, SVMs, Ensemble learning: boosting, bagging.

Neural Network: Artificial Neural Networks: Perceptron, Multilayer networks andbackpropagation. Radial Basis function NN

Probabilistic Models: Maximum Likelihood Estimation, MAP (Maximum a-posteriori), Bayes Classifiers, Naive Bayes. Markov Networks, Bayesian Networks, Factor Graphs, Inference in Graphical Models.

Unsupervised Learning: K-means and Hierarchical Clustering, Gaussian Mixture Models,PAC learning. EM algorithm, Hidden Markov Models.

References:

1. Tom Mitchell, *Machine Learning*, McGraw Hill, 1997.
2. Christopher M. Bishop, *Pattern Recognition and Machine Learning*, Springer 2006.
3. Richard O. Duda, Peter E. Hart, David G. Stork, *Pattern Classification*, John Wiley &Sons, 2006.
4. Trevor Hastie, Robert Tibshirani, Jerome Friedman, *The Elements of StatisticalLearning: Data Mining, Inference, and Prediction*, Springer 2009.
5. Garg, P. Bhartia, Inder Bahl and A. Ittipiboon, *Microstrip Antenna Design Handbook*,Artech House Publishers, 2000

COMMUNICATION SYSTEM DESIGN (ECN17268)

Introduction to RF and Wireless Technology: Complexity comparison, design bottleneck, choice of technology, mobile RF technology. Basic concepts in RF design, frequency and spectrum, nonlinearity and time Variance, intersymbol interference, sensitivity and dynamic range, basic impedance transformation.

Transceiver Architectures: Heterodyne receivers, homodyne receivers, image-reject receivers, digital-IF receivers, subsampling receivers, direct-conversion techniques, two-step transmitters, case studies – Motorola's FM receiver, Phillips' DECT transceiver, Lucent Technologies GSM transceiver, Phillips GSM transceiver.

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Amplifiers, Mixers, and Oscillators: High frequency amplifiers, low noise amplifiers, power amplifiers. Mixers: general considerations, transistor mixers, CMOS mixers, noise in mixers. Oscillators: general considerations, basic LC oscillator topologies, negative resistance oscillators, voltage controlled oscillators, phase noise, oscillator pulling and pushing, quadrature signal generation.

Frequency Synthesizers: General considerations, Phase-Locked Loop (PLL): basic PLL, charge-pump PLL, noise in PLL. RF synthesizer architectures, frequency dividers.
Design and computer simulation of a RF transceiver.

Textbooks/Reference Books:

1. B. Razavi, *RF microelectronics*, Prentice Hall, 1998
2. S. Haykin, *Communication Systems*, John-Wiley & Sons, 4th edition, 2000
3. R. Ludwig and P. Bretchko, *RF circuit design – theory and application*, Prentice Hall, 2000
4. C. W. Sayre, *Complete wireless design*, McGraw-Hill, 2001
5. S. Furber, *ARM System-on-Chip Architecture*, Addison-Wesley Professional, 2 edition, 2000

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