COURSE STRUCTURE

B.TECH.

ELECTRONICS & COMMUNICATION ENGINEERING(ECE)

ELECTRONICS & COMMUNICATION ENGINEERING(ECE) WITH MINOR IN COMPUTER SCIENCE & ENGINEERING (CSE)

ELECTRONICS & COMMUNICATION ENGINEERING(ECE) WITH SPECIALIZATION IN VLSI

Under

Choice Based Credit System(CBCS)

(w.e.f. 2022-23)

Total Credits Required =188

Note: For Minor CS & VLSI Specialization degree, ***additional 20 credits*** are required to be earn from respective bouquet. Three-year B.Tech. ECE/Specialization Degree **Lateral entry students** are required to earn 50 credits less corresponding to four year B.Tech. ECE/Specialization Degree.

Sl.	Area	Dept. / Course	Credit	Total
1	**Humanities & Social Sciences**	Ethics & Values	2	25
		Management	3	
		English Language Skills for Communication	6	
		English for Professional Purpose	4	
		Soft Skills	10	
2	**Basic Sciences**	Environmental Studies	2	24
		Mathematics	12	
		Chemistry	5	
		Physics	5	
3	**Engineering Sciences**	Computer Programming	4	24
		Mechanical Engineering	6	
		Electrical Engineering	5	
		Electronics Engineering	5	
		Department Specific	4	
4	**Project Work / Seminars**	Mini Project	4	17
		Industrial Training	2	
		Minor Project	3	
		Major Project	8	
5	**Program Core**			48
6	**Program Electives**			26
7	**Open Electives**			16
8	**General Proficiency**		8	8
9	**Non Graded Mandatory Courses (Four Course)**		0	0

First Semester (B. Tech ECE & B. Tech ECE with Minor CSE)

S.No.	Cat.	Code	Subject	L	T	P	J	C
1	BS	BMAS1101	Engineering Mathematics- I	3	1	0	0	4
2	BS	BPHS0002	Engineering Physics-I	3	1	0	0	4
3	ES	BMEG0001	Basic Mechanical Engineering	3	1	0	0	4
4	HS	BELH0001	English Language Skills for Communication – I	2	0	0	0	2
5	ES	BECG0001	Electronics Engineering	3	1	0	0	4
6	ES	BECG0800	Electronics Lab-I	0	0	2	0	1
7	BS	BPHS0801	Engineering Physics Lab	0	0	2	0	1
8	ES	BMEG0800	Engineering Workshop Practice Lab	0	0	2	0	1
9	ES	BMEG0801	Engineering Drawing Lab	0	0	2	0	1
10	HS	BELH0801	English Language Lab I	0	0	2	0	1
11	GP	BEGP0001	General Proficiency	0	0	0	0	1
			Total					**24**

Second Semester (B. Tech ECE & B. Tech. ECE with Minor CSE)

S.No.	Cat.	Code	Subject	L	T	P	J	C
1	BS	BMAS1102	Engineering Mathematics-II	3	1	0	0	4
2	BS	BCHS0101	Engineering Chemistry	3	1	0	0	4
3	ES	BCSG0002	Computer Programming	3	0	0	0	3
4	ES	BEEG1001	Basic Electrical Engineering	3	1	0	0	4
5	HS	BELH0002	English Language Skills for Communication-II	2	0	0	0	2
6	ES	BEEG0800	Electrical Engineering Lab	0	0	2	0	1
7	ES	BECG1002	Digital Electronics	3	0	0	0	3
8	ES	BECG0802	Digital Electronics Lab	0	0	2	0	1
9	BS	BCHS0801	Engineering Chemistry Lab	0	0	2	0	1
10	ES	BCSG0801	Computer Programming Lab	0	0	2	0	1
11	HS	BELH0802	English Language Lab – II	0	0	2	0	1
12	PW	APFJ 0001	Field Project	0	0	0	4	1
13	GP	BEGP0001	General Proficiency	0	0	0	0	1
			Total					**27**

First Semester (B. Tech. ECE with Specialization in VLSI)

S.No.	Cat.	Code	Subject	L	T	P	J	C
1	BS	BMAS1104	Engineering Calculus	3	1	0	0	4
2	BS	BECG 0003	Semiconductor Physics	3	1	0	0	4
3	ES	BCSC 0051	Computer Programming Using C	3	1	0	0	4
4	ES	BECG0001	Electronics Engineering	3	1	0	0	4
5	HS	BELH 0014	English for Professional Communication	3	0	0	0	3
6	ES	BECG0800	Electronics Lab-I	0	0	2	0	1
7	ES	BCSC 0851	Computer Programming Lab	0	0	4	0	2
8	BS	BECG 0803	Semiconductor Physics Lab	0	0	2	0	1
9	ES	BECG 1801	Electronics Simulation Lab	0	0	2	0	1
10	ES	BMEG 0804	Engineering Drawing And Modelling	0	0	2	0	1
11	GP	BEGP0001	General Proficiency	0	0	0	0	1
			Total					**26**

Second Semester (B. Tech. ECE with Specialization in VLSI)

S.No.	Cat.	Code	Subject	L	T	P	J	C
1	BS	BMAS0105	Linear Algebra And Differential Equations	3	1	0	0	4
2	ES	BCSC 0053	Learning Python for Data Analysis and Visualization	3	0	0	0	3
3	ES	BEEG1001	Basic Electrical Engineering	3	1	0	0	4
4	ES	BECG1002	Digital Electronics	3	0	0	0	3
5	BS	BECS 0001	Semiconductor Materials and Characterization	3	1	0	0	4
6	HS	BELH0016	English for Professional Communication II	3	0	0	0	3
7	ES	BCSG 0051	Design Thinking	3	0	0	0	3
8	ES	BECG0802	Digital Electronics Lab	0	0	2	0	1
9	ES	BEEG0800	Electrical Engineering Lab	0	0	2	0	1
10	BS	BECS 0800	Material Simulation Lab	0	0	2	0	1
11	ES	BCSC 0852	Learning Python for Data Analysis and Visualization Lab	0	0	2	0	1
12	PW	APFJ 0001	Field Project	0	0	0	4	1
13	GP	BEGP0001	General Proficiency	0	0	0	0	1
	Total							**30**

Program Core (PC)
(Credits – 48)

S. No.	Code	SUBJECT	TEACHING SCHEME				CREDITS	HRS/WK	Prerequisite	Coe requisite
			L	T	P	J				
1	BECC0001	**Network Analysis and Synthesis**	**3**	**1**	**0**	**0**	**4**	**4**	**N/A**	**N/A**
2	BECC1002	**Electromagnetic Field Theory**	**3**	**1**	**0**	**0**	**4**	**4**	**N/A**	**N/A**
3	BECC0003	**Solid State Devices and Circuits**	**3**	**1**	**0**	**0**	**4**	**4**	**N/A**	**N/A**
4	BECC0004	**Signals and Systems**	**3**	**1**	**0**	**0**	**4**	**4**	**N/A**	**N/A**
5	BECC0005	**Microprocessors and Applications**	**3**	**0**	**0**	**0**	**3**	**3**	**N/A**	**Microprocessors Lab**
6	BECC0800	**Microprocessors Lab**	**0**	**0**	**2**	**0**	**1**	**2**	**N/A**	**N/A**
7	BECC10006	**Analog Integrated Circuits**	**3**	**0**	**0**	**0**	**3**	**3**	**SSDC**	**Electronics Lab-II**
8	BECC0801	**Electronics Lab-II**	**0**	**0**	**2**	**0**	**1**	**2**	**N/A**	**N/A**
9	BECC1007	**Control Systems**	**3**	**1**	**0**	**0**	**4**	**4**	**N/A**	**Control Systems Lab**
10	BECC0802	**Control Systems Lab**	**0**	**0**	**2**	**0**	**1**	**2**	**N/A**	**N/A**
11	BECC0008	**Communication Engineering**	**3**	**1**	**0**	**0**	**4**	**4**	**Signals and Systems**	**Communication Lab**
12	BECC0803	**Communication Engineering Lab**	**0**	**0**	**2**	**0**	**1**	**2**	**N/A**	**N/A**
13	BECC0009	**Digital Communication**	**3**	**1**	**0**	**0**	**4**	**6**	**Communication Engineering**	**Digital Communication Lab**
14	BECC0804	**Digital Communication Lab**	**0**	**0**	**2**	**0**	**1**	**2**	**N/A**	**N/A**
15	BECC1010	Digital Signal Processing	3	1	0	0	4	4	Signals and Systems	Digital Signal Processing Lab
16	BECC0805	**Digital Signal Processing Lab**	**0**	**0**	**2**	**0**	**1**	**2**	**N/A**	**N/A**
17	BECC0011	**VLSI Design**	**3**	**0**	**0**	**0**	**3**	**3**	**SSDC**	**CAD of Electronics Lab**
18	BECC0806	**CAD of Electronics Lab**	**0**	**0**	**2**	**0**	**1**	**1**	**N/A**	**N/A**

Note:-L T P J C of 2 0 2 4 4 means the course has 2 Units of Class room Lecture, no Tutorial, 1 Unit of Lab work and 1 Unit of Project.

Program Elective(PE)
(Credits:26)

BOUQUET-I: COMMUNICATION ENGINEERING
BOUQUET-I(A): Communication System Theory

Code	Courses	L	T	P	J	C	Prerequisites	Coe requisite
BECE0070	Simulation Lab-II	0	0	2	0	1	N/A	N/A
BECE0001	Random Variable and stochastic Process	3	0	0	0	3	Fundamentals of Probability	N/A
BECE0003	Data Communication and Networks	3	0	0	0	3	Digital Communication	N/A
BECE0006	Wireless Communication	3	0	0	0	3	Digital Communication	BECE0271
BECE0007	Information Theory & Coding	0	0	2	0	1	Digital Communication	N/A
BECE0008	Multicarrier Communication	0	0	0	8	2	Digital Communication	N/A
BECE0073	Multicarrier Communication Lab	3	0	0	0	3	Digital Communication	N/A
BECE0086	Multicarrier Communication Projects	3	0	0	0	3	Digital Communication	N/A
BECE0009	Spread Spectrum System	3	0	0	0	3	Digital Communication	N/A
BECE0010	Satellite Communication	3	0	0	0	3	Digital Communication	N/A
BECE0010	Long Term Evolution	3	0	0	0	3	Wireless Communication	N/A

BOUQUET-I: COMMUNICATION ENGINEERING
BOUQUET-I(B): Microwave & Optical Engineering

Code	Courses	L	T	P	J	C	Prerequisites	Coe requisite
BECE0070	Simulation Lab-II	0	0	2	0	1	N/A	N/A
BECE0002	Antenna & Wave Propagation	3	0	0	0	3	EMFT	N/A
BECE0004	Microwave Engineering	3	0	0	0	3	EMFT	N/A
BECE0071	Microwave Lab	0	0	2	0	1	EMFT	N/A
BECE0005	Optical Communication						SSDC	Microwave Engineering
BECE0072	Optical communication Lab	0	0	2	0	1	SSDC	Optical Communication

BOUQUET-II: SIGNAL AND IMAGE PROCESSING

Code	Courses	L	T	P	J	C	Prerequisite	Coe requisite
BECE0070	Simulation Lab-II	0	0	2	0	1	N/A	N/A
BECE0108	Signal Detection and Estimation Theory	3	0	0	0	3	Fundamentals of Probability	N/A
BECE0001	Random Variable and stochastic Process	3	0	0	0	3	Fundamentals of Probability	N/A
BECE0101	Fundamentals of Digital Image Processing	3	0	0	0	3	S&S	N/A
BECE0102	Digital Image Processing	3	0	0	0	3	S&S	N/A
BECE0171	Digital Image Processing Lab	0	0	2	0	1	S&S	N/A
BECE0186	Digital Image Processing Project	0	0	0	8	2	S&S	N/A
BECE0103	Bio-Medical Image Processing	3	0	0	0	4	S&S	N/A
BECE0104	Adaptive Signal Processing	3	0	0	0	3	DSP, RV&SP	N/A
BECE0105	Bio-Medical Signal Processing	3	0	0	0	3	Digital Signal Processing	N/A
BECE0171	Bio-Medical Signal Processing Lab	0	0	2	0	1	Digital Signal Processing	N/A
BECE0107	Speech Processing	3	0	0	0	3	Adaptive Signal Processing	N/A
BECE0172	Speech Processing Lab	0	0	2	0	1	Adaptive Signal Processing	N/A

BOUQUET-III: CONTROL AND EMBEDED SYSTEM

Code	Courses	L	T	P	J	C	Prerequisite	Coe requisite
BECE0070	Simulation Lab-II	0	0	2	0	1	N/A	N/A
BECE0305	Introduction to Machine Learning	3	0	0	0	3	Fundamentals of Probability	N/A
BEEC1014	Power Electronics	3	0	0	0	3	SSDC	N/A
BECE0301	Electronic Instruments and Measurements	3	0	0	0	3	N/A	N/A
BECE0302	Microcontrollers and Embedded Systems	3	0	0	0	3	Microprocessors	N/A
BECE0303	Embedded Systems Design	3	0	0	0	3	Microprocessors	N/A
BECE0371	Embedded Systems Lab	0	0	2	0	1	N/A	N/A
BECE0386	Embedded Systems Project	0	0	0	8	2	N/A	N/A
BECE0304	Intelligent System	3	0	0	0	3	Control System	N/A
BECE0306	Industrial Process Control	3	0	0	0	3	Control System	N/A
BECE0372	Industrial Process Control Lab	0	0	2	0	1	Control System	N/A
BECE0387	Industrial Process Control Project	0	0	0	8	2	Control System	N/A
BECE0306	Digital Control System	3	0	0	0	3	Control System and Signal systems	N/A
BECE0307	Modern control system						Control System	N/A
BECE0308	Industrial Automation	3	0	0	0	3	Digital Electronics. Control System	N/A
BECE0373	PLC Automation Lab	0	0	2	0	1	Digital Electronics. Control System	N/A
BECE0311	Adaptive Control	3	0	0	0	3	Control System	N/A

BOUQUET-IV: VLSI

Code	Courses	L	T	P	J	C	Prerequisites	Coe requisite
BECE0070	Simulation Lab-II	0	0	2	0	1	N/A	N/A
BECE0201	Fundamentals of HDL Programming	3	0	0	0	3	DE	N/A
BECE0202	Digital System Design using HDL	3	0	0	0	3	DE	BECE0271
BECE0271	Digital System Design using HDL LAB	0	0	2	0	1	DE	N/A
BECE0286	Digital System Design using HDL PROJECT	0	0	0	8	2	DE	N/A
BECE0203	Analog VLSI Design	3	0	0	0	3	S&S	N/A
BECE0204	VLSI Testing And Testability	3	0	0	0	3	VLSI Design	N/A
BECE0205	Integrated Circuit Technology	3	0	0	0	3	VLSI Design	N/A
BECE0206	Fundamentals of Low-Power VLSI Circuits and Systems	3	0	0	0	3	VLSI Design	N/A
BECE0207	Low-Power VLSI Circuits and Systems	3	0	0	0	3	VLSI Design	N/A
BECE0272	Low-Power VLSI Circuits and Systems Lab	0	0	2	0	1	VLSI Design	N/A
BECE0287	Low-Power VLSI Circuits and Systems Project	0	0	0	8	2	VLSI Design	N/A
BECE0208	Fundamentals of RF Integrated Circuits	3	0	0	0	3	SSDC. Comm Engg.	N/A
BECE0209	RF Integrated Circuits	3	0	0	0	3	SSDC. Comm. Engg.	N/A
BECE0273	RF Integrated Circuits Lab	0	0	2	0	1	SSDC. Comm. Engg.	N/A
BECE0288	RF Integrated Circuits Project	0	0	0	8	2	SSDC. Comm. Engg.	N/A
BECE0210	Micro and Nano devices	3	0	0	0	3	SSDC	N/A
BECE0211	Fundamentals Of Memory Design And Testing	3	0	0	0	3	Digital Electronics	N/A
BECE 0212	Design of Analog/ Mixed Mode VLSI Circuits	3	0	0	0	3	Digital Electronics	N/A

BECE0213	Advanced Digital Design using Verilog	3	0	0	0	3	Digital Electronics	N/A
BECE0274	Advanced Digital Design using Verilog Lab	0	0	2	0	1	Digital Electronics	N/A
BECE 0207	FPGA Prototyping Using System Verilog	3	0	0	0	3	Digital Electronics	N/A
BECE0272	FPGA Prototyping Using System Verilog Lab	0	0	0	8	2	Digital Electronics	N/A
BECE 0214	Hardware Verification Using System Verilog And Uvm	3	0	0	0	3	Digital Electronics	N/A

BOUQUET-IV: Minor CSE

S. NO.	CODE	SUBJECT	TEACHING SCHEME				CREDITS	CONTACTS HR/WK	PRE-REQUISITES
			L	T	P	J			
THEORY									
1.	BCSG1001	Python Programming	3	0	0	0	3	3	
2.	BCSC0002	Object Oriented Programming	3	0	0	0	3	3	Programming
3.	BCSC0003	Database Management System	3	0	0	0	3	3	
4.	BCSC0004	Operating Systems	3	0	0	0	3	3	
5.	BCSC0005	Computer Organization	3	0	0	0	3	3	
6.	BCSC0006	Data Structures and Algorithms	3	1	0	0	4	4	Programming
7.	BCSC0008	Computer Networks	3	1	0	0	4	4	
8.	BCSC0009	Software Engineering	3	0	0	0	3	3	
9.	BCSE0105	Machine Learning	3	0	0	0	3	3	
10.	BCSE0157	Introduction to Big Data Analytics	3	0	0	0	3	3	
PRACTICALS									
1.	BCSG0800	Python Programming Lab	0	0	2	0	1	2	
2.	BCSC0801	Object Oriented Programming Lab	0	0	2	0	1	2	Programming Lab
3.	BCSC0802	Database Management System Lab	0	0	2	0	1	2	
4.	BCSC0803	Operating Systems Lab	0	0	2	0	1	2	
5.	BCSC0804	Computer Organization Lab	0	0	2	0	1	2	
6.	BCSC0805	Data Structures and Algorithms Lab	0	0	2	0	1	2	Programming Lab
7.	BCSE0133	Machine Learning Lab	0	0	2	0	1	2	
8.	BCSE0183	Big Data Analytics Lab	0	0	2	0	1	2	

Project Work(PW)

S. No.	Code	SUBJECT	TEACHING SCHEME				CREDITS	Prerequisite
			L	T	P	J		
1	BECJ0950	Mini Project-I	**0**	**0**	**0**	**4**	**1**	**N/A**
2	BECJ0951	Mini Project-II	**0**	**0**	**0**	**4**	**1**	**N/A**
3	BEC0952	Mini Project-III	**0**	**0**	**0**	**8**	**2**	**N/A**
4	BECJ0971	Project-I	**0**	**0**	**0**	**12**	**3**	**144 Credits earned and CPI>=5.5**
5	BECJ0972	Project-II	**0**	**0**	**0**	**32**	**8**	**144 Credits earned and CPI>=5.5**
6	BECJ0991	Industrial Training	0	0	0	8	2	N/A

Mandatory Non Graded Courses (MNG)

S. NO.	CODE	SUBJECT	TEACHING SCHEME				CREDITS	CONTACTS	PRE-REQUISITES
			L	T	P	J			
THEORY									
1.	BCSM0001	Introduction to Cyber Security	2	0	0	0	0	2	
2.	BCHM0101	Disaster Management	2	0	0	0	0	2	
3.	MBAM0001	Basic Course in Entrepreneurship	2	0	0	0	0	2	
4.	MBAM0002	Leadership And Organizational Behavior	2	0	0	0	0	2	
		TOTAL	**8**	**0**	**0**	**0**	**0**	**8**	

Basic Sciences (BS) & Humanities and Social Sciences (HS)

S.No.	Code	Subject	Teaching Scheme				Credits	Contact (HR/WK)	Pre Requisites
			L	T	P	J			
THEORY									
1	BMAS0103	Engineering Mathematics III	3	1	0	0	4	4	
2	BELH0003	English for Professional Purpose– I	2	0	0	0	2	2	
3	BELH0004	English for Professional Purpose– II	2	0	0	0	2	2	
4	BELH0006	Ethics & Values	2	0	0	0	2	2	
5	BCHS0201	Environmental Studies	2	0	0	0	2	2	
6	MBAC0005	Industrial & Management	3	0	0	0	3	3	
PRACTICALS									
6	BTDH0301	Soft Skills-I	0	0	2	0	1	2	
7	BTDH0302	Soft Skills-II	0	0	2	0	1	2	
8	BTDH0303	Soft Skills-III	0	0	8	0	4	8	
9	BTDH0304	Soft Skills-IV	0	0	8	0	4	8	
Total			**14**	**1**	**20**	**0**	**25**	**35**	

1.

BECG0001: ELECTRONICS ENGINEERING

Credits: 04 **L–T–P-J: 3–1–0-0**

Course Objectives

- Be familiar with the principle and theory of semiconductor materials.
- To facilitate understanding of Analog components such as PN Junction Diode, BJT, Operations Amplifiers.
- To facilitate understanding of Digital logic fundamentals and logic gates.

Module No.	Contents	Teaching Hours
I	**Transport phenomenon in semiconductors:** Semiconductor materials; Intrinsic and Extrinsic semiconductors; Mass-action law, Drift and diffusion of charge carriers. **Junction diodes:** P-N Junction diode: construction, operation & characteristics; Zener and Avalanche breakdown mechanisms; Diode resistance and capacitance **Diode applications:** Rectifiers: half wave, full wave : Centre-tapped and bridge type.; Filters; Clippers; Clampers; Voltage Multipliers; Zener diode as voltage regulator; Regulated power supply. **Bipolar Junction Transistor (BJT):** Bipolar junction transistor: construction & operation; CB ,CE, CC configurations & their Characteristics; Operating point; Transistor as a switch; Need of biasing;	20
II	**Bipolar Junction Transistor (BJT):** Biasing methods: fixed bias, emitter bias, potential divider bias, voltage feedback bias; Bias stabilization; Stability factor; **Field Effect Transistor (FET):** Construction, operation & characteristics of JFET; Shockley's equation; Depletion& Enhancement type MOSFET; Biasing of JFET:-fixed bias, self bias and voltage divider bias; Biasing of depletion type & enhancement type MOSFET. **Digital Electronics:** Number systems; Binary Addition & Subtraction;1's and 2's complement , Subtraction using 2's complement; Boolean algebra; Logic gates; Implementation of basic gates using universal gates; Realization of Boolean functions using basic & universal gates; Canonical forms(SOP & POS); Simplification of Boolean functions using Boolean postulates & K-map up to 4 variables with don't care condition. **Operational Amplifier (Op-Amp):** Operational amplifier: Block diagram, ideal and practical Op-Amp characteristics; Inverting, non-inverting and differential configurations (open loop and closed loop); Applications of Op-Amp as buffer, adder, subtractor, integrator and differentiator.	21

Text Book:

- Robert L. Boylestad and Louis sashelsky, "*Electronic devices and circuit theory*", Pearson Education/PHI, New Delhi.

Reference Books:

- Morris Mano, "*Digital design*", Pearson Education.
- R.A. Gayakwad, "*Op-amps & linear Integrated circuits*", PHI.
- R.J. Smith and R.C. Dorf, Circuits, "*Devices and System,*" Willey, 5th edition.

Course Outcomes: After successfully completing the course students will be able to:

CO1: Understand the basics of semiconductors, PN junction diodes, transistors, operational amplifiers with its characteristics.

CO2: Understand different types of Number systems, theorems, postulates of Boolean algebra and logic gates. Apply theorems of Boolean algebra for minimization of Boolean expression. Apply basics of logic gates to draw logic circuits for any Boolean function.

CO3: Apply the basics of diode as rectifiers, clippers, clampers and voltage regulator circuits.

CO4: Analyze DC biasing circuits of BJT, FET and MOSFET's.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2
CO3	PO1,PO2, PO3 /PSO2, PSO3
CO4	PO1,PO2, PO3 /PSO2, PSO3

BECG 0003: SEMICONDUCTOR PHYSICS

Credits: 04 **Semester I** **L–T–P: 3–1–0**

Module No.	Contents	Teaching Hours (Approx.)
1	**Semiconductors: Energy Band and Charge Carriers:** Energy bands in semiconductors, Types of semiconductors, Charge carriers, Intrinsic and extrinsic materials. Carrier concentration: Fermi Level, Electron and hole concentration equilibrium, Temperature dependence of carrier concentration, Compensation and charge neutrality. Conductivity and mobility, Effect of temperature, Doping and high electric field. **Optical Excitation in Semiconductor:** Optical absorption, carrier generation, Carrier life time, diffusion length and photo conductivity, Direct and indirect recombination and trapping, Photoconductive devices. Diffusion of carriers, Einstein relation, Continuity equation, Carrier injection, Diffusion length. Haynes-Shockley experiment.	20
2	**Junctions:** p-n junction and contact potential, Fermi levels, Space charge, Reverse and Forward bias, Zener and Avalanche breakdown. Capacitance of p-n junction, Schottky barriers; Schottky barrier height, C-V characteristics, current flow across Schottky barrier: thermionic emission, Rectifying contact and Ohmic contact. **Bipolar Junction Transistors (BJT):** Minority carrier distribution, Solution of diffusion equation in base region, Terminal current, Current transfer ratio, Ebers-Moll equations, Charge control analysis. **MOSFET:** Operation, MOS capacitor, Debye screening length, Effect of real surfaces; Work function difference, Interface charge, Threshold voltage and its control Photonics: LED: Radiative transition, Emission spectra, Luminous efficiency and LED materials, Solar cell and photodetectors: Ideal conversion efficiency, Fill factor, Equivalent circuit, Voc, Isc and Load resistance, Spectral response. Reverse saturation current in photodetector.	20

Recommended Books

1. Streetman, B. and Banerjee, S., Solid State Electronics, Prentice Hall India, (2006).

2. Sze, S.M., Physics of Semiconductor Devices, John Wiley, (1981).

3. Tyagi, M.S., Introduction to semiconductor materials and devices, John Wiley, (2000).

4. Pierret, R.F., Semiconductor Device Fundamentals, Pearson Education Inc., (2006).

5.

BECG 0803 : SEMICONDUCTOR PHYSICS LAB

Credits: 01 **Semester I** **L–T–P: 0–0–2**

Module No.	Contents	Teaching Hours (Approx.)
1	1. Study of Hall Effect 2. Energy Gap of A Material of P-N Junction 3. Parameter extraction from I-V characteristics of a PN junction diode 4. Parameter extraction from I-V characteristics of a zener diode 5. Study of diode rectification 6. V-I Characteristics of Light Emitting Diodes 7. Study of a photodiode 8. Study The Characteristics of P-I-N and Avalanche Photodiode Detectors.	20

Recommended Books

1. Streetman, B. and Banerjee, S., Solid State Electronics, Prentice Hall India, (2006).

2. Sze, S.M., Physics of Semiconductor Devices, John Wiley, (1981).

3. Tyagi, M.S., Introduction to semiconductor materials and devices, John Wiley, (2000).

4. Pierret, R.F., Semiconductor Device Fundamentals, Pearson Education Inc., (2006).

5.

BECG 1801 : ELECTRONICS SIMUALTION LAB

Objectives:

- *To become familiar with PSPICE & Xilinx software.*
- *To simulate the basic circuits on PSPICE.*

Credits: 01 **L–T–P-J: 0–0-2-0**

Module No.	Content	Teaching Hours
I	**Software Requirement: PSPICE & Xilinx** **List of Experiments:-** 1. To determine the V-I characteristics of characteristics of PN junction and Zener diode. 2. Half wave rectifier. 3. Full wave rectifier with 2 diodes. 4. Full wave rectifier with 4 diodes (Bridge rectifier). 5. Clipper and Clamper circuits 6. To study the response of RC, RL and RLC circuits 7. Input, Output and Transfer characteristics of CE Amplifier 8. Transfer characteristics of MOSFET (with depletion and enhancement mode) 9. Characteristics of LDR, Photo-diode and Photo transistor. 10. Synthesis and simulation of basic logic gates such as OR, AND, NOT, NAND, NOR. 11. Synthesis and simulation of Full Adder. 12. Synthesis and Simulation of Full Subtractor.	10

Note :At least 10 experiments from Module must be completed for successful credit evaluation.

Outcomes: *After completion of Lab, student will be able to:*

1. *Draw the basic circuit and perform the analysis of simulated results.*
2. *Write a code in PSPICE environment.*

BECS 0001: SEMICONDUCTOR MATERIALS AND CHARACTERIZATION

OBJECTIVES:

1. The students become aware of latest Fabrication Technologies and their relation with material structuring and properties.
2. The common used analytical tools for characterizing modern materials at highest sensitivity
3. To understand stereographic projections and their use in characterization of crystalline materials

Credits: 03 **Semester II** **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours (Approx.)
1	**Introduction and structure of materials:** atomic structures and bonding, types of bonding, band formation. Defects and imperfections in solids: Point, Line and Planer defects; Interfacial defects and volume defects. Special classification of Semiconductor Materials- degenerate (semi-metal) and non-degenerate semiconductor; elemental and compound semiconductor; direct and indirect band gap material **Special Electronic Materials:** Nano materials (ZnO, TiO2, buckeyball carbon and graphene), semiconducting polymers, meta materials. **Optoelectronic materials.** Introduction, properties, factor affecting optical properties, role of optoelectronic materials in solar cell. Solar cell parameters. Electrochemical Approaches: anodic oxidation of alumina films, porous silicon, and pulsed electrochemical deposition,Vapor deposition	20
2	Epitaxial growth techniques, pulsed laser deposition, Magnetron sputtering - Micro lithography (photolithography, soft lithography, micromachining, e-beam writing, and scanning probe patterning). Principle, Theory, Working and Application; X-Ray Diffraction, , Scanning Electron Microscopy, Transmission Electron Microscopy, High Resolution Transmission Electron Microscopy, Field Emission Scanning Electron Microscopy, Atomic Force Microscopy, Scanning Tunnelling Spectroscopy / Microscopy, Photoluminescence Spectroscopy.	20

Text/ References books:

1. W. D. Callister, "Materials Science and Engineering: An Introduction", John Wiley & Sons, 2007.
2. K. Barriham, D.D. Vvedensky, Low dimensional semiconductor structures: fundamental and device applications, Cambridge University Press, 2001.
3. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications , Imperial College Press, 2004.
4. J. George, Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005.
5. B. D. Cullity, “Elements of X-ray Diffraction”, 4th Edition, Addison Wiley, 1978.
6. M. H. Loretto, “Electron Beam Analysis of Materials”, Chapman and Hall, 1984.

7. S.O. Kasap Principles of Electronic Materials and Devices, 3rd edition, McGraw-Hill Education (India) Pvt. Ltd., 2007.

Course Outcomes:

1. Understand the basics of Microstructural aspects with the different processing of materials.
2. Understand the importance of structure-property correlation study of materials and its suitable applications.
3. Compare single crystal and polycrystalline growth
4. Select the characterization tool for specific application
5. Compare the principle and operation of different characterization tools such as optical microscope, Scanning electron microscopes and transmission electron microscope

BECS 0800: MATERIAL SIMULATION LAB

Objectives:

- This laboratory gives practical exposure characterization techniques and teaches to interpret results with knowledge gained from the theory subject on characterization of materials.

CREDITS: 01 **SEMESTER: II** **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
I	**Software Requirement: Atomic Simulation Environment (**ASE) **List of Experiments:-** 13. Model the 0D (molecules) and 3D(bulk) crystal structures to explore the capabi ASE. 14. Model the 1D (nanotube) structure and 2D (nanoribbon) structure using ASE. 15. Model the pristine and defects surfaces of the system using ASE. 16. Find the equilibrium volume, energy, and bulk modulus for cubic Ag usi potential. 17. To plot the V-I Characteristics of the solar cell in dark and light and determine circuit voltage, short circuit current, fill factor and efficiency 18. Perform Defect analysis in third generation solar cell 19. Study of material thickness variation and their effect on solar cell parameters 20. Perform Effect of doping on solar cell parameters on second and third genera cell. **Note:** Demonstration of equipments may be done by visit to Research and development centres or educational institutes.	10

Note :At least 08 experiments must be completed for successful credit evaluation.

Outcomes: *After completion of Lab, student will be able to:*

3. Ability to characteristic the material using advanced characterization tools.

BECG0800: ELECTRONICS LAB - I

Objective:

- Evaluate the performance of PN junction diode, npn BJT and N-channel EMOSFET.
- Analyze the operations of Rectifiers, clampers and clipper circuits.
- Verify the truth tables of basic gates (NOT, OR, AND) and universal gates (NAND, NOR)

Credits: 01 **L–T–P-J: 0–0-2-0**

Module	List of Experiments:	Lab Hours
I	1. Identification of various electronics, electrical components and study of measuring instruments and sources used in electronic circuits. (i) Multi-meters (ii) CRO (iii)Function Generator(iv)DC Supply 2. To determine the V-I characteristics of a semi-conductor diode. 3. To study the working of a Half-Wave & Full Wave (Bridge type) rectifier. 4. To study application of diode as clipper circuit and clamper circuit. 5. To study Zener diode as voltage regulator 6. To study V-I characteristic of CE configuration of BJT. 7. To study V-I characteristic of MOSFET. 8. To verify characteristics of op-Amp and realization of Op-Amp as adder &subtract or. 9. To study various logic gates such as OR, AND, NOT, NAND, NOR. 10. Realization of half adder &subtract or using logic gates. 11. Prove the universality of NAND & NOR gate. **Value Addition for B.Tech ECE Branch:** As a value addition, above experiments should be co-simulated with a suitable simulation software**.(PSPICE/XILINX)**	24

Course outcomes: After completion of this course, student would be able to:

1. Evaluate the performance of PN junction diode, npn BJT and N-channel EMOSFET.
2. Analyze the operations of Rectifiers, clampers and clipper circuits.
3. Verify the truth tables of basic gates (NOT, OR, AND) and universal gates (NAND, NOR)
4. Implement IC-741 of Op-Amp to analyze its applications as adder and subtractor.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO2, PSO3
CO2	PO1,PO2, PO3 /PSO2, PSO3

BECG1002: DIGITAL ELECTRONICS

Credits: 03 **L–T–P-J: 3–0–0-0**

Course Objectives

- To learn the fundamental concepts of Digital logic design.
- To study methods of logic expression simplification.
- To understand procedure for the analysis of Combinational and Sequential logic circuit.
- To design of Combinational and Sequential logic circuit.

Module No.	Content	Teaching Hours
I	Logic Families, Diode, BJT & MOS as a switching element, concept of transfer characteristics, Input characteristics and output characteristics of logic gates, Fan-in, Fan-out, Noise margin, circuit concept and comparison of various logic families: TTL, CMOS Tri-state logic, open collector output, packing density, power consumption & gate delay. Digital system and binary numbers: Signed binary numbers, binary codes, Cyclic Codes, Error Detecting and Correcting Codes, Hamming Codes. Floating point representation. Gate-level minimization: Five variable K-Map, don't care conditions, POS simplification, NAND and NOR implementation, Quine Mc- Clusky method (Tabular method). Combinational Logic : Combinational circuits, analysis procedure, design procedure, Binary Adder-Subtractor	21
II	Combinational Logic : Decimal Adder, Binary Multiplier, Magnitude Comparator, Decoders, Encoders, Multiplexers Synchronous sequential logic: Sequential Circuits, Storage Elements : Latches, Flip Flops, Analysis of Clocked Sequential Circuits, State Reduction and Assignments, Design Procedure Registers and Counters: Shift Registers, Ripple Counter, Synchronous Counter, Other Counters. Memory and programmable logic : RAM, ROM, PLA, PAL, FPGA, PROM, EPROM, EEPROM Asynchronous Sequential Logic : Analysis procedure, circuit with latches, Design procedure, Reduction of state and flow table, Race free state assignment, hazards.	22

Text Book:

1. S. Salivahanan& S. Asivazhagan, "*Digital Circuit & Design*", IInd Edition.
2. M. Morris Mano and M. D. Ciletti, "*Digital Design*" 4th Edition, Pearson Education.

Reference Books:

1. John F Wakerly, Digital Design, Fourth Edition, Pearson/PHI,2006
2. John M Yarbrough, Digital Logic Applications and Design, Thomas Learning,2002
3. Charles H Roth, Fundamentals of Logic Design, Thomson Learning , 2003
4. Donald P Leach and Albert Paul Malvino, Digital Principals and Applications, 6th Edition, TMH,2003.
5. William H Gothmann, Digital Electronocs, 2nd Edition, PHI, 1982

Course Outcomes: After successfully completing the course students will be able to

1: Understand binary codes including 8421, 5421, excess-3, and Hamming code.
2: Understand floating-point representation, simplification of Boolean functions-SoP & PoS, and different logic families.
3: Construct combinational circuits including adder-subtractor, multiplier, comparator, encoder, multiplexer.
4: Construct sequential Circuits which include latches, Flip-Flops, Shift Registers, Ripple Counter, Synchronous Counters, Johnson counter, ring counter, and the analysis of Clocked Sequential Circuits.
5: Compare memory devices like RAM, ROM, PROM, EPROM, EEPROM, PLA, and PAL. Make use of PROM, PAL, and PLA to implement Boolean functions.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3, PO4 /PSO2, PSO3
CO4	PO1,PO2, PO3, PO4 /PSO2, PSO3

BECG0802: DIGITAL ELECTRONICS LAB

Objectives:

- Implement the basic of Combinational and sequential circuits and be able to use integrated circuit packages.
- Test a Combinational and sequential circuit using a computer software application.

Credits: 01 **L–T–P-J: 0–0-2-0**

Module No.	Content	Teaching Hours
I	1. Introduction to the lab and testing of logic gate IC's. 2. Realization of Half Adder and Half Subtractor using basic gate and repeat using Nand gate only. 3. Realization of full-adder & full subtractor using logic gates and using Boolean expression. 4. Realization of 4-bit even / odd parity checkers using Ex-OR gate. 5. Realization of 4-bit binary decoder/ demultiplexer. 6. Realization of decimal to BCD encoder using IC 74147. 7. Realization of 4-bit / 3-bit multiplexer. 8. Implementation of RS,JK, T and D flip-flop using logic gates. 9. Realization and implementation serial in parallel out and parallel in serial out shift register. 10. Realization and implementation of 2-bit up/down synchronous counter. 11. Realization and implementation 4-bit binary ripple counter using JK flip-flop. 12. Realization and implementation of Arithmetic logic unit. **Practical on P- SPICE Schematic Software** 13. Realization of full-adder & full subtractor using logic gates using P-SPICE Schematic Software. 14. Realization of 4-bit / 3-bit multiplexer using P- SPICE Schematic Software. 15. Implementation of RS,JK, T and D flip-flop using logic gates using P-SPICE Schematic Software	10

Course Outcomes

After successfully completing the course students will be able to

1. Implement the basic of Combinational and sequential circuits and be able to use integrated circuit packages.
2. Analyze a Combinational and sequential circuit using a computer software application.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO2, PSO3
CO2	PO1,PO2, PO3, PO4 /PSO2, PSO3

BECC0001: NETWORK ANALYSIS & SYNTHESIS

Course objective:

- To explain the basic concepts and laws of DC and AC electrical networks and solve them using mesh and nodal analysis techniques.
- To learn different network theorem and analyze the electric circuit using network theorem.
- To Introduce Two port network.
- To analyze circuits in time and frequency domain.
- Synthesize the network using passive elements.

Credits: 04 **L–T–P-J: 3–1–0-0**

Module No.	Content	Teaching Hours
I	**A1: Introduction to Network &circuit :** Review of nodal and mesh analysis, super node and super mesh analysis concept of dependent source (VDVS, VDCS.CDVS$CDCS) and its application **A2: Network Theorems (Applications to ac networks):** AC network theorem :(Super-position , Thevenin's, Norton's, Maximum power transfer , Millman's , Tellegen's & Miller Theorem) **A3: Graph Theory:** Graph of a Network, concept of tree, co-tree, link, basic loop and basic cut set, Incidence matrix, cut set matrix, Tie set matrix; Duality; Loop and Nodal methods of analysis. **A4: Two Port Networks:** Characterization of LTI two port networks: ZY, ABCD and h parameters, reciprocity and symmetry. Inter-relationships between the parameters, inter-connections of two port networks, Ladder and Lattice networks. T & Π Representation.	21
II	**B1: Transient Analysis:** RL, RC and RLC circuits – classical approach. **B2: Network Functions:** Concept of Complex frequency, Transform Impedances, Network functions of one port and two port networks, properties of driving point immittance and transfer functions. **B3: Network Synthesis:** Positive real function; definition, properties of LC, RC and RL driving point functions, synthesis of LC, RC and RL driving point immittance, functions using Foster and Cauer first and second forms.Concept of Active Synthesis **B4: Filters:** Image parameters and characteristics impedance, low pass, highpass, (constant K type) filters, and introduction to active filters.	21

Text Books:

"

- Charles K. Alexander and Matthew N.O. Sadiku,"5thEd.Fundamentals of Electric Circuits*Publisher*: McGraw Hill Education.
- D. Roy Choudhary, "*Networks and Systems*" 2nd Ed., New Age International (P) Ltd. Publishers.
- A.Chakrabarti, "*Network Analysis & Synthesis*", Dhanpat Rai & Co.

Reference Books:

- M.E. Van Valkenburg, "*An Introduction to Modern Network Synthesis*", Wiley Eastern Ltd.

- Sudhakar, "*Circuits & Networks: Analysis and Synthesis*", TMH Education Pvt. Ltd.
- K.S. Suresh Kumar, "*Electric Circuits and Networks*" Pearson Education.

COURSE OUTCOMES: Upon completion of this course students will able to:

CO1: Understand the nodal , mesh method , low pass , high pass passive and active filter linear circuit

CO2: Compute two-port network parameters including Z,Y ,h, ABCD for a passive linear network

CO3: Apply the network theorem including thevenin, Norton's, superposition, maximum power transfer, Tellegence, and Millmans for AC and DC linear circuit

CO4: analyze RL, RC, and RLC circuits in time and frequency domains.

CO5 Synthesize the passive network, low pass and high pass passive filter.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO4	PO1,PO2, PO3,PO4 /PSO2, PSO3
CO5	PO1,PO2, PO3,PO4 /PSO2, PSO3

BECC1002: ELECTROMAGNETIC FIELD THEORY

Credits: 04 **L–T–P-J: 3–1–0-0**

Module No.	Content	Teaching Hours
I	**Review of vector algebra** Scalar & vectors, Unit vectors, Vector addition & subtraction, Position vector, Vector Multiplications, Components of Vector. **Coordinate System & Transformation** Cartesian, cylindrical and Spherical coordinates & their transformation. **Vector Calculus** Line, Surface and Volume Integrals, Gradient of a scalar, Divergence of a Vector, Curl of a Vector, Divergence Theorem, Stokes's Theorem. **Electrostatics-I** Coulomb's law & field intensity, Electric fields due to continuous charge distributions. Electric flux density, Gauss's law, Electric potential. **Electrostatics-II** Electric Dipole, Energy density in electrostatic field, Polarization in dielectrics, Continuity equation and relaxation time, Electric Boundary conditions, Poisson's and Laplace's equation, Capacitance.	21
II	**Magneto statics** Biot-savart's law, Ampere's Circuit law, Magnetic flux density, vector magnetic potential, Maxwell's equations for static field, Forces due to magnetic field, Magnetic torque and moment, Magnetization in materials, Magnetic boundary conditions, Inductance, Magnetic energy. **Maxwell's Equations** Faraday's law, Displacement current, Maxwell's equations in point and integral forms. **E M Wave Propagation** Wave propagation in lossy dielectrics, Plane wave in lossless dielectrics, Plane wave in free space, Plane wave in good conductors, Power and the Poynting vector. **Transmission Lines** Transmission line parameters, Transmission line Equation, Lossless and low loss propagation, Wave reflection and VSWR, transmission line of finite length, Reflection Coefficient, Standing wave ratio, Introduction to Smith Chart, Impedance Matching.	21

Text Book:

- W.H. Hayt and J.A. Buck, "*Electromagnetic Field Theory*", 7th TMH.
- M.N.O. Sadiku , "*Elements of Electromagnetics*", 4th Ed, Oxford University Press

Reference Books:

- R.E. Collins, science"Foundations of Microwave Engineering", 2nd Ed., 2001, Wiley Interscience.

Course Outcomes:

1. Understand the concepts of electromagnetic field theory.
2. Apply the laws of electromagnetic fields to solve the charge and current distributions.
3. Examine the Laplace's and Poisson's equations.
4. Analyze the electromagnetics to solve the boundary value problems.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/ PSOs
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3,PO4 /PSO2, PSO3
CO4	PO1,PO2, PO3,PO4 /PSO2, PSO3

BECC0003: SOLID STATE DEVICES AND CIRCUITS

Credits: 04 **L–T–P-J: 3–1-0-0**

Course Objective:

- To understand the background of intrinsic and extrinsic materials.
- To familiarize the students with characteristics and applications of solid state devices like BJT, MOSFET etc. and study their parameters.
- Analysis of BJT and MOFET amplifiers with parasitic, coupling and bypass capacitors and understand the effect of capacitances in its frequency response.
- To understand and compare the concept of voltage, current, trans-conductance and trans-resistance amplifiers circuits.
- To build various classes of power amplifier circuits using solid state devices.

Module No.	Content	Teaching Hours
I	**EXCESS CARRIERS IN SEMICONDUCTORS.** Optical Absorption. Luminescence. Photoluminescence. Electroluminescence. Carrier Lifetime and Photoconductivity. Direct & Indirect Band gap Semiconductor, Direct & Indirect Recombination, Steady State Carrier Generation, Quasi-Fermi Levels. Photoconductive Devices. Diffusion & Drift of Carriers. The Continuity Equation. Steady State Carrier Injection. **JUNCTIONS.** Equilibrium Conditions. The Contact Potential. Equilibrium Fermi Levels. Space Charge at a Junction. Steady State Conditions. **Type of Junctions** Metal-Semiconductor Junctions. Schottky Barriers. Rectifying Contacts. Ohmic Contacts. Typical Schottky Barriers. Heterojunctions Review of transistors: all configurations of BJTs and FETs with their characteristics. h-parameters; Small signal analysis of Single stage CE BJT amplifier The BJT Internal Capacitance and High Frequency Model ,Frequency Response of the Common-Emitter Amplifier	21
II	Small signal analysis of single stage FET amplifier, Single stage MOS Amplifiers, The MOSFET Internal Capacitance and High Frequency Model **Feedback Amplifiers:** Classification of amplifiers, the feedback concept, The transfer gain with feedback, General characteristics of negative feedback amplifiers, input resistance, output resistance, Method of analysis of feedback amplifier, voltage series feedback, voltage shunt feedback, current series, current shunt feedback. Concept of positive feedback in oscillator. **Output stages and Power amplifiers**: Power amplifiers, Power Transistors, Class A, Class B, Class AB, Class C operation, Design Application. Introduction to Double gate MOSFET(DGMOSFET),FINFET, Spin Transistor.	21

Text Book:

- Ben.G.Streetman&Sanjay Banerjee "*Solid State Electronic Devices*"5th Edition PHI Private Ltd, 2003.
- Sedra S., Smith K., "*Micro-electronics*", 5th edition, OXFORD.

Reference Books:

- Thomas L. Floyd "Electronic Devices" 7th Edition Pearson Education International, 2005
- Jacob Millman, Christos Halkias, SatyabrataJit, "*Electronic Devices and Circuits*", TMH.

Outcomes: After successful completion of this course, student would be able to:

1. Understand the semiconductor physics of the intrinsic and extrinsic materials; junctions types; Double gate MOSFET, FINFET, Spin Transistor.
2. Describe characteristics of BJT and MOSFET in different configurations and power amplifiers.
3. Analyze the various feedback topologies of a circuit and small signal model of MOSFET.
4. Design a BJT and MOSFET amplifier for the given specifications.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1
CO2	PO1,PO2, PO3, PO4 /PSO1
CO3	PO1,PO2, PO3,PO4 /PSO2, PSO3
CO4	PO1,PO2, PO3,PO4 /PSO2, PSO3

BECC0004: SIGNALS AND SYSTEMS

Objective: This course enables the students

- To understand the type and representation of continuous-time and discrete-time signals and systems and sampling theorem.
- To apply convolution integral and convolution sum on the given signals.
- To understand the Fourier series representation of the periodic continuous-time signals
- To analyze the frequency domain response by the means of discrete-time Fourier transform, continuous-time Fourier transform, Laplace transform, and Z-transform.

Prerequisites: Basic knowledge of integration, differentiation, and complex numbers.

Credits: 04 **L–T–P-J: 3–1–0-0**

Module No.	Content	Teaching Hours
I	**Signals:** Definition, types of signals and their representations, commonly used signals (in continuous-time as well as in discrete-time), operations on continuous-time and discrete-time signals (including transformations of independent variables). Systems: Classification, linearity, time-invariance and causality, impulse response, characterization of linear time-invariant (LTI) systems, unit sample response, convolution summation, step response of discrete time systems, stability. convolution integral, co-relations, signal energy and energy spectral density, signal power and power spectral density, properties of power spectral density. **Fourier series** Trigonometric & Exponential Fourier Series Analysis, Sampling Theorem, Nyquist criteria for sampling theorem	13
II	Fourier Transforms (FT): (i) Definition, conditions of existence of FT, properties, magnitude and phase spectra, Some important FT theorems, Parseval's theorem, Inverse FT, relation between LT and FT (ii) Discrete time Fourier transform (DTFT), inverse DTFT, convergence, properties and theorems, Comparison between continuous time FT and DTFT. Laplace-Transform (LT) and Z-transform (ZT): (i) One-sided LT of some common signals, important theorems and properties of LT, inverse LT, solutions of differential equations using LT, Bilateral LT, Regions of convergence (ROC) (ii) One sided and Bilateral Z-transforms, ZT of some common signals, ROC, Properties and theorems, solution of difference equations using one-sided ZT, s- to z-plane mapping Application of Signals and Systems in MATLAB.	13

Text Book:

- P. Ramakrishna Rao, "*Signal and Systems"* 2008 Edn., Tata MGH, New Delhi

Reference Books:

- Chi-Tsong Chen, "*Signals and Systems*", 3rd Edition, Oxford University Press, 2004
- V.Oppenheim, A.S. Willsky and S. Hamid Nawab, "*Signals & System*", PEARSON Education, Second Edition, 2003.

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

CO1: Understand sampling, properties of continuous-time and discrete-time signals and systems.
CO2: Compute Fourier series, Fourier transform, Laplace transform, and Z-transform on a given signal.
CO3: Apply continuous-time and discrete-time convolution on the given signals.
CO4: Analyze continuous-time and discrete-time systems in terms of frequency response, magnitude, and phase response.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO3
CO2	PO1,PO2, PO3 /PSO1, PSO3
CO3	PO1,PO2, PO3 /PSO2, PSO3
CO4	PO1,PO2, PO3 /PSO2, PSO3

BECC0005: MICROPROCESSORS AND APPLICATIONS

Credits: 03 **L–T–P-J: 3–0–0-0**

COURSE OBJECTIVES:

1 To impart basic understanding of the internal organization of 8085,8086 and advanced RISC Microprocessor

2 To introduce the concepts of interfacing microprocessors with external devices.

3 To develop Assembly language programming skills.

Module No.	Content	Teaching Hours
I	**Microprocessor and Microprocessor Development Systems:** Evolution of Microprocessor, Microprocessor architecture and its operations, memory, inputs-outputs (I/Os), data transfer schemes interfacing devices, architecture advancements of microprocessors, typical microprocessor development system. **8-bit Microprocessors** **8085 microprocessor:** pin configuration, internal architecture. Timing & Signals: control and status, interrupt: ALU, machine cycles, Instruction Set of 8085, Addressing Modes, Instruction format, op-codes, mnemonics, no. of bytes, RTL, variants, no. of machine cycles and T states **Instruction Classification:** Data transfer, arithmetic operations, logical operations, branching operation, machine control; Writing assembly Language programs, Assembler directives. **8086 Microprocessor:** Pin configuration, internal architecture. Timing & Signals, Addressing Modes.	20
II	**Peripheral Interfacing:** 8255- Programmable peripheral interface, 8253/8254 Programmable timer/counter. 8259 programmable Interrupt Controller **ARM Introduction and Pipeline structures** ARM7 Introduction, Von Neumann and Harvard Architecture, CISC v/s RISC, ARM& Data Flow Model, Core Architecture, Flag Register, Programmers model, Pipelining, Operating Modes, Addressing Modes **ARM assembly instructions and modes** Data processing instructions. Shift Operations, shift Operations using RS lower byte, Immediate value encoding, Swap Instructions, Swap Register related Instructions, Loading Constants. Program Control Flow, Control Flow Instructions	20

Text Books:

- Gaonkar, Ramesh S, "*Microprocessor Architecture, programming and applications with the 8085*" Pen ram International Publishing 5th Ed.
- Ray, A.K. &Burchandi, K.M., "*Advanced Microprocessors and Peripherals: Architecture, Programaming and Interfacing*" Tata Mc. Graw Hill.
- ARM System-on-Chip Architecture,Second Edition, by Steve Furber,PEARSON, 2013
- ARM System Developers Guide, Designing and Optimizing System Software, by Andrew N.SLOSS, Dominic SYMES and Chris WRIGHT,ELSEVIER, 3004

Reference Books:

- Uffenbeck, John, "*Microcomputers and Microprocessors*" PHI/ 3rd Edition 5. Brey, Barry B. "*INTEL Microprocessors*" Prentice Hall (India).
- M. Rafiquzzaman, "*Microprocessors- Theory and applications*" PHI.
- Ram, "*Advanced Microprocessor & Interfacing*" Tata McGraw Hill.
- Renu Singh &B.P. Singh, "*Microprocessor and Interfacing and applications*" New Age International.
- Hall D.V., "*Microprocessors Interfacing*" Tata McGraw Hill.
- Liu and Gibson G.A., "*Microcomputer Systems: The 8086/8088 Family*" Prentice Hall (India).

Course Outcomes: After successfully completing the course students will be able to:

CO1: Understand the architectures, Memory interfacing, interrupts for 8085 and 8086 Microprocessors. & Demonstrate assembly language programming using instruction sets of 8085 and 8086 microprocessors.

CO2: Understanding ARM architecture and demonstrate assembly language programming.

CO3: Apply the interfacing of various peripherals such as LEDs, 7-segment display, keyboard display controller, and ADC's & DAC's with 8085 microprocessors.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3,PO4 /PSO2, PSO3

BECC0800: MICROPROCESSOR LAB

Credits: 01 **L–T–P-J: 0–0–2-0**

Course Objectives:

- Introduce Assembly Language Programming (ALP) concepts and features
- Write ALP for arithmetic and logical operations in 8085 and 8086
- Differentiate Serial and Parallel Interface
- Interface different I/Os with 8085 Microprocessor

Module No.	Content	Teaching Hours
I	**List of Experiments using 8085/8086:** **1.** To Study of 8085 Microprocessor Kit. **2.** ToStudy of 8086 Microprocessor Kit. **3.** Write a program to add two 8-bit numbers. **4.** Write a program to add two 16-bit numbers. **5.** Write a program to subtract two 8-bit number. **6.** Write a program to subtract two 16-bit number. **7.** Write a program to multiply two 8 bit numbers by repetitive addition method. **8.** Write a program to divide two 8 bit numbers. **9.** To develop and run a program for finding out the largest from a given set of numbers. **10.** To develop and run a program for finding out the smallest from a given set of numbers. **11.** To develop and run a program for arranging in ascending/descending order of a set of numbers. **12.** To perform computation of square of a given number **13.** Write a program to transfer the block of data from one memory location to other memory location. . **14.** Interfacing with 8255 in I/O mode/BSR mode to 8085/8086 based system. **15.** Interfacing with 8253 to 8085/8086 based system. **Value addition Experiments** **16**. To write an assembly language program to convert an analog signal into a digital signal and a digital signal into an analog signal using an **17**.ADC interfacing and DAC interfacing respectively. To write an assembly language program to simulate the traffic light at an intersection using a traffic light interface.	24

Course Outcomes: After successfully completing the course students will be able to:

1. Implement the assembly language program for arithmetic and logical operation on microprocessor kit.
2. Demonstrate the interfacing among the peripherals of 8085 and 8086.
3. Interface LED, ADC and DAC modules with microprocessor based system.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2, PSO3
CO3	PO1,PO2, PO3 /PSO2, PSO3

BECC1006: ANALOG INTEGRATED CIRCUITS

Credits: 03 **L–T–P-J: 3–0–0-0**

Objectives:

- Understand the internal circuit of op-amp and design linear and non-linear circuits.
- Design of simple current mirror, Wilson and improved Wilson current mirrors, Widlar current and cascade current mirror circuits.
- Design filters (first and second order LP, HP, BP and all pass active filters, state variable filter, switched capacitor filters circuits) using op-amp.

Module No.	Content	Teaching Hours
I	**Differential amplifier**: differential amplifier as a building block for operational amplifier; differential amplifier configuration, AC-DC Characteristics, **Circuit Mirror Circuits:** Current Mirrors using BJT and MOSFETs, Simple current Mirror, Base Current compensated current Mirror, Wilson and Improved Wilson Current Mirrors, Widlar Current source and Cascade current Mirror. **Operational Amplifier :**Basic Information of Op-Amp, The ideal Operational Amplifier, Operational Amplifier Internal Circuit, DC and AC Characteristics **Linear Applications of Op-Amp:** V to I and I to V converter, Differentiator, Integrator, Instrumentation Amplifier. **Active Filters :** First and Second order LP, HP, BP, BS and All pass active Filters, State Variable Filter, Switched Capacitor Filters. **Non-Linear Applications:** Op-Amp Circuits using diodes, Sample and Hold Circuit, Log and Antilog Amplifier, Multiplier and Divider.	21
II	**Comparators and Waveform Generators:** Regenerative Comparator (Schmitt Trigger), Square Wave Generator (Astable Multi vibrator), Mono stable Multi vibrator, Triangular Wave Generator, Basic Principle of Sine Wave Oscillators. **Voltage Regulator:** Series Op-Amp Regulator, IC Voltage Regulators, 723 General Purpose Regulators, Switching Regulator. **555 Timer :** Description of Functional Diagram, Mono stable Operation, Astable Operation, Schmitt Trigger **Phase-Locked Loop** : Basic Principles, Phase Detector/Comparator, Voltage Controlled Oscillator (VCO), Low Pass Filter, Monolithic Phase-Locked Loop, PLL Applications **D-A and A-D Converters :**Basic DAC Techniques, Weighted Resistors & R-2R D-A Converter, A-D Converters, DAC/ADC Specifications **Introduction to OTA**	21

Text Book:

Text Books:

1. A.S. Sedra and K.C. Smith "*Microelectronics Circuits*"4th Edition, Oxford University Press (India).
2. Roy Choudhury, Shail B. Jain "*Linear Integrated Circuits*", 4th Edition, New Age International Publishers

Reference Books:

- Ramakant A. Gayakwad, "*Op-Amps & Linear Integrated Circuits*", 3rdEdition, PHI.
- Sedra and Smith, "*Microelectronics Circuits*" 4th Edition, Oxford University Press.
- Michal Jacob, "*Applications and Design with Analog Integrated Circuits"*, 2nd Edition, PHI 2006
- Jacob Milliman and Arvin Grabel, "*Microelectronics*", 2nd Edition, TMH, 2008.
- Robert L. Boylestad and Louis nashel sky, "*Electronic devices and circuit theory*", Pearson Education/PHI,

Course Outcomes: After successfully completing the course students will be able to:

CO 1:-Understand the internal circuit of op-amp and design linear and non-linear circuits.

CO 2:-Design of simple current mirror, Wilson and improved Wilson current mirrors, Widlar current and cascade current mirror circuits.

CO 3:-Design filters (first and second order LP, HP, BP and all pass active filters, state variable

filter, switched capacitor filters circuits) using op-amp.

CO 4:- Analyze the concept of oscillators and waveform generators (Schmitt trigger, triangular wave generator, sine wave generators).

CO 5:-Employ IC 555 timer to design stable and mono-stable multi-vibrator.

CO 6:-Understand the working of standard PLL configuration to analyze the locking and capturing frequency range.

CO 7:-Analyze the different types of A/D and D/A converters for signal processing applications.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3,PO4 /PSO2, PSO3
CO4	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO5	PO1,PO2, PO3,PO4 /PSO2, PSO3
CO6	PO1,PO2, PO3,PO4 /PSO2, PSO3
CO7	PO1,PO2, PO3,PO4 /PSO2, PSO3

BECC0801: ELECTRONICS LAB – II

Credits: 01 **L–T–P-J: 0–0-2-0**

Course Objectives: The main aim of this lab is to teach the linear and non-linear applications of operational amplifiers (741). Students are made familiar with theory and applications of 555 timers. Students are made to Design analog circuits using ICs.

Module No.	Content	Teaching Hours
I	**List of Experiments** 1. Realization of JFET as amplifier and determine various parameters. 2. Realization of tuned amplifier and its application in Hartley and Collpit oscillator. 3. Realization of Wien Bridge oscillator and crystal oscillator. 4. A. Realization of MOSFET as a switch. B. Transient analysis of CMOSinverter using step and pulse input using P-SPICE Schematic Software. 5. A. Realization of BJT as a buffer amplifier. B. Plot the voltage transfer characteristics of BJT inverter and perform transient analysis with step and pulse input using P-SPICE Schematic Software. 6. A. Realization of multistage amplifier using BJT and calculation of current gain B. Draw the input and output characteristic of BJT transistor in common-emitter configuration using P-SPICE Schematic Software. 7. Realization of comparator and zero crossing detector-using op- Amp. 8. A. Realization of second order active low pass and high pass filter. B. Design and simulation of 2nd order Active Low Pass and High Pass Filter. 9. Realization of Astable and Mono stable multi vibrator using IC 555. 10. Realization of voltage controlled oscillator using IC 8038/2206 & 723. 11. Realization of V to I and I to V convertor. 12. To study PLL and analyze the locking and capturing frequency range	24

Course Outcomes: After successfully completing the course students will be able to:

CO 1 Implement the amplifying characteristics of BJT and JFET as well as transient analysis of CMOS and MOSFET as a switch and the different types of oscillators and multi vibrators circuits, comparator, V to I and I to V convertors, 2nd order filters using op-amp..

CO 2 Simulate analog circuits on p-spice environment.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/ PSOs
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2, PSO3

BECC1007: CONTROL SYSTEMS

Credits: 04 **L–T–P-J: 3–1–0-0**

Control System

Course Objectives:

- To learn the fundamental concepts of Control systems and mathematical modeling of the system
- To study the concept of time response and frequency response of the system
- To learn the basics of stability analysis of the system
- To study state space representation of the system.

Module No.	Content	Teaching Hours
I	**Introduction to control system:** Industrial control examples, Transfer function models of mechanical, Various electrical systems: Synchros, DC and AC servomotors, tacho-generators, potentiometers. **Open and closed-loop systems**: Block diagram representation and reduction, Signal flow graph analysis. **State-space model:** State variable, State models for LTI systems, Diagonalization. **Time domain analysis:** Time responses of first and second order LTI systems, Test signals, Time-domain specifications and performance indices.	21
II	**Stability analysis:** Stability concept, Relative stability, Hurwitz and Routh stability criterion, Root locus technique. **PID controller:** Design, tuning and applications **Frequency domain analysis:** Correlation between time & frequency responses, Performance specifications in frequency-domain. Polar plot, Bode plot, Stability in frequency domain, Nyquist plot and stability criterion, Lead and Lag compensators, Frequency-domain design methods.	21

Text book:

1. J. Nagrath& M. Gopal, "Control System Engineering", New Age International Publishers

References books:

2. B.C. Kuo&FaridGolnaraghi, "Automatic Control Systems", 8th Edition, John Wiley India.
3. William A. Wolovich, "Automatic Control Systems", Oxford University Press.
4. Joseph J. Distefano III, Allen R. Stubberud, Ivan J. Williams, "Control Systems" Schaums Outlines Series, 3rdEdition, Tata McGraw Hill, Special Indian Edition .

Course Outcomes:

After successfully completing the course students will be able to:

1. Understand the basic steps of mathematical model of a mechanical, electrical system and their analogy and block-diagram reduction technique and SFG to obtain transfer function of system.
2. Compute the time response and frequency response specifications of 1st and 2nd order systems.
3. Analyze the stability of the system using RH criterion, Nyquist criterion, root locus and Bode plots.
4. Design the P, D, I, PD, PI and PID controllers and Lag, Lead and Lead-Lag compensators.

BECC0802: CONTROL SYSTEM LAB

Credits: 01 **L–T–P-J: 0–0–2-0**

Objective:

- To perform the experiment related to the different controlling component.
- To analyze transient and steady state response of the overall system.
- To simulate transient response of control system in Matlab environment

Module No.	Content	Teaching Hours
I	**List of Experiments** 1. DC SPEED CONTROL SYSTEM (a) To study D.C. speed control system on open loop and close loop. (b) To study of Transient performance, another time signal is added at the input of control Circuit. 2. DC MOTOR POSITION CONTROL (a) To study of potentiometer displacement constant on D.C. motor position control. (b) To study of D. C. position control through continuous command. (c) To study of D.C. position control through step command. (d) To study of D.C. position control through Dynamic response. 3. AC SERVOMOTOR (a) To study speed-torque characteristic of an AC Servomotor. 4. SYNCHRO TRANSMITTER / RECEIVER (a) To study of Synchro Transmitter in term of Position v/s Phase and voltage magnitude with respect to Rotor Voltage Magnitude/Phase. (b) To study of remote position indication system using Synchro-transmitter/receiver. 5. PID CONTROLLER (a) To observe open loop performance of building block and calibration of PID Controls. (b) To study P, PI and PID controller with type 0 system with delay. (c) To study P, PI and PID controller with type 1 system. 6. LEAD LAG COMPENSATOR (a) To study the open loop response on compensator. (b) Close loop transient response. 7. LINEAR SYSTEM SIMULATOR (a) Open loop response (i) Time constant, (iii) Integrator (b) Close loop system (I) First order system (II) Second order system 8. Introduction to MATLAB (Control System Toolbox), Implement at least two experiments in MATLAB. (a) Determine transpose, inverse values of given matrix. (b) Plot the pole-zero configuration in s-plane for the given transfer function. (c) Determine the transfer function for given closed loop system in block diagram representation. (d) Plot unit step response of given transfer function and find peak overshoot, peak time. (e) Plot unit step response and to find rise time and delay time. (f) Plot locus of given transfer function, locate closed loop poles for different values of k.	24

	(g) Plot root locus of given transfer function and to find out S, Wd, WN at given root & to discuss stability. (h) Plot bode plot of given transfer function. (i) Plot bode plot of given transfer function and find gain and phase margins. (j) Plot Nyquist plot for given transfer function and to compare their relative stability. (k) Plot the Nyquist plot for given transfer function and to discuss closed loop stability, gain and phase margin.	

Outcomes: After successful completion of this course, student are able to

CO 1: Implement the input/output relation of different control element as potentiometer, dc motor, synchro and servo motor and their transient behavior.

CO 2: Simulate control algorithms Root Locus, Bode plots, Nyquist plots, Lead, Lag and Lead-Lag compensator, PID controllers on MTLAB environment.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2 /PSO1
CO2	PO1,PO2 /PSO2, PSO3

BECC0008: COMMUNICATION ENGINEERING

Credits: 04 L–T–P-J: 3–1–0-0

Course Objectives:

- To understand the elements of electronic communication system and the need for modulation, their application and specification.
- To understand the process of amplitude and angle modulation and demodulation; calculate its modulation index, power & bandwidth; sampling and quantization; and compare the continuous, pulse and digital modulation schemes.
- To comparison between the variants of AM and Pulse modulation techniques; including DSB-SC, SSB-SC and VSB Modulation, PAM, PWM, PPM and PCM
- To design the modulator and demodulator for amplitude modulator including balance, ring, square law, phase shift and filtering method; frequency modulator including direct and indirect method; amplitude demodulation including coherent and non-coherent method; angle demodulation including frequency and phase discriminator
- To classify the sources of noise and evaluate the performance of demodulators in presence of AWGN.

Module No.	Content	Teaching Hours
I	**Amplitude – Modulation** Frequency translation, amplitude modulation, double side band – suppressed carrier (DSB-SC) modulation, double side band with carrier (DSB-C), single-sideband modulation (SSB), vestigial-sideband modulation. **Angle -Modulation** Angle modulation, phase and frequency modulation; tone modulated FM signal, arbitrary modulated FM signal, FM modulators and demodulators, radio transmitter and receiver. **Noise in Communication Systems** Sources of noise, frequency-domain representation of noise, superposition of noises, linear filtering of noise, quadrature components of noise, representation of noise using orthonormal coordinates	21
II	**Noise Analysis of Communications system** single-sideband suppressed carrier, double-sideband suppressed carrier, double sideband with carrier, FM receiving system, calculation of signal to noise ratio, comparison of FM and AM, reemphasis and de-emphasis, noise in phase modulation, threshold in frequency modulation. **Pulse Modulation and Digital Transmission of Analog Signal** Analog to digital: noisy channel and role of repeater, pulse amplitude modulation and concept of time division multiplexing, pulse width modulation and pulse position modulation, digital representation of analog signal, differential pulse code modulation and delta modulation, noise in PCM transmission, noise in delta modulation transmission.	22

Textbook:

Herbert Taub, Donald L Schilling, GoutamSaha "*Principles of Communication Systems*" Third. Edition.TMH

Reference Books:

- B.P.Lathi and Zhi Ding "*Modern Digital and Analog Communication Systems*" fourth edition, Oxford University Press.
- S. Haykins "*Communication Systems*" 5th ed. John wiley.

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

1. Understand the elements of electronic communication system and the need for modulation, their application and specification, the process of amplitude and angle modulation, sampling, quantization and pulse modulation.
2. Classify the DSB-SC, SSB-SC and VSB Modulation Techniques, Narrowband FM and Wideband FM, sources of noise.
3. Analyze the performance of demodulators in presence of AWGN.
4. Design the modulator and demodulator circuits for continuous wave and pulse modulation.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3,PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3,PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3,PO4 /PSO2, PSO3
CO4	PO1,PO2, PO3,PO4 /PSO2, PSO3

BECC0803: COMMUNICATIONENGINEERING LAB

Credits: 01 **L–T–P-J: 0–0–2-0**

- Implement the Amplitude modulation and demodulation techniques including AM, DSB-SC, SSB-SC
- Implement the Frequency demodulation and demodulation techniques including Direct and

Module No.	Content	Teaching Hours
I	**List of Experiments** • Realization of amplitude modulation using transistors and determine its modulation Index. • Realization of envelope detector for demodulation of AM wave and observe diagonal peak clipping effect. • Realization of frequency modulation & demodulation. Find its modulation index. • Realization of DSB-SC modulation and demodulation. • Realization of SSB modulation and demodulation. • Realization of pulse amplitude modulation and demodulation. • Realization of pulse width modulation and demodulation. • Measurement of characteristic impedance of transmission line. • Plot the radiation pattern of Yagi-Uda antenna and find its beam width. • Measurement of selectivity, sensitivity and fidelity of super heterodyne receiver.	24

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

1. Implement the Amplitude modulation and demodulation techniques including AM, DSB-SC, SSB-SC, Frequency demodulation and demodulation techniques including Direct and Indirect generation method; Frequency discriminator and phase discriminator.
2. Demonstrate signals for PAM and PWM and their detection.
3. Draw radiation pattern of Yagi Uda antenna and calculate beam width.

R Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/ PSOs
CO1	PO1,PO2, PO3,PO4 /PSO2, PSO3
CO2	PO1,PO2, PO3,PO4 /PSO2, PSO3
CO3	PO1,PO2, PO3,PO4 /PSO2, PSO3

BECC0009: DIGITAL COMMUNICATION

Credits: 04 **L–T–P-J: 3–1–0-0**

Course Objectives:

- To understand the different basic blocks of digital communication system.
- To design mathematical model of communication channels and digital signals.
- To analyze the signal flow in a digital communication system.
- To analyze the performance of digital communication in the presence of noise and interference.
- To understand the basic concept of information theory and different coding techniques

Module No.	Contents	Teaching Hours
I	**Introduction:** Digital communication system (description of different modules of the block diagram), Complex baseband representation of signals, Gram-Schmidt orthogonalization procedure, bi-orthogonal signals, simplex signal waveforms. Pulse shape design for channels with ISI: Nyquist pulse, Partial response signaling (duobinary and modified duobinary pulses). **Stochastic model of signal**: Power spectral density of random signal, Multiple random processes. Transmission through LTI system, Gaussian and white process, bandpass process. **Modulation:** Pulse amplitude modulation (binary and M-ary, QAM), Pulse position modulation (binary and M-ary), Carrier modulation (M-ary ASK, PSK, FSK, DPSK), Continuous phase modulation (QPSK and variants, MSK, GMSK).	21
II	**Receiver in additive white Gaussian noise channels:** Coherent and noncoherent demodulation: Matched filter, Correlator demodulator, square-law, and envelope detector, Bit-error-rate, symbol error rate for coherent and noncoherent schemes. **Information Theory and Coding:** Measure of information, Source encoding, Error free communication over a noisy channel, Channel capacity of discrete and continuous memory less channel **Error Correcting codes**: Hamming sphere, Hamming distance and Hamming bound, Relation between minimum distance and error detecting and correcting capability, Linear block codes, Encoding & syndrome decoding, Cyclic codes, Systematic cycle codes, convolution codes, code tree & Trellis diagram, Viterbi and sequential decoding, burst error correction, Turbo codes.	21

Text Books:

- B.P. Lathi&Zhi Ding, "*Modern Digital and Analog Communication System*", 4th editin, Oxford University Press, 2010.

Reference Books:

- J. G. Proakis and M. Salehi, "*Fundamentals of Communication Systems*", Pearson Education, 2005.
- S. Haykins, "*Communication Systems*", 5th ed., John wiley, 2008.

- M. K. Simon, S. M. Hinedi and W. C. Lindsey, "*Digital Communication Techniques*": Signaling and detection, Prentice Hall India, N. Delhi, 1995.

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

1. Understand the functions of basic blocks in digital communication and basic error correcting coding and decoding techniques.
2. Represent the digital signal in baseband, pass-band format and vector space.
3. Apply the digital modulation schemes ASK, PSK, FSK, QPSK.
4. Analyze the performance of digital communication in presence of AWG noise.
5. Design the optimum receivers for digital communication.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3,PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3,PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3,PO4 /PSO2, PSO3
CO4	PO1,PO2, PO3,PO4 /PSO2, PSO3
CO5	PO1,PO2, PO3,PO4 /PSO2, PSO3

BECC0804: DIGITAL COMMUNICATION LAB

Credits: 01 **L–T–P-J: 0–0–2-0**

1. Implement the basic modulation and demodulation techniques in Lab Kit.
2. Write Matlab program to analyze the performance of different modulation schemes

Module No.	Content	Teaching Hours
I	**List of Experiments** • To study and realization of sample & hold circuit. • To study and realization of delta modulator and demodulator. • To study and realization of pulse code modulator and demodulator. • To study coding and decoding of NRZ-L, NRZ-M data format. • To study coding and decoding of AMI, Manchester data format. • To study and realization of ASK modulator and demodulator. • To study and realization of FSK modulator and demodulator. • To study and realization of PSK modulator and demodulator. • To study and realization of hamming error detection and correction codes. • Simulation of digital communication transmitter. • Simulation of digital communication receiver. **Value addition experiments** • To study and realization of QPSK modulator and demodulator. • To study GSM Mobile trainer & observe Transmitted/Received RF Signal.	24

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

1. Implement the basic modulation and demodulation techniques in Lab Kit.
2. Write MatLab program to analyze the performance of different modulation schemes

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3,PO4 /PSO2, PSO3
CO2	PO1,PO2, PO3,PO4 /PSO2, PSO3

BECC1010: DIGITAL SIGNAL PROCESSING

Credits: 04 **L–T–P-J: 3–1–0-0**

Module No.	Content	Teaching Hour
I	Review of signals and systems. Linear Time Invariant System and its Characterization. Transform domain representation of signals and systems: Discrete Fourier series, Discrete Fourier Transform and its Properties, Radix-2 Fast Fourier Transform, Decimation in Time & Frequency, Gortezel Algorithm. Review of Z- transform.	21
II	Structures for discrete time systems: Block diagram and signal flow representation. FIR Filters: Definition, Symmetric and Anti-symmetric FIR Filters, Design of Linear-Phase FIR Filters Using Windowing technique & Frequency Sampling Method. IIR Filters: IIR Filter design by Approximation of Derivatives, Impulse Invariance & Bilinear Transformation. Design of Butterworth Filters. Effect of finite word length in Filter Design. Introduction to Multi-rate Signal Processing.	21

Text Book:

- John G. Prokias, Dimitris G. Manolakis, "Digital Signal Processing", Pearson Education, Fourth Edition
- S Salivahanan, A Vallavaraj, C Ganapriya, "Digital Signal Processing", TMH, Second Edition

Reference Book:

- Alan V.Oppenheim, Ronald W.Schafer, John R. Buck "Discrete Time Signal Processing" PHI, Second Edition

Focus: This course focuses on Employability aligned with all COs.

Outcomes: After completion of course, the student will be able to:

1. *Understand the basic discrete-time signals and systems, concepts of continuous time sampling, convolution, impulse response and frequency response concepts for linear, time-invariant (LTI) systems, difference equation for realization of LTI systems .*
2. *Discrete Time Fourier Transform, Properties & Computations, Discrete Fourier Series, linear convolution using DFT. FFT algorithms*
3. *Build discrete time system structures for IIR and FIR systems such as Direct-I, Direct-II, lattice structures, etc.*
4. *Design discrete time IIR and FIR filters using different approaches.*
5. *Analyze the effects of coefficient quantization, round-off noise in digital filters and limit cycles.*

Mapping of Course Outcomes (CO) With Program Outcomes(PO) and Program Specific Outcomes(PSO)

COs	POs/ PSOs
CO1	PO1, PO2/ PSO1, PSO2
CO2	PO1, PO2, PO3, PO4,/ PSO1, PSO2
CO3	PO1, PO2, PO3, PO4, PO5/ PSO2, PSO3
CO4	PO1, PO2, PO3, PO4, PO5/ PSO2, PSO3
CO5	PO1, PO2, PO3, PO4, PO5/ PSO2, PSO3

BECC0805: DIGITAL SIGNAL PROCESSING LAB

Objective: This course enables the students

- To recall DFT, inverse DFT, DFT properties, and FFT algorithms.
- To experiment with DSP Starter Kit (DSP) and familiar with Code Composer (CC) Studio software.
- To apply DFT, FFT, and circular convolution on DSK.
- To analyze IIR and FIR filters outputs with the help of codecs and CRO.

Prerequisites: Signals & Systems and Digital Signal Processing (DSP)

Credits: 01 **L–T–P-J: 0–0–2-0**

Module No.	Content	Teaching Hours
I	1. To study TMS320C6713 Digital Signal Processing Kit (DSK). 2. To show sampling and waveform generation using TMS320C6713 Digital Signal Processing (DSK). 3. To compute DFT of any particular sequence using TMS320C6713 Digital Signal Processing (DSK). 4. To compute FFT using TMS320C6713 Digital Signal Processing Kit (DSK). 5. To implement DSP processor using TMS320C6713 Digital Signal Processing Kit (DSK). 6. To study various Digital Modulation Schemes using TMS320C6713 Digital Signal Processing(DSK). 7. To Design FIR filter using TMS320C6713 Digital Signal Processing Kit (DSK). 8. To Design IIR filter using TMS320C6713 Digital Signal Processing Kit (DSK) **VALUE ADDITION EXPERIMENTS** 1. To Design Low pass digital butterworth IIR Filter using Bilinear Transformation method that satisfies the following constraints through MATLAB. $0.9 \le \left\|H\left(e^{j\omega}\right)\right\| \le 1, \quad 0 \le \omega \le \pi/2$ $\left\|H\left(e^{j\omega}\right)\right\| \le 0.2, \quad 3\pi/4 \le \omega \le \pi$ 2. To Design High pass butterworth FIR Filter ($w_c=\pi/4$) using Rectangular Window function (N=5).	32

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

CO1: Implement sine waveform, DFT, FFT, linear convolution, circular convolution, ASK, PSK, and FSK through Code Composer Studio on DSP starter kit.
CO2: Analyze the output of low-pass, high-pass, band-pass, and band-stop IIR and FIR Butterworth filters.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3,PO4 /PSO1, PSO3
CO2	PO1,PO2, PO3,PO4 /PSO2, PSO3

BECC0011: VLSI DESIGN

Credits: 03 **L–T–P-J: 3–0–0-0**

Course Objectives

- To understand the fundamental concepts of VLSI design methodologies and the fabrication process of an IC.
- To learn the modeling of MOS transistor and CMOS technology.
- To implement the digital circuits using state of art technologies to achieve a highly efficient performance in terms of area, speed and power dissipation.

Module No.	Contents	Teaching Hours
I	**Introduction:** Overview of VLSI Design Methodologies, VLSI Design Flow, Design Hierarchy, Concepts of Regularity, Modularity and Locality. **MOSFET Fabrication:** Fabrication process flow, NMOS and CMOS Fabrication .Layout design rules stick diagram and mask layout design. **MOS Transistor :** MOS Structure, Operation of MOSFET, MOSFET - Current /Voltage Characteristics, Scaling and Small geometry effects and capacitances. **MOS Inverters:** Introduction, Resistive Load Inverter, Inverters with n-type MOSFET load-Depletion load inverter, Enhancement load, CMOS Inverter **MOS Inverters** - Switching Characteristics: Introduction, Delay – Time Definitions, Calculation of Delay Times	21
II	**Combinational MOS Logic Circuits**: Introduction, MOS logic circuits with depletion NMOS Loads, CMOS logic circuits, complex logic circuits, CMOS transmission gates. **Sequential MOS Logic Circuits:** Introduction, behavior bistable elements, SR latch circuits, clocked latch and FF circuits, CMOS D latch and edge triggered FF. **Dynamic logic circuits:** Introduction, basic principle of pass transistor circuits, synchronous dynamic circuit techniques, dynamic CMOS circuit techniques, Domino CMOS logic. **Low Power CMOS Logic Circuits:** Introduction, Overview of Power Consumption, Low – Power Design through voltage scaling, Estimation and Optimization of switching activity	20

Text Books:

- Sung-Mo Kang &YosufLeblebici, "*CMOS Digital Integrated Circuits: Analysis & Design*", TMH, 3rd Edition.

Reference Books:

- A. Pucknell and K. Eshraghian, "*Basic VLSI Design: Systems and Circuits*", PHI, 3rd Ed., 1994.
- S.M.Sze, "*VLSI Technology*", Tata McGraw-Hill, Second Edition -2003.

Course Outcomes

After successfully completing the course students will be able to

1. understand the design steps to make the layout of a VLSI circuit with the help of Y-chart and the fabrication process of a CMOS transistor using n-well technology.
2. Illustrate the modeling of a MOS transistor and the effect of scaling on its characteristics.
3. Calculate the noise margin, propagation delay and the transient delay of the CMOS circuits and various gates implemented by the CMOS technology.
4. Design the efficient IC of various combinational and sequential circuits using CMOS technology and other state of art technologies like CMOS transmission gate etc.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2
CO3	PO1,PO2, PO3 /PSO1, PSO2, PSO3
CO4	PO1,PO2, PO3,PO4 /PSO1, PSO2, PSO3

BECC0806: CAD OF ELECTRONICS LAB

Credits: 01 **L–T–P-J: 0–0–2-0-0**

Objective:

- To describe and verify each step of VLSI design flow to design a digital circuit.
- To synthesize and simulate the various combinational and sequential circuits through different modeling of the VHDL.

Module No.	Content	Teaching Hours
I	**Software Requirement: Xilinx (VHDL)** **List of Experiments** 1. Synthesis and simulation of Full Adder. 2. Synthesis and Simulation of Full Subtractor. 3. Synthesis and Simulation of 3 X 8 Decoder. 4. Synthesis and Simulation of 8 X 1 Multiplexer. 5. Synthesis and simulation of priority encoder. 6. Synthesis and simulation of 2bit comparator. 7. Synthesis and Simulation of 9 bit odd parity generator. 8. Synthesis and Simulation of Flip Flop (D, and T). 9. Synthesis and simulation of MOD 10 counter. 10. Synthesis and simulation of Johnson counter. **Tool to be Used: Tanner EDA Using TSPICE** 1. Draw the forward and reverse bias characteristic curves of PN Junction diode. 2. A. Transient analysis of CMOS inverter using step and pulse input. B. DC analysis (voltage transfer characteristics) of CMOS inverter. 3. A. Transient & DC Analysis of CMOS-NOR Gate. B. Transient& DC Analysis of CMOS-NAND Gate. 4 . Perform DC and Transient Analysis for CMOS Implementation of SR Latch. 5. Perform DC and Transient Analysis for 1 Bit CMOS Full Adder. 6. Perform DC and Transient Analysis for 8T TSPC D Flip Flop	28

Note:At least 6 Experiments from Module I and 4 Experiments from Module II must be completed for successful credit evaluation.

Course Outcomes: After successfully completing the course students will be able to:

1. Synthesize and simulate the various combinational and sequential circuits through different modeling of the VHDL
2. Analyze the DC and transient characteristics of the CMOS digital circuit using Tanner tool.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2, PSO3
CO3	PO1,PO2, PO3, PO4 /PSO1, PSO2, PSO3

BECE0070: SIMUALTION LAB-II

Credits: 01 **L–T–P-J:0–0-2-0**

Objective:

- Describe the program structure of LabVIEW and cadence software.
- Implementation of programming in LabVIEW as well as cadence for basic control system problems and circuit analysis, respectively.

Module No.	Content	Teaching Hours
I	**List of Experiments of LabVIEW Academy** Basics of LabVIEW and to learn different Matrix operations. Plot the response of a first order system using unit step input. To learn about the data input and output feature of myRIO. **Experiments based Cadence Virtuoso** Study of MOS Device Characterization using cadence virtuoso tool implementation of Inverting Amplifiers Design simulation of simple Current Mirrors using cadence virtuoso	16

COURSE OUTCOMES: After successfully completing the course students will be able to:

CO1: Describe the program structure of LabVIEW and cadence software.
CO2: Implementation of programming in LabVIEW as well as cadence for basic control system problems and circuit analysis, respectively.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO2, PSO3

BECE0001: RANDOM VARIABLES & STOCHASTIC PROCESSES

Objectives:

- To understand the concepts of basic probability and random variables.
- To familiarize some standard distributions function and their properties.
- To understand the concepts of random process, properties.
- To apply the knowledge of random processes in communication signal.

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	PROBABILITY: Introduction of Probability through Sets and Relative Frequency: Experiments and Sample Spaces, Discrete and Continuous Sample Spaces, Events, Probability Definitions and Axioms, Mathematical Model of Experiments, Probability as a Relative Frequency, Joint Probability, Conditional Probability, Total Probability, Bayes' Theorem, Independent Events. THE RANDOM VARIABLE: Definition of a Random Variable, Conditions for a Function to be a Random Variable, Discrete and Continuous, Mixed Random Variable, Distribution and Density functions, Properties, Binomial, Poisson, Uniform, Gaussian, Exponential, Rayleigh, Conditional Distribution, Methods of defining Conditioning Event, Conditional Density, Properties. OPERATION ON ONE RANDOM VARIABLE: Introduction, Expected Value of a Random Variable, Function of a Random Variable, Moments about the Origin, Central Moments, Variance and Skewness, Chebychev's Inequality, Characteristic Function, Moment Generating Function.	22
II	MULTIPLE RANDOM VARIABLES: Vector Random Variables, Joint Distribution Function, Properties of Joint Distribution, Marginal Distribution Functions, Conditional Distribution and Density – Point Conditioning, Conditional Distribution and Density – Interval conditioning, Statistical Independence, Sum of Two Random Variables, Sum of Several Random Variables, Central Limit Theorem, (Proof not expected). Expected Value of a Function of Random Variables: Joint Moments about the Origin, Joint Central Moments. RANDOM PROCESSES: The Random Process Concept, Classification of Processes, Deterministic and Nondeterministic Processes, Distribution and Density Functions, concept of Stationarity and Statistical Independence. Stationary Processes, Wide-Sense Stationarity, Strict-Sense Stationarity, Time Averages and Ergodicity, Mean-Ergodic Processes, Correlation-Ergodic Processes, Autocorrelation Function and Its Properties, Cross-Correlation Function and Its Properties, Covariance Functions, Gaussian Random Processes, Poisson Random Process. The Power Spectrum: Properties, Relationship between Power Spectrum and Autocorrelation Function, The Cross-Power Density Spectrum, properties, Relationship between Cross-Power Spectrum and Cross-Correlation Function. Random process on LTI System. Arbitrary Noise Sources, Effective Noise Temperature, Average Noise Figures, Average Noise Figure of cascaded networks.	21

Text Book:

1. Probability, Random Variables & Random Signal Principles - Peyton Z. Peebles, TMH, 4th Edition.
2. Probability, Random Variables and Stochastic Processes – Athanasios Papoulis and S. Unnikrishna Pillai, PHI, 4th Edition.

Reference Books:

1. Communication Systems Analog & Digital – R.P. Singh and S.D. Sapre, TMH.
2. Probability and Random Processes with Application to Signal Processing – Henry Stark and John W. Woods, Pearson Education, 3rd Edition.
3. Probability Methods of Signal and System Analysis. George R. Cooper, Clave D. MC Gillem, Oxford, 3rd Edition.
4. Statistical Theory of Communication - S.P. Eugene Xavier, New Age Publications.

Web materials: video lecture by Prof Mrinjunjay Chakraborthy, IIT, Kharagpur

Outcomes: After the successful completion of this course, students should able to

CO1: Understand the basic probability theory and modeling of random variable from random experiment.
CO2: Demonstrate statistical distributions of one and two dimensional random variables and correlations
CO3: Compute the statistical properties parameters of given random variables and processes.
CO4: Apply different statistical theorem like Bay's, CLT, Chebycheff's inequality theorem to model the communication system.
CO5: Analyze the power and energy spectral density function and spectrum estimation stochastic signals.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2
CO3	PO1,PO2, PO3 /PSO1, PSO2
CO4	PO1,PO2, PO3 /PSO1, PSO2
CO5	PO1,PO2, PO3 /PSO1, PSO2

BECE0108: Signal Detection and Estimation Theory

Credits: 04 **L–T–P-J: 3–1–0-0**

Module No.	Contents	Teaching Hours
I	**Background:** Review of Gaussian variables and processes; problem formulation and objective of signal detection and signal 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; generalized matched filter; detection of sinusoid with unknown amplitude, phase, frequency and arrival time, linear model. **etection of Random Signals:** Estimator-correlator, linear model, general Gaussian detection, detection of Gaussian random signal with unknown parameters, weak signal detection.	20
II	**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, dynamical signal model, discrete Kalman filtering.	21

References:

1. H. L. Van Trees, "Detection, Estimation and Modulation Theory: Part I, II, and III", John Wiley, NY, 1968.
2. H. V. Poor, "An Introduction to Signal Detection and Estimation", Springer, 2/e, 1998.
3. S. M. Kay, "Fundamentals of Statistical Signal Processing: Estimation Theory", Prentice Hall PTR, 1993.
4. S. M. Kay, "Fundamentals of Statistical Signal Processing: Detection Theory", Prentice Hall PTR, 1998.

BECE0002: ANTENNA ANDWAVE PROPAGATION

Credits: 03 **L–T–P: 3–0–0**

Course Objectives:

- To understand the fundamental parameters of antenna.
- To design different types of wire, aperture, Patch, reflector, Broadband and
- Frequency Independent antennas.
- To analyze the different types of arrays and their radiation pattern.
- To describe the measurement techniques of various antenna parameters.
- To understand the basic concept of wave propagation and different wave propagation methods

Module No.	Content	Teaching Hours
I	**Introduction:** Basic Antenna parameters: Patterns, Beam Area (Beam solid angle), Radiation Intensity, Beam efficiency, Directivity & Gain, Directivity & Resolution, Antenna Apertures, Effective height, Radio Communication link , Retarded Potential, Power Radiation by small Current element. **Antenna Arrays**: Introduction. Arrays of two isotropic point sources, Non isotropic but similar point sources, Principle of pattern multiplication, Linear arrays of n isotropic point sources of equal amplitude and spacing, Linear broadside arrays with non-uniform Amplitude distributions: General consideration, Example of Dolph-Tchebyscheff(D-T) distribution for an array of eight sources. **Practical antennas I:** Horizontal Antennas above plane ground, Vertical Antenna above plane ground, Folded dipole antenna, Yagi-Uda antenna, The small loop, comparison of Far fields of small loop and short dipole, Radiation resistance of loops, slot antenna, Babinet's principle of complementary antennas, Impedance of slot antenna.	24
II	**Practical antennas II**: Patch or micro-strip antennas, Designing of MSA, Horn Antennas, the rectangular Horn antenna, Helical Antenna, Reflector antennas: Flat sheet reflector, corner reflector and design, Paraboloid Reflector, Comparison between parabolic and corner reflector, Broadband and frequency independent antenna: Basics, log periodic Antenna. **Antenna Measurements**: Gain, Directional pattern, Phase, polarization **Wave propagation:** Electromagnetic or radio waves, modes of propagation, Structure of atmosphere, Ground waves or surface wave propagation, Ground wave attenuation factor A, Sky wave or ionosphere wave propagation, space wave propagation , Propagation of radio waves through ionosphere or expression for the refractive index of the ionosphere, Mechanism of radio waves bending by the ionosphere, critical frequency, virtual height, maximum usable frequency, calculation of MUF, LUF, skip distance, range of space wave propagation or Line of sight, effective earth radius, Duct propagation	20

Text Books

- John D Kraus and RonalatoryMarhefka "Antennas and Wave Propagation" Tata Mc Graw Hill 2002
- C. A. Balanis "Antenna Theory Analysis and Design", Wiley 3rd Edition, 2012.

Reference Books:

- "Antenna for all Applications 3rd edition" Krauss, Marhefka& Ahmed S khan, TMH publication.
- "Antenna & Wave Propagation" by K.D. Prasad, Satya Publication.
- Jordan and Balmain, "Electromagnetic waves and radiating systems", PHI, 1968, Reprint 2003

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

1. Understand the basic characteristic parameters antenna and various modes of wave propagation and propagation effects in radio frequency.
2. Analyze the performance of different antennas.
3. Design the aperture, Patch, reflector, Broadband antennas for radio frequency communication.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2
CO3	PO1,PO2, PO3 /PSO1, PSO2

BECE0003: DATA COMMUNICATION AND NETWORKS

Objective: This course enables the students

- To understand LAN, MAN, and WAN networks. Also, understand different layers of OSI and TCP/IP model.
- To explain different protocols used in data link, network, and transport layer.
- To compare guided and unguided transmission media.
- To distinguish different multiple access methods such as Random, CSMA/CD, CSMA/CA.
- To explain IPv4 and IPv6 addressing schemes.

Prerequisites: Digital communication system

Credits: 03 **L–T–P-J: 3–0–0-0**

Module No.	Contents	Teaching Hours
I	**Introduction to Networks & Data Communications:** OSI Model, TCP / IP, Transmission Media: Guided and unguided Media Review. **Switching:** Datagram Networks, Virtual Circuit Networks, Structure of a switch, Ethernet Physical Layer, **Data Link Layer:** Error detection and Correction. **Data Link Control:** Framing, Flow and Error Control Protocols, Noiseless Channel and Noisy Channel Protocol, HDLC, Point-to-Point Protocol.	14
II	**Multiple Access:** RANDOM, CDMA, CSMA/CD, CSMA/CA, Token Bus, Token Ring, FDDI, IEEE Standards 802.2,802.3, Hubs, Bridges, Routers. **Network Layer:** Design Issues. Adaptive and non-Adaptive Routing Algorithms. Congestion control Algorithms, IPV4 Addresses, Connecting Devices, Virtual LAN IPV6 Addresses, **and Transport Layer Protocol:** UDP and TCP, ATM Protocol Architecture.	12

Text Book:

- Behrouz A. Forouzan and Richard F. Gilberg, "*Computer Science – A Structured Programming Approach Using C*", C Language Learning, 2007.

Reference Books:

- K. N. King, "*C Programming a Modern Approach*", W. W. Norton, 2nd Edition, 2008.
- Kernighan and Ritche, "*The C programming Language*", PHI, 2nd Edition, 2011.
- P. Dey and M. Ghosh, "*Programming in C*", Oxford University Press 1st Edition, 2000.

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

CO1: Understand OSI, TCP/IP, various protocols, IPv4, IPv6 addressing schemes, and switching techniques.
CO2: Apply routing techniques in forming the routing table at each node of a network.
CO3: Analyze the efficiency of a network by using multiple access techniques including CSMA, CSMA/CD, CSMA/CA.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO3
CO2	PO1,PO2, PO3 /PSO1,PSO3
CO3	PO1,PO2, PO3 /PSO2,PSO3

BECE0004: MICROWAVE ENGINEERING

Objective:

1. To understand the performance of the Wave Guides and Resonators.
2. To apply the basic concepts of special type transmission lines.
3. To analyze the different Microwave Components.

Credits: 03 **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours
I	**Introduction:** Microwave frequencies, Standard Frequency bands, Behaviour of circuits at conventional and microwave frequencies, Microwave applications. **Waveguide:** Review of Rectangular waveguide, Circular waveguides, Solutions of wave equation in cylindrical co-ordinates, Field distribution of TE &TM Modes, Dominant and Degenerate modes, Phase & group velocities, Wave impedances, Power transmission and Power losses. **Cavity Resonators:** Rectangular & circular cavities, coupling to Cavities, Quality factors of cavities**.** **Introduction to Strip lines, Micro strip lines and MMIC's.** **Microwave Passive Components:** Scattering matrix, Microwave T-Junctions: E-plane, H-plane and Hybrid Tees, Rat-Race Junction, Directional couplers. Attenuators, Phase Shifters, Microwave Bends, Corners and Twists, Irises. Microwave propagation in ferrites, Faraday rotation, Isolators, and Circulators.	22
II	**Solid State Microwave Devices:** PIN diode, Schottky barrier diode, Tunnel diode, Transferred electron devices (Gunn diode), Avalanche Transit –time devices: IMPATT Diode, TRAPATT Diode. **Microwave Tubes:** Limitation of conventional active devices at microwave frequency, Two cavity klystron, Reflex klystron, Magnetron, Traveling wave tube, backward wave oscillators: Principle of operation, Performance characteristic and their applications. **Microwave Measurements:** General set up of a microwave test bench, Slotted line carriage, VSWR meter, Microwave power measurements techniques, Measurement of frequency and wavelength, Impedance and losses. Measurement of S-parameters.	20

Text Books:

- Samuel Y. Liao, "*Microwave Devices and Circuits*", 3rd Ed, Pearson Education.

Reference Books:

- R.E Collin, "*Foundation for Microwave Engineering*", 2nd Ed., John Wiley India.
- D.M.Pozar ,"Microwave Engineering",John Wiley India.
- Das and S. K. Das, "*Microwave Engineering*", 2nd Edition, TMH.

Corse Outcomes: After successful completion of the course students will be able to

1. Understand the performance of the Wave Guides and Resonators.
2. Apply the basic concepts of special type transmission lines.
3. Analyze the different Microwave Components.
4. Examine the characteristics of high frequency diodes.
5. Analysis and performance of Microwave Tubes.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3, PO4 /PSO1, PSO2,PSO3
CO4	PO1,PO2, PO3, PO4 /PSO1, PSO2,PSO3
CO5	PO1,PO2, PO3, PO4 /PSO1, PSO2,PSO3

BECE0071: MICROWAVE LAB

L–T–P: 0–0–2 **CREDITS: 01**

Objectives:

- To study the characteristics and applications of microwave frequency bands, propagation of E.M wave through waveguides, and understand the working of various microwave passive and active devices and circuits.

List of Experiments

Part – A: Microwave Test Bench Based (Any 6 Experiments):

1. Study of Reflex Klystron Characteristics.
2. Measurement of guide wavelength and frequency of the signal in a rectangular waveguide using slotted line carriage in a Microwave Bench.
3. Measurement of isolation coefficient, insertion loss and cross coupling of a circulator.
4. Determine the S-parameter of any three port Tee.
5. Determine the S-parameter of a Magic Tee.
6. Determine coupling coefficient, Insertion loss, Directivity and Isolation coefficient of any Multi-Hole directional coupler.
7. Study of waveguide horn and its radiation pattern and determination of the beam width.

Part – B: Mini project using Keysight Advanced Design system:

1. **Microwave Passive comoponents Design** such as Microwave Discrete and Microstrip Filter Design, Discrete and Microstrip Coupler Design, Microstrip and CPW Power Divider Design
2. **Microwave Active comoponents Design** such as Microwave Amplifier Design, Frequency Multiplier Design, Active Mixer Design, Microwave Oscillator Design, Power Amplifier Design

Course Outcomes

1. Examine the performance of microwave circuits and devices.
2. Design and simulate the passive and active microwave components as Filters, Couplers, Power Dividers, Amplifiers, Frequency Multiplier, Mixer, Oscillators and Power Amplifiers.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO2,PSO3
CO2	PO1,PO2, PO3, PO4 /PSO2,PSO3

BECE0005: OPTICAL COMMUNICATION

Objectives:

- Understand the various optical fiber modes, configurations and various signal degradation factors associated with optical fiber.
- Analyze the various optical sources and optical detectors and their use in the optical communication system.

Credits: 03 **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours
I	**INTRODUCTION:** Overview of optical fiber communication- The general system, advantages of optical fiber communications. Optical fiber wave guides- Introduction, Ray theory transmission, Optical fiber Modes and configuration, Mode theory for circular Waveguides, Step Index fibers, Graded Index fibers. **TRANSMISSION CHARACTERISTICS OF OPTICAL FIBER:** Single mode fibers- Cut off wavelength, Mode Field Diameter, Effective Refractive Index. Fiber Material and its Fabrication Techniques Signal distortion in optical fibers- Attenuation, Absorption, Scattering and Bending losses, Core and Cladding losses. Information capacity determination, Group delay, Attenuation Measurements Techniques, Types of Dispersion - Material dispersion, Wave-guide dispersion, Polarization mode dispersion, Intermodal dispersion. Pulse broadening. Overall fiber dispersion in Multi mode and Single mode fibers, Fiber dispersion measurement techniques, Non linear effects. Optical fiber Connectors: Joints, Couplers and Isolators. **OPTICAL SOURCES:** Optical sources- LEDs, Structures, Materials, Quantum efficiency, Power, Modulation, Power bandwidth product. Laser Diodes- Basic concepts, Classifications, Semiconductor injection Laser: Modes, Tunable and fixed laser, Threshold conditions, External quantum efficiency, Laser diode rate equations, resonant frequencies, reliability of LED & ILD.	22
II	**SOURCE TO FIBER POWER LAUNCHING:** Output patterns, Power coupling, Power launching, Equilibrium Numerical Aperture, Laser diode to fiber coupling. **OPTICAL DETECTORS:** Physical principles of PIN and APD, Detector response time, Temperature effect on Avalanche gain, Comparison of Photo detectors. **FIBER OPTIC RECEIVER AND MEASUREMENT:** Optical receiver operation- Fundamental receiver operation, Digital signal transmission, error sources, Receiver configuration, Digital receiver performance, Probability of error, Quantum limit, Analog Receivers Various switching elements, OADM, OXC, CLOS architecture, MEMS, wavelength convertors.	21

Test Books:

- John M. Senior "*Optical Fiber Communication*", Pearson Education – Second Edition. **2007**

Reference Books:

- Gerd Keiser "Optical Fiber Communication", McGraw Hill – Third Edition. 2000
- Govind P. Agrawal "Fiber-optic communication systems", Wiley , Third Edition

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

1. Understand the various optical fiber modes, configurations and various signal degradation factors associated with optical fiber.
2. Demonstrate the ability to design a system, component or process as per needs and specification.
3. Analyze the various optical sources and optical detectors and their use in the optical communication system.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1,PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1,PSO2
CO3	PO1,PO2, PO3, PO4 /PSO1, PSO2,PSO3

BECE0072: OPTICAL COMMUNICATION LAB

Objectives:

- Implement the intensity modulation for optical sources including LED and LASER
- Evaluate the numerical aperture and bending loss for an optical fiber

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
I	1. To setting up fiber optic analog link. 2. Intensity modulation of LED output through an optical fiber. 3. Intensity modulation of Laser output through an optical fiber. 4. Study and measurement of numerical aperture of optical fiber. 5. Study and measurement of bending losses in optical fiber. 6. Study and measure DC characteristics of LED. 7. Study and measure DC characteristics of Laser. 8. Study and measure DC characteristics of photo detector	08

Outcomes: -After successful completion of the course students will be able to

1. Implement the intensity modulation for optical sources including LED and LASER
2. Evaluate the numerical aperture and bending loss for an optical fiber
3. Demonstrate the DC characteristic of optical sources (including LED and LASER) and optical photo-detector.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO2,PSO3
CO2	PO1,PO2, PO3, PO4 /PSO2,PSO3
CO3	PO1,PO2, PO3, PO4 /PSO2,PSO3

BECE0006: WIRELESS COMMUNICATION

Credits: 03 **L–T–P: 3–0–0**

Course Objectives:

- Know the characteristic of wireless channel
- Learn the various cellular architectures
- Understand the concepts behind various digital signaling schemes for fading channels
- Be familiar the various multipath mitigation techniques
- Understand the various multiple antenna systems

Module No.	Contents	Teaching Hours
I	**Introduction to Wireless Communication Systems**, Modern Wireless Communication Systems. **Multiple Access techniques for wireless communications**: Frequency division multiple access, Time division multiple access, Spread spectrum multiple access. Code division multiple access, Frequency hopped multiple access, Space division multiple access, Packet radio, Packet radio protocols, Pure ALOHA, Slotted ALOHA. Carrier sense multiple access (CSMA) protocols, Reservation Protocols, Capture effect in Packet radio. **Cellular Systems-System Design Fundamentals:** Introduction, Frequency reuse**,** channel assignment strategies, Handoff strategies, Prioritizing handoffs, Practical handoff considerations, Interference and system capacity, Co-channel interference and system capacity, Channel planning for wireless system, Adjacent channel interference, Power control for reducing interference, Improving coverage & capacity in cellular system: Cell splitting, Sectoring, Repeaters for range extension, Microcell zone concept. **Mobile Radio Propagation: Large Scale Path Loss:** Introduction to radio wave propagation, Free-space propagation model, Propagation mechanism Reflection, Ground reflection (two ray model) , Diffraction, Fresnel zone geometry, Knife edge diffraction model, Multiple knife edge diffraction, Scattering, Radar cross section model, Practical link budget design using path loss model, Log distance path loss model , log normal shadowing, Determination of percentage of coverage area , Outdoor propagation models , Okumura model, Hata model, Indoor propagation model, Partition losses, log distance Path loss model., Ercisson multiple breakpoint model	21
II	**Mobile Radio Propagation: Small scale fading & multipath**: Factors influencing small scale fading, Doppler shift, Impulse response model of multipath channel, Small scale multipath measurements, Direct RF Pulse system, Spread spectrum sliding correlator channel sounding, Frequency domain channel sounding, , Parameters of mobile multipath Channels, Time coherence parameters, Coherence bandwidth, Doppler spread and Coherence time, Types of small scale fading, Flat fading , Frequency selective fading , Fast fading, Slow fading , Rayleigh & Ricean distribution. **Equalization**: Fundamentals of equalization, Training a generic adaptive equalizer, Equalizers in communication receiver, Survey of equalization techniques, Linear equalizers, Nonlinear equalizers, Algorithms for adaptive equalization, Zero forcing algorithm, Least mean square algorithm, Recursive least square algorithm, **Diversity techniques**: Space Diversity: Selection Diversity, Feedback or Scanning diversity, Maximal ratio combining., Equal gain combining, Polarization diversity, frequency diversity, Time diversity, Rake Receiver.	21

Text Books:

- T.S.Rappaport, "*Wireless Communication-Principles And Practice*", Pearson,Second Edition.
- R. Pandya, "*Mobile and Personal Communication System*", PHI.

Reference Books:

- Andrea Gold smith, "*Wireless Communications*", Cambridge University press.
- Andreas F. Molisch, "*Wireless Communications*", Wiley Student Edition.
- S.Haykin&M.Moher, "*Modern Wireless Communication*",Pearson,2005

Course Outcomes: After successfully completing the course students will be able to:

CO1: Understand the cellular design fundamentals, path-loss models, small scale fading, equalizers, diversity techniques and multiple access techniques.
CO2: Comprehend the cellular system design fundamentals.
CO3: Apply the concept of adaptive equalizer to compensate the errors present in the wireless channel.
CO4: Analyze the performance of wireless communication system in presence of large scale path-loss models and small scale fading.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1,PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1,PSO2
CO3	PO1,PO2, PO3, PO4 /PSO1,PSO2, PSO3
CO4	PO1,PO2, PO3, PO4 /PSO1,PSO2, PSO3

BECE0007: INFORMATION THEORY AND CODING

Credits: 03 **L–T–P: 3–0–0**

Course Objectives:

- To acquaint students with the basics of probability, information and its properties
- To familiarize students with different channel models and their capacity
- To teach different types of source coding techniques
- To explain various types of channel coding techniques

Module No.	Contents	Teaching Hours
I	**Introduction to Information Theory :-**Concept of amount of information, entropy, marginal, conditional and joint entropies and relation among entropies mutual information, information rate, Source coding Kraft's inequality, coding efficiency and redundancy, Noiseless coding theorem **Construction of basic source codes**: Shannon Fano Algorithm, Huffman coding, Channel capacity, redundancy and efficiency of a channel, binary symmetric channel (BSC), Binary error channel (BEC) capacity of band limited Gaussian channels, Shannon Hartley theorem, Bandwidth- SNR trade off, capacity of a channel of infinite bandwidth, Shannon's limit. Introduction to rings, fields, and Galois fields, Codes for error detection and correction, parity check coding linear block codes error detecting and correcting capabilities generator and parity check matrices, standard array and syndrome decoding, perfect codes.	22
II	Hamming codes encoding and decoding. Cyclic codes polynomial and matrix descriptions generation of cyclic codes, decoding of cyclic codes, BCH codes description and decoding, Reed Solomon Codes, Burst error correction.Convolution Codes, Trellis diagrams, transfer function and minimum free distance, Maximum likelihood decoding of convolution code, the Viterbi algorithm, Sequential decoding, Turbo codes, LDPC.	20

Text books:

- Thomas M. Cover, Joy A. Thomas, "*Elements of Information Theory* ", Wiley Publication.
- R Bose, "*Information Theory, Coding and Cryptography*", TMH publication

Reference Books:

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- Das Mullick Chatterjee "*Principles of Digital communication"* Wiley Eastern Ltd.
- P.S.Sathya Narayana "Concepts of Information Theory & Coding*"* Dynaram Publications, 2005.

Course Outcomes: After successfully completing the course students will be able to:

CO1: Understand the basics of probability, information theory and its properties, binary and non-binary source coding and channel coding.

CO2: Compute channel capacity for different types of channels including BSC, BEC and Gaussian channel.

CO3: Analyze the performance of source coding, channel coding techniques in image processing and wireless applications.

CO4: Construct, Linear block code, cyclic code, convolution code, LDPC code and Hamming codes.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1,PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1,PSO2
CO3	PO1,PO2, PO3, PO4 /PSO1,PSO2, PSO3
CO4	PO1,PO2, PO3, PO4 /PSO1,PSO2, PSO3

BECE0008: MULTI CARRIER COMMUNICATION

L–T–P: 3–0–0

Credits: 03

Course Objectives:

1. To characterize the basics of multipath fading channel.
2. To understand the concept of wireless communication generations.

Module No.	Contents	Teaching Hours
I	**Mobile Communications Systems**: Past, Present, and Future,4G Systems, Multicarrier Techniques for 4G Systems. **Characteristics of Multipath Fading Channels:** Introduction, Rayleigh and Ricean Fading Channels, Multipath Delay Profile, Multicarrier Techniques for 4G Mobile Communications, Frequency Selective and Frequency, Nonselective Fading Channels, Spaced-Time Correlation Function, Time Selective and Time Nonselective Fading Channels, Examples of Multipath Fading Channels. **OFDM :** The concept of multicarrier transmission, OFDM as multicarrier transmission ,Implementation by FFT , Orthogonal Multiplexing Principle	22
II	**OFDM:**Peak-to-Average Power Ratio and Sensitivity to Nonlinearity Sensitivity to Carrier Frequency Offset and Time-Varying Channels,Timing Offset and Cyclic Prefix Dimensioning. **Applications of OFDM:** Overview, MIMO Signal Model. Single-User MIMO Techniques , Multi-User Techniques **Future Research Directions**: OFCDM System, OFDM Adaptive Array Antennas, MIMO-OFDM	18

Text books:

- Shinsuke Hara and Ram jee Prasad, "*Multicarrier Techniques for 4G Mobile Communications*", Artech House universal personal communication.

Reference Books:

- Henrik Schulze and Christian L¨uders, "*Theory and Applications of OFDM and CDMA*", John Willey Publication.

Corse Outcomes:

Outcomes:

1. Understand the technologies of wireless communication generations.
2. Characterize the multipath fading channels and OFDM.
3. Analyze the performance of OFDM and multipath fading channels.
4. Compare the different multicarrier techniques.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1,PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1,PSO2
CO3	PO1,PO2, PO3, PO4 /PSO2, PSO3
CO4	PO1,PO2, PO3, PO4 /PSO2, PSO3

BECE0073: MULTICARRIER COMMUNICATIONLAB

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Objectives:

- Implement the various digital modulation technique in Matlab.
- Analyze the performance of CDMA & OFDM system.

Credits: 01 **L–T–P-J: 0–0–2-0**

Module No.	Content	Teaching Hours
I	• Realization of AM, PM and FM modulation and demodulation • Realization ASK, PSK and FSKmodulation and demodulation • Realization of QPSK modulation and demodulation • Realization of CDMA transmitter using MATLAB. • Realization of CDMA receiver using MATLAB. • Realization of OFDM transmitter using MATLAB. • Realization of ODMA receiver using MATLAB • BER calculation of CDMA system in AWGN channel environment using MATLAB. • BER calculation of OFDM system in AWGN channel environment using MATLAB.	**22**

Outcomes: -

1. Implement the various digital modulation technique in Matlab.
2. Analyze the performance of CDMA & OFDM system.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO2,PSO3
CO2	PO1,PO2, PO3, PO4 /PSO2,PSO3

BECE0086: MULTICARRIER COMMUNICATION PROJECT

Projects List:

1) - Transmit diversity scheme in wireless communication.

In this project, the three receive diversity schemes – Selection combining, Equal Gain Combining and Maximal Ratio Combining have been widely used. All the three approaches used the antenna array at the receiver to improve the demodulation performance, with different levels of complexity. Now Time to move on to a transmit diversity scheme where the information is spread across multiple antennas at the transmitter. This is popularly abbreviated as Alamouti Space Time Block Coding (STBC).

2) - Inter Carrier Interference (ICI) in OFDM due to frequency offset.

This project deals in evaluation of the impact of frequency offset resulting in Inter Carrier Interference (ICI) while receiving an OFDM modulated symbol. First, the OFDM transmission and reception should be discussed, then the effect of frequency offset and the loss of orthogonality and resulting signal to noise ratio (SNR) loss due to the presence of frequency offset.

3) - BER for BPSK in OFDM with Rayleigh multipath channel.

This project deals with the performance of an OFDM modulated system in a frequency selective Rayleigh fading channel.

4) - IEEE 802.11ac – Very High Throughput for lower 6GHz band.

IEEE 802.11ac Very High Throughput (for <6GHz band) is an upcoming standard which is development by IEEE standardization committee. The mandate of Task Group AC is supposed to enhance the High Throughput rates achieved by 802.11n.

5) - Frequency offset estimation using 802.11a short preamble.

This is understood that an OFDM waveform is made of sum of multiple sinusoidal (also called subcarriers) each modulated independently. Let us try to understand the estimation of frequency offset in a typical OFDM receiver (using the short preamble specified per IEEE 802.11a specification as a reference).

Outcomes: -

1. Acquire the knowledge of diversity techniques used in multicarrier communication.
2. Implement the state of art in Inter Carrier Interference (ICI) in OFDM System.
3. Examine the BER performance of Rayleigh Multipath Channel.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4, PO9 /PSO2,PSO3
CO2	PO1,PO2, PO3, PO4, PO5, PO9 /PSO2,PSO3
CO3	PO1,PO2, PO3, PO4, PO5, PO9 /PSO2,PSO3

BECE0009: SPREAD SPECTRUM SYSTEM

Credits: 04 **L–T–P-J: 3–1–0-0**

Course Objectives:

- To provide the fundamentals of spreading techniques, spreading codes,code acquisition and tracking and analyze the performance of spread spectrum techniques.

Module No.	Content	Teaching Hours
I	**Spread spectrum Technique**: Principle of a Spread Spectrum(SS) **T**echnique and Code Division Multiple Access (CDMA),Advantages of SS Systems,Main Types of SS Techniques, Direct Sequence (DS) SS System, **Theory and Application of Pseudo Random Binary Sequences:** Properties of Random Binary Sequences, Autocorrelation of Binary Sequences, Crosscorrelation of Binary Sequences **Pseudo-Noise Sequences:** Linear Feedback Shift Register (LFSR),Properties of PN-Sequences, Preferred Pairs of PN Sequences. **Gold Sequences:** Properties and Generation of Gold Sequences **Maximum Length (ML)Sequences:**Properties and Generation of ML Sequences	21
II	**Frequency Hopped Spread Spectrum:** Definition/Description, Slow versus Fast Hopping, **Other SS Techniques:** Hybrid DS/FH/SS, chirp modulation, time hopping **Spreading Code Acquisition and Tracking:** Initial Code Acquisition, Acquisition strategies, Serial search, Parallel search, Multidwell detection, Matched filter acquisition, Code Tracking **Performance Spread Spectrum System:** Performance of Direct Sequence and Frequency Hopping Spread Spectrum systems	21

Text book:

1. Don Torrieri, Principles of Spread Spectrum system, Springer

References books:

2. Valery P. Ipatov, Spread Spectrum and CDMA Principles and Applications, John Willey Publication.
3. M. K. Simon, Spread Spectrum Handbook, Tata Mc Graw Hill Publication.

Course Outcomes: After successfully completing the course students will be able to

1. Understand principles and types of spread spectrum systems including Hybrid DS/FH/SS, chirp modulation, time hopping.
2. Explain the properties and generation of various spreading codes including random binary sequence, PN sequence, Gold codes, ML sequences.
3. Analyze the performance of DS-SS, FHSS, acquisition and tracking of spreading code.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2,PSO3
CO3	PO1,PO2, PO3, PO4 /PSO1, PSO2,PSO3

BECE0010: SATELLITE COMMUNICATION

Objectives:

- To understand the basic concept of satellite communication.
- To design different class of satellites orbits.
- To analyze different modulation schemes used in satellite communication.

Credits: 03

L–T–P: 3–0–0

Module No.	Contents	Teaching Hours
I	**Orbital mechanics and Launchers:** Elements of Satellite Communication, Orbital mechanics, look angle and orbit determination, orbital perturbation, launches and launch vehicle, Orbital effects in communication system performance. **Satellites:** Satellite subsystems, attitude and orbit control systems, Telemetry Tracking Command & Monitoring, Power systems, Communication subsystem, satellite antennas **Earth Station.** Introduction, earth station subsystem, Singe and double conversion types of heterodyne earth stations. **Multiple access Techniques:** Introduction, space segment access methods, FDMA, TDMA, CDMA, SDMA, assignment methods.	21
II	**Satellite link design** Basic transmission theory, system noise temperature and G/T ratio, design of downlink, satellite systems using small earth station, Uplink design, design for specified Carrier to noise ratio. **Introduction of various satellite systems:** **VSAT:** Network architectures **Low earth orbit and non-geostationary satellite system:** Orbit considerations, **Direct broadcast satellite television and radio:** Digital DBS TV, DBS-TV system design, DBS-TV link budget, Error control in digital DBS-TV. Master control station and uplink, Installation of DBS-TV antenna, Satellite radio broadcasting, **Satellite navigation and Global positioning System:** GPS Position location principles, GPS Receiver and codes.	21

Text Books:

- Timothy Pratt, Charles W. Bostian, Jeremy E. Allnutt “Satellite Communications” 2nd Ed. John Wiley & Sons.

Reference Books:

1. Dennis Roddy “Satellite Communications” 3rd Ed. Mc-Graw-Hill.
2. Tri T. Ha. “*Digital Satellite Communications*” Tata-McGraw-Hill.1990.

Outcomes: After successfully completing the course students will be able to

1. Determine the parameters of orbital mechanics and launching of satellite communication
2. Understand the principles of operation of various satellite subsystems such as Attitude & Orbit Control Subsystems, Telemetry Tracking Command & Monitoring, Power Systems, Communication Subsystems & Satellite Antennas
3. Analyze the multiplexing & multiple access techniques of satellite communication.
4. Design the uplink and downlink of satellite communication.
5. Understand principles of operation of satellite systems such as Very Small Aperture Terminal. Low Earth Orbit Satellite, Non Geostationary Satellite Systems, Direct Broadcast Satellite Television, Satellite Navigation and Global Positioning System.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2, PSO3
CO3	PO1,PO2, PO3, PO4 /PSO1, PSO2, PSO3

BECE 0011: LONG TERM EVOLUTION

Credits: 03 **L–T–P: 3–0–0**

Course Objectives:

- To understand the different basic blocks of digital communication system.
- To design mathematical model of communication channels and digital signals.
- To analyze the principle of Orthogonal frequency division multiplexing.
- To analyze the performance of OFDM systems in the presence of noise and interference.
- To understand the basic concept of recent trends in wireless communication for future communication.

Module No.	Content	Teaching Hours
I	**Introduction and Background**: Long Term Evolution of UMTS ,Requirements and Targets for the Long Term Evolution **Technologies for the Long Term Evolution:** Multicarrier Technology, Multiple Antenna Technology, Packet-Switched RadioInterface, UserEquipment Capabilities. **Physical Layer for Downlink**: History of OFDM Development, Orthogonal Multiplexing Principle, Peak-to-Average Power Ratio and Sensitivity to Nonlinearity, Sensitivity to Carrier Frequency Offset and Time-Varying Channels, Timing Offset and Cyclic Prefix Dimensioning**.**	22
II	**Synchronization and Cell Search:** Coherent Detection, Non-Coherent Detection. **Multiple Antenna Technique:** Overview, MIMO Signal Model, Single-User MIMO Techniques, Multi-User Techniques. **Physical Layer for Uplink:** Introduction, SC-FDMA Transmission Structure, Time-Domain Signal Generation, Frequency-Domain Signal Generation **Uplink Capacity and Coverage:** Factors Affecting Uplink Capacity, LTE Uplink Capacity Evaluation, LTE Uplink Coverage and Link Budget.	20

Text Book:

- StefaniaSesia, Matthew Baker, “LTE – The UMTS Long Term Evolution”, Ist Edition, John Wiley & sons Ltd.

Reference Books:

- StefaniaSesia, Matthew Baker, “LTE – The UMTS Long Term Evolution”, Ist Edition, John Wiley & sons Ltd.

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

1. Represent the digital signal in baseband and pass-band format.
2. Understand the fundamentals of PAPR reduction techniques in OFDM
3. Represent the digital signal in vector space.
4. Design the OFDM transmitter and receiver scheme for digital communication.
5. Analyze the performance of OFDM communication in presence of noise.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2,PSO3
CO3	PO1,PO2, PO3, PO4 /PSO1, PSO2,PSO3
CO4	PO1,PO2, PO3, PO4 /PSO1, PSO2,PSO3
CO5	PO1,PO2, PO3, PO4 /PSO1, PSO2,PSO3

BECE0101: FUNDAMENTALS OF DIGITAL IMAGE PROCESSING

Objective: This course enables the students

- To understand the human visual system, formation of the digital images, pixels neighboring relationship.
- To define various image intensity transformations such as image negative, log transformation, and piece-wise linear transformations.
- To apply image enhancement in both spatial and frequency domain. Also apply different morphological image operations on the given input image matrix.
- To explain image segmentation and compression techniques.

Prerequisites: Digital signal processing

Credits: 03 **L–T–P-J: 3–0–0-0**

Module No.	Contents	Teaching Hours
I	**Introduction and Fundamentals** Motivation and Perspective, Applications, Components of Image Processing System, Element of Visual Perception, A Simple Image Model, Sampling and Quantization, Some Basic Relationships between Pixels, An Introduction to the color image model **Image Enhancement in Spatial domain** Introduction, Some Basic Intensity Transformation Functions, Histogram Equalization, Histogram Specification, Enhancement using Arithmetic/Logic Operations, Basics of Spatial Filtering, Smoothing - Mean filter, Ordered Statistic Filter, Sharpening – The Laplacian **Image Enhancement in Frequency Domain** Basis of Filtering in Frequency Domain, Filters – Low-pass, High-pass; Correspondence Between Filtering in Spatial and Frequency Domain; Smoothing Frequency Domain Filters – Gaussian Lowpass Filters; Sharpening Frequency Domain Filters – Gaussian Highpass Filters.	13
II	**Morphological Image Processing** Introduction, Logical Operations involving Binary Images, Dilation and Erosion, Opening and Closing, The Hit-or-Miss Transformation, Morphological Algorithms. **Image Segmentation:** Point, Line & Edge detection, Thresholding, Edge and Line Detection - Basic Edge Detection, Canny edge detection, Edge Linking - Hough Transform, Region-based segmentation, Region Extraction – Pixel based approach & Region based approach. **Fundamental Image Compression:** Coding redundancy, Image compression model, some basic compression methods, Image compression standards, Discrete Cosine Transform (DCT).	13

Text Book:

- R.C.Gonzalez and R.E.Woods (2008), "*Digital Image Processing"*, 3rd Edition, Prentice Hall.

Reference Books:

- Anil K. Jain (1989). "*Fundamentals of Digital Image Processing"*, Prentice-Hall.
- BhabatoshChanda, D. DuttaMajumder (2011). "*Digital Image Processing and Analysis"*, PHI.

Outcome: Upon successful completion of this course, students will be able to

CO1: Understand the formation of the digital images, representation in spatial domain, and compression techniques.
CO2: Demonstrate the methodologies for image segmentation techniques like edge detection, thresholding, region growing, and region split and merge.
CO3: Apply adjacencies to define path, various intensity transformations, spatial filters like averaging, median, and Gaussian and morphological operations.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO3
CO2	PO1,PO2, PO3, PO4 /PSO2, PSO3
CO3	PO1,PO2, PO3, PO4 /PSO1, PSO3

BECE0102: DIGITAL IMAGE PROCESSING

Objective: This course enables the students

- To define various image intensity transformations such as image negative, log transformation, and piece-wise linear transformations.
- To explain image enhancement in both spatial and frequency domain.
- To explain morphological operations and image segmentation techniques.

Prerequisites: Digital signal processing

Credits: 03 **L–T–P-J: 3–0–0-0**

Module No.	Contents	Teaching Hours
I	**Image Enhancement in Spatial domain** Introduction, Some Basic Intensity Transformation Functions, Histogram Equalization, Histogram Specification, Basics of Spatial Filtering, Smoothing - Mean filter, Ordered Statistic Filter, Sharpening – The Laplacian **Image Enhancement in Frequency Domain** Basis of Filtering in Frequency Domain, Filters – Low-pass, High-pass; Correspondence Between Filtering in Spatial and Frequency Domain; Smoothing Frequency Domain Filters – Gaussian Lowpass Filters; Sharpening Frequency Domain Filters – Gaussian Highpass Filters.	13
II	**Morphological Image Processing** Introduction, Logical Operations involving Binary Images, Dilation and Erosion, Opening and Closing, The Hit-or-Miss Transformation, Morphological Algorithms. **Image Segmentation:** Point, Line & Edge detection, Thresholding, Edge and Line Detection - Basic Edge Detection, Canny edge detection, Edge Linking - Hough Transform, Region-based segmentation, Region Extraction – Pixel based approach & Region based approach.	13

Text Book:

- R.C.Gonzalez and R.E.Woods (2008), "*Digital Image Processing"*, 3rd Edition, Prentice Hall.

Reference Books:

- Anil K. Jain (1989). "*Fundamentals of Digital Image Processing"*, Prentice-Hall.
- BhabatoshChanda, D. DuttaMajumder (2011). "*Digital Image Processing and Analysis"*, PHI.

Outcome: Upon successful completion of this course, students will be able to:

CO1: Understand the image enhancement techniques including intensity transformation, histogram equalization, specification, and filtering methods.
CO2: Demonstrate the methodologies for image segmentation techniques like edge detection, thresholding, region growing, and region split and merge.
CO3: Apply binary morphological operations on input images.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO3
CO2	PO1,PO2, PO3, PO4 /PSO2, PSO3
CO3	PO1,PO2, PO3, PO4 /PSO1, PSO3

BECE0171: DIGITAL IMAGE PROCESSING LAB

Objective: This course enables the students

- To demonstrate the basic operations on images such as image reading, resizing, image negative, and geometric transformations in MATLAB environment.
- To apply the histogram equalization as a pre-processing step in image processing.
- To experiment with noise filtering methods such as median, low-pass, and high-pass filters on an arbitrary image

Prerequisites: Programming Skills – The student should have slight experience in a high level programming language such as MATLAB or C/C++.

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
I	1. Write program to read any image, resize it to 256 ×256. Apply square mask such that only middle part of the image is visible. 2. To perform image negative of 256 ×256 gray scale image 3. To check similarity between two images by using XOR/XNOR operations. 4. Take your own photograph in dark area. Improve its appearance using histogram equalization technique. 1. Write and execute program for geometric transformation of image (a) Translation (b) Scaling (c) Zooming (d) shrinking (e) Rotation 2. To add salt and pepper noise and apply median filter for its removal. 3. Write and execute programs to remove noise using 3×3 spatial low-pass and high pass filter 4. Write and execute programs for image frequency domain filtering (a) Apply FFT on given image (b) Perform low pass and high pass filtering in frequency domain	28

Outcome: Upon successful completion of this course, students will be able to:

CO1: Implement pre-processing techniques like averaging, median filtering, Gaussian filtering, contrast enhancement, and histogram equalization and mathematical equations on MATLAB.

CO2: Analyze the output image and change the required parameters to get desired result.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO3
CO2	PO1,PO2, PO3, PO4 /PSO2, PSO3

BECE0186: DIGITAL IMAGE PROCESSING PROJECT

Objective: This course enables the students

- To recall the facts, basic terms, methods, and algorithms studied in digital image processing.
- To understand the MATLAB functions and their utility related with image processing.
- To apply image pre-processing, filtering in spatial and frequency domain, segmentation, morphological image operations in MATLAB environment.
- To develop programs based on lower level and higher level image processing.

Prerequisites:

- Programming Skills – The student should have slight experience in a high level programming language such as MATLAB or C/C++.
- Digital image processing

Credits: 02 **L–T–P-J: 0–0–0-8**

Module No.	Contents	Teaching Hours
I	Computer imaging system, Digital image representation, Classes and image types, Introduction to MATLAB. **Image pre-processing:** image enhancement, image transforms functions. Generating and plotting image histograms, histogram equalization. **Image filtering in spatial domain:** sharpening, smoothening. **Image filtering in frequency domain:** Basic steps in DFT filtering. conversion of spatial domain filters into frequency domain filters. **Program:** Image filtering **Image segmentation:** global thresholding, adaptive thresholding, region split & merge. **Program:** Image segmentation using thresholding methods. **Morphological image processing functions:** closing, opening, erosion, dilation, connected components, region filling. **Working on mini project:** application to image enhancement, segmentation. Present project to the class	32

Books:

1. Digital Image Processing, *R.C Gonzalez and R.E Woods*

2. Digital Image Processing Using MATLAB, *R.C Gonzalez and R.E Woods*
3. Fundamentals of Digital Image Processing, *A.K Jain*

Outcome: Upon successful completion of this course, students will be able to:

CO1: Apply high level tasks such as segmentation and morphological operation on input images to handle real-life problems related to object detection.
CO2: Design the algorithms as the solution to the problem related to pattern recognition and features extraction.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO3
CO2	PO1,PO2, PO3, PO4 . PO5, PO9 /PSO2, PSO3

BECE0103: BIOMEDICAL IMAGE PROCESSING

Credits: 03 **L–T–P: 3–0–0**

Objective:

- To understand the fundamentals of medical images like different modalities.
- To learn the different image enhancement techniques
- To represent the medical images in spatial and frequency domain
- To learn different image operation like edge detection, image growing, histogram equalization etc.
- To analyze features of medical images.

Module No.	Contents	Teaching Hours
I	Nature of biomedical images: body temperature as an image, trans-illumination, light and electron microscopy, different modalities of medical image, x-ray, tomography, ultrasonography, MRI. Image quality and information: characterization of image quality, optical density, dynamic range, contrast, histogram, entropy, Fourier Transform and spectral content. Removal of artifact, space domain local-statistic based filters, frequency domain filters, matrix representation of image processing.	21
II	Image enhancement: digital structure angiography, gray-scale transform, histrogram transformation, convolution mask operator, contrast enhancement. Detection of region of interest: thresholding and binarization, detection of point and line, edge detection, segmentation and region growing, detection of object of known geometry. Feature analysis: shape, shapes and contour, shape factors, Fourier descriptors, Texture analysis, texture in biomedical images, statistics of textures, texture energy, Fourier domain analysis of texture, audification and sonification of texture in image.	21

TEXT BOOKS:

- Rangaraj M. Rangayyan – Biomedical Signal Analysis. IEEE Press.

Outcomes: After the successful completion of this course students are able to

CO 1. Understand the different modalities, representation techniques of biomedical images.

CO 2. Demonstrate different preprocessing techniques to enhance the medical images.

CO 3. Apply the feature extraction techniques like image segmentation, ROI, texture, shape, contour, Fourier descriptor.

CO 4. Analyze the performance of algorithm used in medical images.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2
CO3	PO1,PO2, PO3, PO5 /PSO1, PSO2, PSO3
CO4	PO1,PO2, PO3 , PO5 /PSO1, PSO2, PSO3

BECE0105: ADAPTIVE SIGNAL PROCESSING

Credits: 03 **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours
I	**Introduction:** Basic Concepts of signal processing, IIR & FIR Filters, Random variables, Random Processes, Filtered Random Process, Correlation, Co variance, Power spectrum, Cross Power Spectrum, Ergodi city, Time Averages and estimators **Linear Prediction:** Direct form linear prediction filtering, normal equations for linear prediction filtering, Levinson algorithm, Linear prediction lattice filtering.	21
II	**Digital Wiener Filtering:** Wiener smoothing prediction filter, Application of Weiner smoothing to noise cancelling. **LMS adaptive Filters:** LMS adaptive algorithm, Properties of LMS adaptive filters. **LS Adaptive Filters:** Godard algorithm, lattice **Blind Adaptive Filtering Techniques:** Cost Function, Higher Order Statistics & examples	21

Text book:

- S. Haykin "*Adaptive Filter theory*", Prentice Hall, 4th Edition, 2001

Reference Books:

- S. Haykin "*Adaptive Filter theory*", Prentice Hall, 4th Edition, 2001
- Ali H. Sayed "*Fundamentals of Adaptive Filtering*", John- Willey Publication, 2003.
- A. Papoulis, S. U. Pillai "*Probability, Random Variables and Stochastic Process*" TMH publication.

Outcomes:

1. Understand the basic concept of random signal, analog and digital filters,
2. Demonstrate the different structure of adaptive filters and the parametric methods for power spectrum estimation.
3. Apply the linear prediction, Levinson algorithm to design adaptive filter like Digital Wiener filter.
4. Analyze the performance of different adaptive filtering techniques including LMS, RLS and blind filtering techniques.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2, PSO3
CO3	PO1,PO2, PO3, PO4 /PSO1, PSO2, PSO3
CO3	PO1,PO2, PO3, PO4 /PSO1, PSO2, PSO3

BECE0106: BIOMEDICAL SIGNAL PROCESSING

Credits: 03 **L–T–P: 3–0–0**

Objectives:

- To introduce origin and characteristics of biomedical signals
- To provide an understanding on the application of signal processing concepts in analyzing biomedical signals
- To implement algorithms for various biomedical signal processing tasks Course Outcomes

Module No.	Contents	Teaching Hours
I	Preliminaries; Biomedical signal origin & dynamics (ECG), Filtering for Removal of artifacts Statistical Preliminaries; Time domain filtering (Synchronized Averaging, Moving Average), Time domain filtering (Moving Average Filter to Integration, Derivative-based operator), Frequency Domain Filtering (Notch Filter), Optimal Filtering: The WeinerFilter, Adaptive Filtering SelectingAppropriate Filter, Data Compression Techniques:Cardiological Signal Processing: Pre-processing. QRS Detection Methods. Rhythm analysis. Arrhythmia detection Algorithms. Automated ECG Analysis. ECG Pattern Recognition. Heart rate variability analysis.	21
II	Adaptive Noise Canceling: Principles of Adaptive Noise Canceling. Adaptive Noise Canceling with the LMS adaptation Algorithm. Noise Canceling Method to Enhance ECG Monitoring. Fetal ECG Monitoring. Signal Averaging, polishing–mean and trend removal, linear prediction. Yule–walker (Y–W) equations. Their applications in ECG and EEG. Modeling of EEG Signals. Detection of spikes and spindles Detection of Alpha, Beta, and Gamma Waves. Auto Regressive (A.R.) modeling of seizure EEG. Sleep Stage analysis. Inverse Filtering. Least squares and polynomial modeling	21

TEXT BOOKS:

- Rangaraj M. Rangayyan – Biomedical Signal Analysis. IEEE Press, 2001.
- D. C. Reddy, Biomedical Signal Processing- principles, and techniques, Tata McGraw-Hill, 2005.
- Biomedical Digital Signal Processing, Willis J. Tompkins, PHI,

REFERENCE BOOKS:

- Weitkunat R, Digital Bio signal Processing, Elsevier, 1991.
- AkayM , Biomedical Signal Processing, Academic: Press 1994
- Cohen.A, Biomedical Signal Processing -Vol. I Time & Frequency Analysis, CRC Press, 1986.

Course Outcomes:

CO1: Understand techniques for various levels of tasks in biomedical signal analysis.
CO2: Demonstrate appropriate algorithms according to nature of the signal and acquisition characteristics.
CO3: Apply biomedical signal processing algorithms using appropriate tools.
CO4: Develop contemporary algorithms to address complex problems.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2
CO3	PO1,PO2, PO3, PO5, PO9 /PSO1, PSO2, PSO3
CO4	PO1,PO2, PO3, PO5, PO9 /PSO1, PSO2, PSO3

BECE0171: BIOMEDICAL SIGNAL PROCESSING LAB

L–T–P: 0–0–2

Credits: 01

Objective:

1. **To** implement different algorithm of signal enhancement in MatLab Environment.

Module No.	Content	Teaching Hours
I	1. Computation of Convolution and Correlation Sequences. 2. Analog and Digital Signal Conditioning. 3. Signal Averaging Improvement in the SNR Using Coherent Averaging. 4. Signal Averaging Improvement in the SNR Using Incoherent Averaging. 5. Exponential Averaging. 6. Data Polishing: Mean and Trend Removal. 7. Design or I I R Filter. 8. Design of F I R Filter. 9. PSD Estimation ECG, EEG 10. Implementation of IIR and FIR filters on ECG and EEG signals. 11. Noise Cancellation Techniques. 12. QRS Detections and HRV Analysis.	

Note: – Minimum of 10 experiments has to be conducted using MATLAB and Signal Processing Toolboxes.

Outcomes: After successful completion of the course, student should able to

1. Implement various signal enhancement techniques in MATLAB platform.
2. Design IIR and FIR filters depending on nature of biomedical signal.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO2, PSO3
CO2	PO1,PO2, PO3, PO5 /PSO2, PSO3

BECE0107: SPEECH PROCESSING

Credits: 03 **L–T–P: 3–0–0**

Objective:

- To provide the knowledge of basic characteristics of speech signal in relation to production and hearing of speech by humans.
- To describe basic algorithms of speech analysis common to many applications.
- To give an overview of applications (recognition, synthesis, coding)

Module No.	Contents	Teaching Hours
I	**Digital Models for the Speech Signal:** Process of speech production, Acoustic theory of speech production, Lossless tube models, and Digital models for speech signals **Time Domain Models For Speech Processing:** Time dependent processing of speech, Short time energy and average magnitude, Short time average zero crossing rate, Speech Vs silence discrimination using energy & zero crossings, Pitch period estimation, Short time autocorrelation function, Short time average magnitude difference function, Pitch period estimation using autocorrelation function, Median smoothing. **Digital Representations of the Speech Waveform:** Sampling speech signals, Instantaneous quantization, Adaptive quantization, Differential quantization, Delta Modulation, Differential PCM, Comparison of systems, direct digital code conversion.	21
II	**Homomorphic Speech Processing:** Homomorphic systems for convolution, Complex cepstrum, Pitch detection, Formant estimation, Homomorphic vocoder. **Linear Predictive Coding of Speech:** Basic principles of linear predictive analysis, Solution of LPC equations, Prediction error signal, Frequency domain interpretation, Relation between the various speech parameters, Synthesis of speech from linear predictive parameters, Applications. **Speech Enhancement:** Spectral subtraction & filtering, Harmonic filtering, parametric re-synthesis, Adaptive noise cancellation. **Speech Synthesis:** Principles of speech synthesis, Synthesizer	21

Text Book:

- L. R. Rabiner and R. W. Schafer, “Digital Processing of Speech Signals”, Pearson Education (Asia) Pte. Ltd.

Reference Books:

- D. O’Shaughnessy, “Speech Communications: Human and Machine”, Universities Press.
- L. R. Rabiner and B. Juang, “Fundamentals of Speech Recognition”, Pearson Education (Asia) Pte. Ltd.
- Z. Li and M.S. Drew, “Fundamentals of Multimedia”, Pearson Education (Asia) Pvt. Ltd.

Outcomes: After successful completion of the course, student should able to

1. Demonstrate the representation of the speech signals in time and discrete domain.
2. Apply the speech processing algorithm to enhance the quality of speech
3. Analyze the algorithm to recognize and synthesize the speech of speaker.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/ PSOs
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2
CO3	PO1,PO2, PO3 /PSO2, PSO3

BECE0172: SPEECH PROCESSING LAB

Credits: 01 **L–T–P: 0–0–2**

Objective:

- To represent the speech in spatial and spectral domain
- To implement different speech processing algorithm in matlab environment

Module No.	Content	Teaching Hours
I	1. Handling Speech files in MATLAB. a. Read a speech file, its sampling rate and bits per sample. b. Write a speech file, at different sampling rates, at different bits per sample. c. Play a speech file at different sampling rates. 2. Fourier Transform and inverse Fourier Transform of Speech signals, plot of the spectrum of audio signals. 3. Convert the sampling rate associated with a speech file (MATLAB array) to adifferent sampling rate. 4. High-pass filter a speech file (MATLAB array) to eliminate hum and low frequency noise 5. plot a spectrogram of a speech file (MATLAB array) 6. plot a frame of speech and its associated spectral log magnitude	08

Course Outcomes:

After the successful completion of this course, the student will able to

CO 1: Analyze spectrum of speech signals.

CO 2: Implement speech processing algorithm in MATLAB environment.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO2, PSO3

BEEC1014: POWER ELECTRONICS

Objective: The course aims to enable students to understand application of power semiconductor switches in modern power application, and to analyze performance of different power electronics converters for various industrial and household applications.

Credits: 3 **L-T-P-J:3-0-0-0**

Module No.	Content	Teaching Hours
I	**Thyristor:** Construction, V-I and Switching characteristics (Turn-On and Turn-Off), Two Transistor Model, Methods of Turn-On, Operation of GTO, DIAC, TRIAC, Firing Circuits for SCR, Protection of Devices, Series and Parallel Operation of Thyristors. **Commutation:** Commutation Techniques of Thyristor. **Phase Controlled Converters:** Single Phase Half Wave Controlled Rectifier With Resistive and Induction Loads, Effects of Freewheeling Diode, Single Phase Fully Controlled and Half Controlled Bridge Converters, Performance Parameters, Three Phase Half Wave Converters, Three Phase Fully Controlled and Half Controlled Bridge Converters, Effect of Source Impedance, Single Phase and Three Phase Dual Converters.	20
II	**Inverters:** Introduction (VSI), VSI-Single Phase Half and Full Bridge Inverters for R, RL and RLC Loads, Three Phase Bridge Inverters 180° and 120° Mode Operations. CSI-Single Phase Series Resonant and Parallel Inverters, Voltage Control of Inverters, Harmonic Reduction Techniques. **DC-DC Converters:** Principle of Step-Down Chopper, Step Down Chopper, control strategies for varying duty cycle, quadrant base classification of Choppers. **Cyclo converters:** Basic Principle of Operation, Single Phase to Single Phase, Three Phase to Single Phase and Three Phase to Three Phase Cyclo converters, Output Voltage Equation. **AC Voltage Controllers:** Introduction, Single Phase Ac Voltage Controller With Resistive and Inductive Loads, Three Phase Ac Voltage Controllers (Various Configurations And Comparison Only).	22

Text Books:

1. M. H. Rashid, Power, "Electronics: Circuits, Devices & Applications", Prentice Hall of India Ltd, 4th edition, 2013.

References:

1. M.D. Singh & K. B. Khanchandani "*Power Electronics*", TMH, 2nd edition (paperback), 2017.
2. Ned Mohan, T. M. Undeland and W. P. Robbins, "*Power Electronics: Converters, Applications and Design*", Wiley India Ltd, 3rd edition (paperback), 2009.
3. S. N. Singh, "*Modern Power Electronics and AC Drives*", Prentice Hall, 2001 (paperback edition).
4. V.R. Moorthy, "*Power Electronics: Devices, Circuits, Industrial Applications*", Oxford Univ. Press, 2005 (paperback edition).
5. P.S. Bhimbra, "*Power Electronics"*, Khanna Publishers, 2018.

Course Outcomes: *After learning the course the students should be able to:*

CO1: Understand the switching characteristic's and working of power semiconductor devices such as SCR, GTO, DIAC, TRIAC.

CO2: Compare the power converter performance for practical loads (R and RL).

CO3: Apply the different modulation techniques to PWM inverters for harmonic reduction.

CO4: Design power converter (controlled rectifier, inverter, DC-DC Converters, cyclo converters and ac voltage controller) circuits by assessing the requirements of application fields.

Mapping of Course Outcomes(CO) With Program Outcomes(PO) and Program Specific Outcomes(PSO)

COs	POs/ PSOs
CO1	PO1, PO2, PO3, PO4, PSO1, PSO2, PSO3
CO2	PO1, PO2, PO3, PO4, PSO1,
CO3	PO1, PO2, PO3, PO4, PSO2,PSO3
CO4	PO1, PO2, PO3, PO4, PSO1, PSO2, , PSO3
CO5	PO1, PO2, PO3, PO4, PSO1, PSO3
CO6	PO1, PO2, PO3, PO4, , PSO3

BECE0301: ELECTRONICINSTRUMENTS AND MEASUREMENTS

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Theory of Measurement** Introduction, Performance characteristics:Static & dynamic characteristics, Standards, Error and uncertainty, Statistical analysis. **Transducers**: Classification, Transducers for the measurement of displacement, temperature, pressure, level and humidity etc. Signal conditioning aspects. **Analog Meters:** Current and voltage measurements, resistance measurements. **Bridge:** Various DC/ AC bridges and their applications. **Electronic Analog Meters**: Electronic analog DC ammeter and voltmeter, Electronic analog AC ammeter and voltmeter, Electronic multimeter.	21
II	**Digital Meters:** Digital measurements, Specification of digital meters, Digital ammeter, voltmeter and wattmeter, Digital frequency measurement. **Display devices:** 7 Segment display, LCD, LED. **Oscilloscopes and Waveform Measurements** **Types of Oscilloscopes :** CRO, Dual beam, Dual trace & Sampling oscilloscope, DSO, Waveform measurements, Typesofprobes,Probeloading&measurementeffect,Probespecifications. **Signal Analyzers** Signal Analyzers: Distortion Measurement and Spectrum Analyzers. **Advances and future trends in measurement technology**	21

Text Books:

- "*Electronic Instruments & Instrumentation Technology*" by MMS Anand, PHI Pvt. Ltd.
- "Instrumentation Measurement and Analysis " by B. C. Nakra and K. K. Chaudhary, McGraw-Hill.
- "*Electronic Instrumentation and Measurements*" by David A. Bell, 2nd Ed., PHI.

Reference Books:

- "*Modern Electronic Instrumentation and Measurement Techniques*" by Albert D. Helfric and William D. Cooper, PHI Pvt. Ltd.

Course Outcomes: After successfully completing the course students will be able to

CO 1 Understand of basics of measurement techniques, working of transducers and sensors.
CO 2 Demonstrate electronics/ electrical instruments, their use, peculiar errors associated with the instruments and how to minimize such errors.
CO 3 Explain the industrial and laboratory applications of instruments including analog and digital meters, signal generator and Oscilloscope.
CO 4 Analyze the error performance of measuring instruments.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2, PSO3
CO3	PO1,PO2, PO3 /PSO1, PSO2, PSO3
CO4	PO1,PO2, PO3 /PSO1, PSO2, PSO3

BECE0302: MICROCONTROLLERS AND EMBEDDED SYSTEMS

Credits: 03

L–T–P: 3–0–0

Module No.	Contents	Teaching Hours
I	**Introduction to Embedded Systems:** Overview of Embedded Systems, Classification of Embedded Systems, Processor Embedded into a system, Embedded Hardware Units and Devices in system, Embedded Software, Design Process in Embedded System. **Embedded C:** Constants, Variables & Data Types, Operators: Types Of Operators, Bitwise Operators. Control Structures & Loops, Functions, Pointers. **PIC Architecture:** Introduction to PIC microcontrollers, PIC architecture, comparison of PIC with other CISC and RISC based systems and microprocessors, memory mapping. **C Programming and Interfacing with PIC:** **I/O Programming**: PIC I/O ports, I/O bit manipulation programming, timers/counters, programming to generate delay and wave form generation, I/O programming. **INTERFACING** of LED, 7 Segment Display, Introduction to 16x2 LCD, Commands of 16x2 LCD, Interfacing Circuit Description of 16x2 LCD, Programming of 16x2 LCD. **INTERFACING OF MOTORS:** Introduction to Motors, Programming & Controlling of motors in Embedded System.	21
II	**INTERFACING OF SWITCHES & KEYBOARD MATRIX:** Introduction to Switches & Keyboard Matrix, Interfacing Circuit of Switches & Keyboard Matrix, Programming of Keyboard Matrix & Switches, Controlling of LED's by using Switches, Key board Matrix & LCD Interfacing Program. **INTERFACING OF ADC:** Introduction to ADC, Programming of ADC **SENSOR INTERFACING:** Introduction to sensing devices, Interfacing of IR Sensors, Interfacing of Temperature Sensor. **Interfacing with ATMEGA328PB:** Interfacing of LED and 7 Segment Display, Introduction to 16x2 LCD, Commands of 16x2 LCD, Interfacing Circuit Description of 16x2 LCD, Programming of 16x2 LCD. **INTERFACING OF MOTORS:** Introduction to Motors, Programming & Controlling of motors in Embedded System. **INTERFACING OF SWITCHES & KEYBOARD MATRIX:** Introduction to Switches & Keyboard Matrix, Interfacing Circuit of Switches & Keyboard Matrix, Programming of Keyboard Matrix & Switches, Controlling of LED's by using Switches, Key board Matrix & LCD Interfacing Program. **INTERFACING OF ADC:** Introduction to ADC, Programming of ADC **SENSOR INTERFACING:** Introduction to sensing devices, Interfacing of IR Sensors, Interfacing of Temperature Sensor.	21

Text Book:

- John.B.Peatman, "*Design with Microcontrollers*", Person Education, 1st Edition, 2004.

Reference Books:

- David E. Simon, "*An Embedded Software Primer*", Pearson Education, 1999.
- V. Deshmukh, "*Microcontrollers: theory and applications*", Tata McGraw Hill, 12th reprint, 2005

Course Outcomes: After successfully completing the course students will be able to

CO 1 Understand the basics of embedded systems, internal Architecture of PIC and AVR microcontroller.
CO 2 Demonstrate both analog and digital sensor interfacing with a programmable platform.
CO 3 Analyze Peripherals and their programming aspects.
CO 4 Design techniques to develop software for embedded systems.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2
CO3	PO1,PO2, PO3, PO4 /PSO1, PSO2, PSO3
CO4	PO1,PO2, PO3, PO5 /PSO1, PSO2, PSO3

BECE0303: EMBEDDED SYSTEMS DESIGN

Credits: 03 **L–T–P-J: 3–0–0-0**

Module No.	Contents	Teaching Hours
I	**EMBEDDED SYSTEM INTRODUCTION:** Introduction to embedded system, embedded system architecture, classifications of embedded systems, challenges and design issues in embedded systems, fundamentals of embedded processor and microcontrollers, CISC vs. RISC, fundamentals of Vonneuman/Harvard architectures, types of microcontrollers. **Embedded C:**Constants, Variables & Data Types, Operators: Types Of Operators,Bitwise Operators.Control Structures & Loops, Functions, Pointers. **ARM Microntroller:** Introduction to ARM CORTEX M4F based MCU (TIVA C Secirs**TM4C123G**), Architectural Overview, The Cortex-M4F Processor, Cortex-M4 Peripherals, JTAG Interface, System Exception Module, Hibernation Module, Internal Memory.General-Purpose Input/Outputs (GPIOs), General-Purpose Timers, Watchdog Timers, Analog-to-Digital Converter (ADC), Universal Asynchronous Receivers/Transmitters (UARTs), Pulse Width Modulator (PWM). **INTERFACING WITH TIVA :** Interfacing of LCD, **INTERFACING OF MOTORS:** Introduction to Motors, Programming & Controlling of motors in Embedded System.	21
II	**INTERFACING OF SWITCHES & KEYBOARD MATRIX:** Introduction to Switches & Keyboard Matrix, Interfacing Circuit of Switches & Keyboard Matrix, Programming of Keyboard Matrix & Switches, Controlling of LED's by using Switches, Key board Matrix & LCD Interfacing Program. **SENSOR INTERFACING:** Introduction to sensing devices, Interfacing of IR Sensors, Interfacing of Temperature Sensor. **INTERFACING WITH ATSAM :** Interfacing of LCD, **INTERFACING OF MOTORS:** Introduction to Motors, Programming & Controlling of motors in Embedded System. **INTERFACING OF SWITCHES & KEYBOARD MATRIX:** Introduction to Switches & Keyboard Matrix, Interfacing Circuit of Switches & Keyboard Matrix, Programming of Keyboard Matrix & Switches, Controlling of LED's by using Switches, Key board Matrix & LCD Interfacing Program. **SENSOR INTERFACING:** Introduction to sensing devices, Interfacing of IR Sensors, Interfacing of Temperature Sensor.	21

References books:

1. Joseph Yiu, The Definitive Guide to ARM® Cortex®-M0 and Cortex-M0+ Processors, 2015, 2nd Edition, Elsevier Science & Technology, UK.
2. Andrew N Sloss, Dominic Symes, Chris Wright, ARM System Developer's Guide, 2010, Morgan Kaufmann Publishers.

Course Outcomes: After successfully completing the course students will be able to

1. Understand the concept of embedded system, the key concepts of microcontroller including I/O, timers, interrupts and interaction with peripheral devices.
2. Demonstrate the programming in embedded C using code composer studio.
3. Explain the architecture, features of ARM processors and their interfacing with peripherals.
4. Apply the Interfacing techniques to connect ARM processors with the input and output devices including LEDs, LCDs, 7-segment display, keypad, dc motor and different sensors.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2
CO3	PO1,PO2, PO3 /PSO1, PSO2, PSO3
CO4	PO1,PO2, PO3, PO9 /PSO1, PSO2, PSO3

BECE0371: EMBEDDED SYSTEMS DESIGN LAB

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
I	1. To blink an LED with GPIO. 2. LED Control using a switch. 3. Running LED. 4. Interfacing Potentiometer using GPIO. 5. LCD Interfacing. 6. Keyboard and LCD Interfacing. 7. Interrupts & Collecting Sensor Information. 8. Distance Determination Using Ultrasonic Sensor. 9. Interfacing of Temperature Sensor. 10. Interfacing with Stepper Motor. 11. Speed Control of DC motor using PWM. 12. Servo Position Control with PWM. 13. Serial Communications Using UART. 14. RTC interfacing using I^2C.	24

Course Outcomes: After successfully completing the course students will be able to

1. Implement programs in embedded C and serial communication protocols (UART, I^2C) used for microcontroller.
2. Interface the commonly used peripherals with TIVA C TM4C123GH6PM.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/ PSOs
CO1	PO1,PO2, PO3, PO4, PO9 /PSO1, PSO2, PSO3
CO2	PO1,PO2, PO3, PO5, PO9 /PSO1, PSO2, PSO3

BECE0386: EMBEDDED SYSTEMS PROJECT

Course objective: The project will introduce students to the challenge of Embedded Systems Design & Integration. The project is an example of '*hardware and software co-design'* and the scale of the task is such that it will require teamwork as a coordinated effort.

Course Outcomes: After successfully completing the course students will be able to

1. Recognize issues to be addressed in a combined hardware and software system design.
2. Apply hands-on experience in electronic circuit implementation for designing Embedded System and its testing.
3. Develop group working, including task sub-division and integration of individual contributions from the team.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2
CO3	PO1,PO2, PO3 /PSO1, PSO2, PSO3

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BECE0304: INTELLIGENT SYSTEM

Course Objectives

- To provide students an opportunity to study the concepts of classical control design techniques like, P, PI and PID controllers.
- To provide students an opportunity to study the aspects of computational intelligence methods in depth to develop intelligent adaptive controllers.
- It focuses on designing intelligent controller using fuzzy logic, artificial neural networks, genetic algorithm, PSO and CSA techniques.
- It gives the analysis of learning systems in combination with feedback control systems, computer simulation of intelligent control systems to evaluate the performance.

Credits: 03 **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours
I	Introduction: Conventional and Modern Control System, Intelligence, Soft and Hard Computing, Artificial Intelligence. Fuzzy Logic System: Introduction to crisp sets and fuzzy sets, examples. basic fuzzy set operation. Fuzzification, rule base, inference engine and defuzzification. Membership functions: triangular, trapezoidal, bell shaped, guassian, sigmoidal etc. Introduction to fuzzy logic modeling and control. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Fuzzy logic control for nonlinear time-delay system. Hybrid Fuzzy Control: Fuzzy P Controller, Fuzzy PI controller, Fuzzy PD and Fuzzy PD+I Control, Fuzzy Logic Toolbox in MATLAB.	**21**
III	Artificial Neural Networks: Concept of ANN and its basic mathematical model. Feed forward networks, Multi-layered neural network, Learning and Training the neural network. Radial basis function networks, Recurrent neural networks, Chebyshev neural network, System identification using neural network. Neural Network Toolbox in MATLAB, Neural Network based control. Genetic Algorithm-Basic concept of Genetic algorithm and detail algorithm steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept of some other search techniques like PSO and Cuckoo Search Algorithms for solving optimization problems in MATLAB.	**13**

BOOKs

1. Simon Haykin, “Neural Networks: Acomprehensive Foundation,” Second edition, Prentice Hall.
2. J. H. Lilly, “Fuzzy Control and Identification,” J Wiley.
3. Stuart J. Russel & Peter Norvig “Artificial intelligence: A modern approach,” Prentice Hall.

Course Outcomes:

After successfully completing the course students will be able to:

1. Understand the classical control techniques for linear as well as nonlinear systems.
2. Apply the knowledge of fuzzy logic to design the controllers for nonlinear systems.
3. Analyzes the performance of different meta-heuristic optimization algorithms like GA, PSO and CSA.
4. Design an Artificial Neural Networks for training and testing purpose of a system.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2
CO3	PO1,PO2, PO3 /PSO1, PSO2, PSO3
CO4	PO1,PO2, PO3, PO5 /PSO1, PSO2, PSO3

BECE0305: INTRODUCTION TO MACHINE LEARNING

Credits: 03 **L–T–P-J: 3–0–1-0**

Objectives:

- Understand Learning and related concepts
- Understand and apply dimensionality reduction techniques
- Design supervised classifiers and unsupervised clustering techniques

Module No.	Content	Teaching Hours
I	**Learning:** Types of Learning, Hypothesis Space & Inductive Bias, Training & Test Set, Evaluation & Cross Validation **Dimensionality Reduction:**Feature Selection, Feature Extraction, Principal Component Analysis, Singular Value Decomposing **Supervised Learning:**Linear Regression, k-nearest neighbor classifier, Collaborative Filtering, Decision tree classifier, Identification Trees ID3, Logistic Regression, Bayesian Learning, Naïve Bayes Classifier, Support Vector Machine	20
II	**Unsupervised Learning:** k-means Clustering, Agglomerative Hierarchical Clustering **More on Supervised Learning**: Multi-layer Neural Network, Back Propagation Neural Network **Concepts** of Convolution Neural Network, Deep Neural Network & Reinforcement Learning **More on Learning** : Ensemble, Bagging & Boosting, Ada Boost **Applications of Machine Learning** Electronics & Communications Engineering Problems	20

Text Book:

1. Tom M. Mitchell, Machine Learning. Tata McGraw-Hill Education, 2013.
2. Alpaydin, E. . Introduction to machine learning. MIT press, 2009. Reference Books: • Harrington, P. , " Machine learning in action", Shelter Island, NY: Manning Publications Co, 2012.

Reference Books:

1. Harrington, P., ." Machine learning in action". Shelter Islan", NY: Manning Publications Co, 2012.
2. Bishop, C. M. . Pattern recognition and machine learning (information science and statistics) springer-verlag new york. Inc. Secaucus, NJ, USA. 2006

Course Outcomes: After successfully completing the course students will be able to:

CO 1:-Understand Concepts related to Learning - Hypothesis Space & Inductive Bias, Training & Test Set, and Evaluation & Cross Validation, supervised & unsupervised

CO 2:-Mathematical understanding of Principal Component Analysis and Singular Value Decomposition

CO 3:- Design of Classifiers and Clustering Technique

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/ PSOs
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3,PO4 /PSO2, PSO3

BECE0306: INDUSTRIAL PROCESS CONTROL

Course Objectives

- To learn the fundamental concepts of design aspects of process control.
- To develop the concepts of mathematical modeling of different nonlinear systems and its linearization.
- To learn the basics of feedback control schemes like P, I, D, PD, PI and PID controllers and its tuning.
- To build the concepts of final control elements like control valves.
- To develop the concepts of control systems with multiple loops like cascade control, selective control, split range control etc.

Credits: 03

Module No.	Contents	Teaching Hours
I	Introduction to process control; Design aspects of process control, mathematical modeling; Development of mathematical models. Modeling considerations for control purposes. Dynamic Behavior of Chemical Processes, Computer simulation and the linearization of nonlinear systems, Transfer functions and the input-output models. Dynamics and analysis of first, second and higher order systems. Feedback Control Schemes: P, I, D, PD, PI and PID controllers.	**21**
II	Dynamics and analysis of feedback-controlled processes. Stability analysis. Tuning of PID controller, Feedback response of the system with large dead time or inverse response Final control elements, Control Valves Control systems with multiple loops, cascade control, selective control, split range control, Feedforward and ratio control, Adaptive and inferential control, Control configuration of MIMO systems.	**21**

BOOKS:

1. Stephanopoulos, G.(1984)."Chemical process control: an introduction to theory and practice," Prentice-Hall, New Delhi.
2. Seborg, D.E.,Edgar, T.F. and Mellichamp, D.A.(2003). "Process dynamics and control," Wiley, New York.
3. Smith, C.A. and Corripio,A.B.(1997)."Principles and practice of automatic process control," Wiley, New York.
4. Johnson, C.D.(2006)."Process control instrumentation technology," Prentice-Hall, New Delhi.

Course Outcomes

After successfully completing the course students will be able to

1. Understand the knowledgeof Design an Artificial Neural Networks for training and testing purpose of a system.
2. Demonstrate the mathematical modeling of nonlinear systems and its linearization.
3. Design and tune the classical control techniques for linear as well as nonlinear systems.
4. Analyzes and apply the concept of different meta-heuristic optimization algorithms like GA, PSO and CSA.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO4 /PSO2, PSO3
CO3	PO1,PO2, PO4 /PSO2, PSO3
CO4	PO1,PO2, PO4 /PSO2, PSO3

BECE0372: INDUSTRIAL PROCESS CONTROL LAB

Credits: 01 **L–T–P: 0–0–2**

Lab No.	Contents	LAB Hours
I	1. Design of fundamental control structure for a second order LTI system on Lab VIEW. 2. Design of PID controller for a linear system and find the tuned gains of the controller on Lab VIEW. 3. Design of nonlinear PID controller for complex systems on Lab VIEW. 4. Study of fundamental structure of a level control system on process plant interfaced with Lab VIEW. 5. Study of fundamental structure of a flow control system on process plant interfaced with Lab VIEW.	24

Outcomes:*After completion of Lab, student will be able to:*

1. Implement the programming of controllers in Lab VIEW.
2. Simulate controllers using myRIO data acquisition system in a process control trainer including P, PD, PI and PID controllers.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO2, PSO3
CO2	PO1,PO2, PO4, PO5 /PSO2, PSO3

BECE0387: INDUSTRIAL PROCESSC CONTROLPROJECT

1. Title: - A robust parallel control structure for nonlinear and uncertain systems
2. Title:- Design of self tuned fuzzy PD controller for uncertain and nonlinear system
3. Title: - Design of nonlinear PID controller for complex systems.
4. Title: - Design of gain scheduling controller for nonlinear uncertain system.
5. Title:-Parameters estimation of nonlinear system using meta-heuristic optimization algorithm.

Common Abstract: - The dynamical control of industrial systems has been quite important in process control industries for improving the performance and profitability of the industry. These industries potentially rely on various control loops present in a plant. These loops often include control of flow rate, level, pressure, temperature and ratio etc. which incorporate nonlinear and uncertain dynamics in the control loops. Due to this, considerable attention must be paid to effective control of these complex systems to significantly improve the productivity of overall process. For this, design of robust parallel control structure, fuzzy PD controller, nonlinear PID controller, gain scheduling etc. will help in the effective control of these complex systems.

Exact parameters of plant are necessary for efficient control design and for which meta-heuristic optimization algorithms can be used to find the accurate parameters of the plant.

Course Outcome: On the completion of this course the student will be able to

CO1-Implement the classical controllers for complex systems.

CO2-Design the intelligent adaptive controllers for complex systems.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4, PO9 /PSO2, PSO3
CO2	PO1,PO2, PO4, PO5, PO9 /PSO2, PSO3

BECE0306: DIGITAL CONTROL SYSTEM

Course Objectives:

- To introduce the students with the basic knowledge of A/D and D/A conversion
- To represent the system in Z-domain.
- To introduce the students about the design of digital controller.
- To study the stability analysis of digital control system

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	Introduction - Advantages of Digital control systems - Practical aspects of the choice of sampling rate and multirate sampling - Basic discrete time signals - Quantization – Sampling theorem – Data conversion and Quantization - Sampling process - Mathematical modeling - Data reconstruction and filtering of sampled signals – zero - order hold. z - transform and inverse z - transform, Relationship between s - plane and z - plane – Difference equation - Solution by recursion and z - transform - pulse transfer functions of the zero - order Hold and relationship between G(s) and G(z)– Bilinear transformation. Digital control systems - Pulse transfer function - z transform analysis of open loop, closed loop systems - Modified z Transform - transfer function - Stability of linear digital control systems -Stability tests. Root loci - Frequency domain analysis - Bode plots - Gain margin and phase margin - Design of Digital Control Systems based on Root Locus Technique. Cascade and feedback compensation by continuous data controllers - Digital controllers	22
II	Design using bilinear transformation - Realization of Digital PID controllers State equations of discrete data systems, solution of discrete state equations, State transition Matrix: z -transform method. Relation between state equations and transfer functions. Concepts on Controllability and Observability - Digital state observer: Design of the full order and reduced order state observer - Pole placement design by state feedback. Design of Dead beat Controller - some case studies - Stability analysis of discrete time systems based on Lyapunov approach.	21

Text Books:

Gopal, Digital Control and State Variable Methods, Tata McGraw Hill, India, 1997.

References :

1. K. Ogata, Discrete Time Control Systems, PHI/Addison - Wesley Longman Pte. Ltd., India, Delhi, 1995.
2. B.C Kuo, Digital Control Systems, 2nd Edition, Oxford Univ Press, Inc., 1992.
3. F. Franklin, J.D. Powell, and M.L. Workman, Digital control of Dynamic Systems, Addison - Wesley Longman, Inc., Menlo Park, CA , 1998.
4. John S. Baey, Fundamentals of Linear State Space Systems, Mc. Graw – Hill, 1st edition
5. C. H. Houpis and G.B. Lamont, Digital Control Systems, McGraw Hill, 1985.

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

1. Understand the basic components of digital control system signals.

2. Represent the system in discrete time domain.
3. Compute the response of the system to different discrete time input signals.
4. Analyze the stability of the system using Lyapunov approach.
5. Design the digital controller and compensator, state observer.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2
CO3	PO1,PO2, PO3 /PSO1, PSO2, PSO3
CO4	PO1,PO2, PO3, PO5 /PSO1, PSO2, PSO3
CO5	PO1,PO2, PO3, PO5 /PSO1, PSO2, PSO3

BECE0307: MODERN CONTROL SYSTEM

Credits: 03 **L–T–P: 3–0–0**

Course Objectives

- To learn the fundamental concepts of state-space model of linear and non-linear system
- To evaluate the time response of linear and nonlinear systems.
- To learn the Liapunov stability analysis of nonlinear systems.
- To learn the concept of optimal control, LQR and Kalman filters.

Module No.	Contents	Teaching Hours
I	Basics of state space, eigen values, its invariance, diagonalization and Jordan canonical form, Caylay- Hamilton theorem, Computation of state transition matrix by a) Inverse Laplace method and b) Caylay Hamilton method, controllability and observability, state equations in Diagonal Canonical form, Decompositions of Transfer Functions, Effect of Pole-Zero cancellation in Transfer Function. Pole placement design, Ackermann's Formula for Pole Placement, design of full and reduced order state observers. Non-liner system: some common types of non linearlities, comparison of linear and non-linear systems, properties of nonlinear control systems, describing functions	**20**
II	Stability analysis using describing functions, limit cycle, Liapunov Stability Analysis of Linear Systems, Second method of Liapunov with four Stability theorems. Calculus of Variations: An Overview, Optimal Control Formulation using Calculus of Variations, Classical Numerical Methods for Optimal Control, Linear Quadratic Regulator (LQR) Design – I, Linear Quadratic Regulator (LQR) Design – II, An Overview of Kalman Filter Theory.	**22**

BOOKS:

1. I. J. Nagrath and M. Gopal, Control Systems Engineering, New Age International Publishers, Fourth Edition..

Course Outcomes: After successfully completing the course students will be able to

1. Represent the linear and nonlinear system in state space model.
2. compute the state response, observability and controllability of system.
3. Analyze the stability of nonlinear systems using Liapunov stability theorem.
4. Design state observer, LQR and Kalman Filter for the given system.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2
CO3	PO1,PO2, PO3 /PSO1, PSO2, PSO3
CO4	PO1,PO2, PO3 /PSO1, PSO2, PSO3
CO5	PO1,PO2, PO3 /PSO1, PSO2, PSO3

BECE0308: INDUSTRIAL AUTOMATION

Credits: 03 **L–T–P-J: 3–0-0-0**

Module No.	Contents	Teaching Hours
I	Review of computers in process control: Data loggers, Data Acquisition Systems (DAS), Direct Digital Control (DDC). Supervisory Control and Data Acquisition Systems (SCADA), sampling considerations. Functional block diagram of computer control systems.	14
II	Programmable logic controller (PLC) basics: Definition, overview of PLC systems, input/output modules, power supplies and isolators. General PLC programming procedures, programming on-off inputs/ outputs. Auxiliary commands and functions, PLC Basic Functions, register basics, timer functions, counter functions. PLC intermediate functions: Arithmetic functions, comparison functions, Skip and MCR functions, data move systems. PLC Advanced intermediate functions: Utilizing digital bits, sequencer functions, matrix functions. PLC Advanced functions: Alternate programming languages, analog PLC operation, networking of PLC, PLC-PID functions, PLC installation, troubleshooting and maintenance.	14
III	Design of interlocks and alarms using PLC. Distributed Control systems (DCS): Definition, Local Control Unit (LCU) architecture, LCU languages, LCU -Process interfacing issues, communication facilities, redundancy concept. Introduction–Evolution of signal standards –HART communication protocol –communication modes–HART networks. Introduction –General field bus architecture – basic requirements of field bus standard. Case studies of PLC and DCS with industrial applications.	14

Text Book:

1. John.W. Webb Ronald A Reis, “Programmable Logic Controllers –Principles and Applications”, 4th Edition, Prentice Hall Inc., New Jersey.
2. Lukcas M.P, “Distributed Control Systems”, Van Nostrand Reinhold Co., New York.

Course Outcomes: After successfully completing the course students will be able to

1. Understand the role of data loggers and the data acquisition system in a process control.
2. Analyze the programming of PLC for industrial application.
3. Design the controller programming using PLC.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/ PSOs
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO2, PSO3
CO3	PO1,PO2, PO3, PO4, PO5 /PSO2, PSO3

BECE0373: PLC AUTOMATION LAB

Credits: 1 **L–T–P: 0–0–2**

Module No.	Content
I	1. To study and configure PLC modules. 2. To study and create basic Boolean logics. 3. To develop ladder program for simple logic gates (AND, OR, NOR, NAND, NOT, XOR, XNOR). 4. To construct PLC program using the bit logic instructions. 5. To study the operation of different types of timers and to use the PLC timers in a process control. 6. To study the operation of different types of counters and to use the PLC counters and timers in a process control. 7. To design basic open loop and closed loop control structure in PLC. 8. To study the pump control system. 9. To study pump control system using HMI. 10. To configure and study of Servo drive system.

Outcomes: After successfully completing the course students will be able to

1. Implement the concept of basic digital electronics and data manipulation use timer, counter, and other intermediate programming functions.
2. Design and program basic PLC circuits for entry-level PLC applications for open loop and closed loop process control system.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO2, PSO3
CO2	PO1,PO2, PO3, PO4, PO5 /PSO2, PSO3

BECE0311: ADAPTIVE CONTROL

Credits: 03 **L–T–P-J: 3–0-0-0**

Module No.	Contents	Teaching Hours
I	Concepts of adaptive control. Adaptive control structures: direct and indirect adaptation. Distinction between tune on demand and continuous adaptation. Gain scheduling, model reference adaptive control and adaptive pole placement control. Overview of industrial adaptive controllers. Case study: internal model adaptive control. Fuzzy adaptive control	**24**
II	ANN based adaptive controllers	**20**

BOOKS:

1. K. J. ASTROM, B. WITTENMARK, Adaptive control. Massachusetts: Addison-Wesley Publishing Company, 1996. 589 p.

Outcomes: *After completion of this course student will able to:*

1. Understand the concept of adaptive filter, fuzzy sets and neural network.
2. Analyze the performance of adaptive controller with fuzzy logic and neural networks.
3. Design the adaptive control algorithm in fuzzy logic.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 PO5/PSO2, PSO3
CO3	PO1,PO2, PO3, PO4 PO5/PSO2, PSO3

BECE 0201: FUNDAMENTALS OF HDL PROGRAMMING

Credits: 03 **L–T–P: 3–0–0**

Course Objectives:

- Utilize HDL to design and analyze digital systems
- Know different FPGA's and implementation methodologies.
- Learn field programmable gate array (FPGA) technologies and implementation of digital circuits using EDA Tools and FPGA board.
- Understand configuring and implementing digital embedded system, microcontrollers, and microprocessors on FPGA.

Module No.	Contents	Teaching Hours
I	**Design and analysis of typical digital circuits**: Array multiplier, Booth multiplier, Sequence Detector, Shifter design, Mux Tree **Memory management concepts :**Memory hierarchy, associative memory, and cache memory organization, Direct Mapped,Fully Associative ,Set Associative **Basic VHDL Language Elements.** Identifiers. Data Objects. Data Types. Operators. **Behavioral Modeling.** Entity Declaration. Architecture Body. Process Statement. Variable Assignment Statement. Signal Assignment Statement. Wait Statement. If Statement. Case Statement. Null Statement. Loop Statement. Exit Statement. Next Statement. Assertion Statement. Report, Multiple Processes. Postponed Processes.	20
II	**Dataflow Modeling.** Concurrent Signal Assignment Statement. Concurrent versus Sequential Signal Assignment. Delta Delay Revisited. Multiple Drivers. Conditional Signal Assignment Statement. Selected Signal Assignment Statement. The UNAFFECTED Value. Block Statement. Concurrent Assertion Statement. Value of a Signal. **Structural Modeling.** Component Declaration. Component Instantiation. Resolving Signal Values **Description and design of sequential circuits using VHDL**: Flip-flop, Register and Counter, Design of a Serial Adder with Accumulator, design of a Binary Multiplier, Multiplication of a Signed Binary Number. VHDL models for a multiplexer. **Generics and Configurations.** Generics. Why Configurations? Configuration Specification. Configuration Declaration. Default Rules. Conversion Functions. Direct Instantiation. Incremental Binding.	20

Text Book:

- "*Computer System Architecture*", M. Morris Mano, PHI.
- "*VHDL Programming*" by Example – By Douglas L.Perry., 4th Ed., TMH. 2002.
- "*A VHDL Primer"* - By J.Bhasker ., Pearson Education Asia, 11th Indian Reprint, 2004.

Reference Books:

- "*The Designer's Guide to VHDL*" - By Peter J. Ashenden, 2nd Ed., 1st Indian Reprint, Harcourt India Pvt. Ltd., 2001.
- "*Fundamentals of Digital Logic with VHDL Design*" – By Stephen Brown &ZvonkoVranesic., TMH. 2002

- "*Digital Systems Design using VHDL*" by Charles H.Roth Jr., PWS Pub.,1998
- "*Introductory VHDL*" : From Simulation to Synthesis – By SudhakarYalamanchili., Pearson Education Asia., 2001

Course Outcomes: After successfully completing the course students will be able to

CO-1: Understand the process, importance in VHDL and Apply the same in stimulus block and design block.

CO2: Analyze performance characteristics of memory hierarchy

CO3: Design and implement Sequential digital circuits as per the specifications.

CO4: Apply gate level modeling and data flow modeling procedures to develop the software modules for digital systems.

CO5: Analyze the behavior of structural, dataflow and behavior modeling procedures written in VHDL language.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3, PO4 /PSO1, PSO2, PSO3
CO4	PO1,PO2, PO3, PO4 /PSO1, PSO2, PSO3
CO5	PO1,PO2, PO3, PO4 /PSO1, PSO2, PSO3

BECE0202: DIGITAL SYSTEM DESIGN USING HDL

Objectives:

- Design combinational circuits.
- Design simple synchronous circuits including counters and state machines.
- Use VHDL to produce digital designs suitable for implementation on Xilinx.

Credits: 03 **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours
I	**Design and analysis of typical digital circuits**: Array multiplier, Booth multiplier, Sequence Detector **Memory management concepts**Memory hierarchy, associative memory, and cache memory organization, Direct Mapped, Fully Associative ,Set Associative **Basic VHDL Language Elements.** Identifiers. Data Objects. Data Types. Operators. **Behavioral Modeling.** Entity Declaration. Architecture Body. Process Statement. Variable Assignment Statement. Signal Assignment Statement. Wait Statement. If Statement. Case Statement. Null Statement. Loop Statement. Exit Statement. Next Statement. Assertion Statement. Report, Multiple Processes. Postponed Processes. **Dataflow Modeling.** Concurrent Signal Assignment Statement. Concurrent versus Sequential Signal Assignment. Delta Delay Revisited. Multiple Drivers. Conditional Signal Assignment Statement. Selected Signal Assignment Statement. **Structural Modeling.** Component Declaration. Component Instantiation. Resolving Signal Values. **Introduction to VerilLog HDL:** Verilog as HDL, Levels of Design Description, Concurrency, **Language Constructs and Conventions:** Introduction, Keywords, Identifiers, White Space, Characters, Comments, Numbers, Strings, Logic Values, Strengths, Data Types, Scalars and Vectors, Parameters, Operators. **Gate Level Modeling:** Introduction, AND Gate Primitive, Module Structure, Other Gate Primitives, Illustrative Examples, Tristate Gates, Array of Instances of Primitives, Design of Flip-Flops with Gate Primitives, Delay **Behavioural Modeling:** Introduction, Operations and Assignments, 'Intial' Construct, Assignments with Delays, 'Wait' Construct, Multiple Always Block, Designs at Behavioural Level, Blocking and Non-Blocking Assignments, The 'Case' Statement, Simulation Flow, 'If' an 'if-Else' Constructs, 'Assign- De-Assign' Constructs, 'Repeat' Construct, for loop, 'The Disable' Construct, 'While Loop', Forever Loop, Parallel Blocks, Force-Release, Construct, Event.	28

Text Book:

- "*Computer System Architecture*", M. Morris Mano, PHI.
- "*VHDL Programming*" by Example – By Douglas L.Perry., 4th Ed., TMH. 2002.
- "*A VHDL Primer"* - By J.Bhasker ., Pearson Education Asia, 11th Indian Reprint, 2004.
- T.R. Padmanabhan, B Bala Tripura Sundari, Design Through Verilog HDL, Wiley 2009.
- ZainalabdienNavabi, Verliog Digital System Design,TMH, 2nd Edition.

Reference Books:

- "*The Designer's Guide to VHDL*" - By Peter J. Ashenden, 2nd Ed., 1st Indian Reprint, Harcourt India Pvt. Ltd., 2001.
- "*Fundamentals of Digital Logic with VHDL Design*" – By Stephen Brown &ZvonkoVranesic., TMH. 2002
- "*Digital Systems Design using VHDL*" by Charles H.Roth Jr., PWS Pub.,1998
- "*Introductory VHDL*" : From Simulation to Synthesis – By SudhakarYalamanchili., Pearson Education Asia., 2001

Course Outcomes: After successfully completing the course students will be able to

1. Understand the various primitives of Verilog and VHDL
   .
2. Design combinational and sequential circuits using Verilog and VHDL.
3. Implement the digital logic circuits using HDL on Xilinx.
4. Analyze the performance parameters like leakage power, delays and area of digital circuits

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3, PO4 /PSO1, PSO2, PSO3
CO4	PO1,PO2, PO3, PO4, PO5 /PSO1, PSO2, PSO3

BECE0271 DIGITAL SYSTEM DESIGN USING HDLLAB

Objectives:

- *The objective of this Lab to design and simulate learn the Hardware Descriptive Language (Verilog/VHDL) and the fundamental principles of VLSI circuit design in digital domain.*
- *To provide hands on design experience with professional design (EDA) platforms.*

Credits: **Semester VI** **L–T–P: 0–0–0**

Module No.	Content	Teaching Hours
I	PART A **2 Bit-Counter** The purpose of this lab is to write a HDL description of 2-bit counter as a finite state machine (FSM). The 2-bit counter has several inputs such as clk, rst, enable, load, and should beable to reset, accept an input, count-up or count-down, etc... **Parallel to Serial Converter** The purpose of this lab is to write a HDL description of a parallel to serial converter as an FSMD. The parallel to serial converter will accept an eight-bit number and send one bit of data over the data line per clock cycle. There is also a go bit, which tells the converter to start transmitting data. **VHDL Calculator** The purpose of this lab is to implement a finite state machine in VHDL to perform simple calculations like addition, subtraction, and multiplication. **A Simplified HDL UART** In this lab the students design a UART to send data to the PC.	
II	PART B **I^2C Bus Lab** HDL implementation of I2C bus protocol **Design of A Hardware Multiplier** In this lab students are going to implement hardware multiplier using Sequential Circuit Components. **ALU Design** The purpose of this lab is to build a 4/8 -bit ALU. The ALU is written behaviorally. It should take in two numbers and be able to add the numbers, subtract the numbers, NOR the numbers, or NAND the numbers.	

Outcomes: *After completion of Lab, student will be able to:*

4. *Write HDL code for basic as well as advanced digital integrated circuits.*
5. *Perform the Simulation and Analysis of Digital Blocks using EDA tools.*

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4, PO5 /PSO1, PSO2, PSO3

BECE0286: DIGITAL SYSTEM DESIGN USING HDLPROJECT

PART A

Programming using Verilog

1. HDL code to realize all the logic gates
2. HDL program for the following combinational designs
   a.2 to 4 decoder
   b. 8 to 3 (encoder without priority & with priority)
   c. 8 to 1 multiplexer
   D. 4 bit binary to gray converter
   e. De-multiplexer, comparator.
3. HDL code to realize 32 bit ALU
4. HDL Code for the following flipflops: SR, D, JK, and T
5. 4-bit binary ,BCD counters (Synchronous reset and asynchronous reset) and "any sequence" counters

PART B

Project

1. **Design and Verilog HDL Implementation of power efficient Carry Skip Adder Using Kogge-Stone Tree Logic**
   The portable equipment's such as cellular phones, Personal Digital Assistant (PDA), and notebook personal computer, arise the need of effective circuit area and power efficient VLSI circuits. Addition is the most common and often used arithmetic operation in digital computers and also, it serves as a building block for synthesis all other arithmetic operations. In this Experiment, student will perform a carry skip adder (CSKA) structure that has a higher speed yet lower energy consumption compared with the conventional one. The speed enhancement is achieved by applying concatenation and incrementation schemes to improve the efficiency of the conventional CSKA (ConvCSKA) structure. In addition, instead of utilizing multiplexer logic, the structure makes use of AND-OR-Invert (AOI) and OR-AND-Invert (OAI) compound gates for the skip logic. The structure may be realized with both fixed stage size and variable stage size styles, wherein the latter further improves the speed and energy parameters of the adder.

2. **Low Power High Performance memory Design on FPGA Using Different IO Standard**
   In this experiment student will design energy efficient ROM/RAM. Concept of io standard will be used to further improve the performance.Student can use most energy efficient I/O standard among LVCMOS, HSLVDCI, HSTL, LVDCI_DV2 and SSTL. I/O standard is used to match impedance of transmission line, impedance of port and impedance of memory for avoidance of transmission line reflection. In naming convention of I/O Standard, LV is Low Voltage, HS is High Speed, DV2 is Half Impedance, CMOS is Complementary Metal Oxide Semiconductor, DCI is Digitally Control Impedance and SSTL is Stub… CONTINUE READING

3. **Design and Implementation of Vending Machine using Verilog HDL**
   The vending machines are used to dispenses small different products (snacks, ice creams, cold drinks etc.), when a coin is inserted. These machines can be implemented in different ways by using microcontroller and FPGA board. Here in this experiment, the student will

learn an efficient algorithm for implementation of vending machine. Since FPGA based vending machine give fast response and uses less power than the microcontroller based vending machine.

4. **Efficient Implementation of 16-Bit Multiplier-Accumulator Using Radix-2 Modified Booth Algorithm and Spurious Power Suppression Technique(SPST) Adder Using Verilog.**

   In this experiment, student will learn a new multiplier-and-accumulator (MAC) architecture for low power and high speed arithmetic. High speed and low power MAC units are required for applications of digital signal processing like Fast Fourier Transform, Finite Impulse Response filters, convolution etc. For improving the speed and reducing the dynamic power, there is a need to reduce the glitches (1 to 0 transition) and spikes (0 to 1 transition). Adder designed using spurious power suppression technique (SPST) avoids the unwanted glitches and spikes, thus minimizing the switching power dissipation and hence the dynamic power. Radix -2 modified booth algorithm reduces the number of partial products to half by grouping of bits from the multiplier term, which improves the speed.

5. **Different IO Standard Based Green Multiplexer Design and Implementation using verilog**

   In this experiment student will use different IO Standard on the simplest VLSI circuit multiplexer and analyze the power dissipation with different class. Power and delay analysis will be performed.

Course Outcomes: After successfully completing the course students will be able to

CO1: Identify the suitable Abstraction level for a particular digital design.

C02: Design of Combinational and sequential logic circuits using HDL and its implementation on FPGA/CPLD

CO3: Analyze power, area, delay of various digital circuits for IoT applications.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4, PO5, PO(/PSO1, PSO2, PSO3
CO3	PO1,PO2, PO3, PO4, PO5, PO9 /PSO1, PSO2, PSO3

BECE0203: ANALOG VLSI DESIGN

Credits: 03 **L–T–P: 3–0–0**

Module No:	Content	Teaching Hours
I	Introduction to CMOS ICs, Body effect , small and large signal behavior of basic amplifier circuits, MOSFET Capacitances, Gain-boosed and Folded Cascode circuits, Cascode - Cascode current mirrors, Introduction to noise Representation of noise in circuits Noise in common-source and cascode circuits. Introduction to negative feedback, Nyquist plots and stability criteria, Loop gain and stability Single-stage opamp	12
II	Telescopic opamp, Folded-cascode opamp Two-stage opamp, Fully-differential opamps, Phase Detectors, PLL building blocks,Charge pump PLL and its limitations,Introduction to VCOs	14

Text books:

- Design of Analog CMOS Integrated Circuits by BehzadRazavi, TMH Edition.
- CMOS Analog Circuit Design by Philip E. Allen and Douglas R. Holberg, Oxford University Press, International Second Edition, 2010.

Reference books:

- Design of Analog CMOS Integrated Circuits by BehzadRazavi, TMH Edition.
- CMOS Analog Circuit Design by Philip E. Allen and Douglas R. Holberg, Oxford University Press, International Second Edition, 2010.
- Analysis and Design of Analog Integrated Circuits by Paul R. Gray, Paul J. Hurst, S. Lewis and R. G. Meyer, Wiley India, Fifth Edition, 2010.
- Analog Integrated Circuit Design by David A. Johns, Ken Martin, Wiley Student Edition, 2013.

Course Outcomes: After successfully completing the course students will be able to

CO1: Understand the basic concepts of MOSFET

CO2: Apply the CMOS Technology to design and analysis of analog integrated circuits.

CO3: Design the single stage and two stage amplifier

CO4: Analyze the performance of analog circuits

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3, PO4 /PSO2, PSO3
CO4	PO1,PO2, PO3, PO4 /PSO2, PSO3

BECE0204: VLSI TESTING AND TESTABILITY

Course Objective

- To know the various types of faults and also to study about fault detection, dominance
- To know the concepts of the test generation methods-DFT-BIST.
- To understand the fault diagnosis methods

Credits: 03 **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours
I	**Fault modeling and simulation:** Logical fault models- stuck-at faults, bridging faults; Fault detection, equivalence and dominance; General fault simulation techniques serial, parallel, concurrent and deductive fault simulation, critical path tracing, statistical fault analysis. **Test pattern generation for combinational and Sequential circuits:** ATPG for single stuck-at faults and multiple stuck-at faults, various ATPG algorithms-D algorithm. ATPG for single stuck-at faults in sequential circuits;	20
II	**Test pattern generation for Sequential circuits:** Test generation using iterative array models-TG from known initial state, generation of self-initializing test sequences,Extended backtrace method; Simulation based TG; TG using RTL models; random test generation **Design for testability:** Ad-hoc design for testability- test points, oscillators and clocks, logical redundancy; Controllability and observability, boundary scan partial/ full scan, serial and non-serial scan; boundary scan standard; Compression techniques; Built-in self test (BIST).	20

Text book:

- Abramovici, M., Breuer, M. A. and Friedman, "*A. D. Digital Systems Testing And Testable Design"*. IEEE press (Indian edition available through Jayco Publishing house), 2001.

Reference Books:

- Abramovici, M., Breuer, M. A. and Friedman, "*A. D. Digital Systems Testing And Testable Design"*. IEEE press (Indian edition available through Jayco Publishing house), 2001.
- Bushnell and Agarwal, "*V. D. VLSI Testing*", Kluwer.
- Agarwal, V. D. and Seth, S. C. "*Test Generation For VLSI Chips"*. IEEE computer society press.
- Hurst, S. L. "*VLSI Testing: Digital And Mixed Analog/Digital Techniques"*. INSPEC/IEE, 1999.

Course Outcomes:

CO1: Understand various types of fault model and the design for testability in various circuits

CO2: Demonstrate Fault Simulation techniques and Fault Diagnosis techniques.

CO3: Analyze the various combinational and sequential ATPG Techniques

CO4: Evaluate the significance of Built in Self-Test

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3, PO4 /PSO2, PSO3
CO4	PO1,PO2, PO3, PO4 /PSO2, PSO3

BECE0205: INTEGRATED CIRCUIT TECHNOLOGY

Credits: 03 **L–T–P: 3–0–0**

Objectives:

1. To get processes on semiconductor fabrication technologies.
2. Explore principles and theory of micro- and nanofabrication.
3. Understanding the fabrication and be able to apply to future research and processes.

Module No.	Contents	Teaching Hours
I	Introduction To IC Technology: SSI, MSI, LSI, VLSI Integrated Circuits. Crystal Growth and Wafer Preparation: Electronic Grade Silicon, Czochralski Crystal Growth, Silicon Shaping, Processing Considerations. Epitaxial: Vapour –Phase Epitaxial, Molecular Beam Epitaxy, Silicon on Insulators, Epitaxial Evaluation. Oxidation: Growth Kinetics, Thin Oxides, Oxidation Techniques and Systems, Oxides Properties. Lithography: Optical Lithography. Photo masks, Wet Chemical Etching. Dielectric and Polysilicon Film Deposition: Deposition Processes, Polysilicon , Silicon Dioxide, Silicon Nitride	21
II	Diffusion: Diffusion of Impurities in Silicon and Silicon Dioxide, DiffusionEquations, Diffusion Profiles, Diffusion Furnace, Solid, Liquid and Gaseous Sources , Sheet Resistance and its Measurement. Ion-Implantation: Ion-Implantation Technique, Range Theory, ImplantationEquipment. Metallization: Metallization Application, Metallization Choices, PhysicalVapour Deposition, Vacuum Deposition, Sputtering Apparatus. Packaging of VLSI devices: Package Types, Packaging Design Consideration, VLSI Assembly Technologies, Package Fabrication Technologies VLSI Process Integration: Fundamental Considerations For IC Processing, NMOS IC Technology, CMOS IC Technology, Bipolar IC Technology, Monolithic and Hybrid Integrated Circuits, IC Fabrication	21

Text Books:

- Stephen A. Campbell, “Fabrication Engineering at the micro and nano scale”, Oxford Univ Press.

Reference Books:

- S. M. Sze, “VLSI Technology”, 2nd Edition, McGraw –Hill Publication.
- S.K. Ghandhi, “VLSI Fabrication Principles”, 2nd Edition,. Willy-India Pvt. Ltd.
- J. D. Plummer, M. D. Deal and Peter B. Griffin, “Silicon VLSI Technology: Fundamentals,
  practice and modelling”, Pearson Education.
- Stephen A. Campbell, “Fabrication Engineering at the micro and nano scale”, Oxford Univ

Course Outcomes: After successfully completing the course students will be able to

1. Understand the fundamentals of crystal growth methods, Oxidation, Lithography, Deposition, Diffusion, Ion Implantation, Metallization methods.
2. Apply the fabrication processes implemented in a sequential manner for NMOS IC Technology, CMOS IC Technology, Bipolar IC Technology.
3. Compare the performance of low K and high K Dielectrics for integration of CMOS Technology, Bipolar IC Technology, Monolithic and Hybrid Integrated Circuits.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2,PSO3
CO3	PO1,PO2, PO3, PO4 /PSO2, PSO3

BECE 0206: FUNDAMENTALS OF LOW-POWER VLSI CIRCUITS AND SYSTEMS

Objectives:

- Get knowledge of MOS circuits design.
- Analyze various types of power dissipation in CMOS circuits.
- Explain the various power reduction techniques.
- Design and implementation of power reduction techniques to minimize the power dissipation.

Credits: 03 **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours
I	**Basics of MOS circuits:** MOS Structure, Operation of MOSFET, MOSFET - Current /Voltage Characteristics, Scaling and Small geometry effects and capacitances MOS Inverters, Resistive Load Inverter, Inverters with n-type MOSFET load-Depletion load inverter, Enhancement load, CMOS Inverter MOS Combinational Circuits - Different Logic Families, **Sources of Power dissipation:** Dynamic Power Dissipation, Short Circuit Power Switching Power, Gliching Power, Static Power Dissipation, Degrees of Freedom **Supply Voltage Scaling Approaches:** Device feature size scaling, Multi-Vdd Circuits, Architectural level approaches: Parallelism, Pipelining, Voltage scaling using high-level transformations, Dynamic voltage scaling, Power Management	23
II	**Switched Capacitance Minimization Approaches:** Hardware Software Tradeoff, Bus Encoding, Two's complement Vs Sign Magnitude, Architectural optimization, Clock Gating, Logic styles **Leakage Power minimization Approaches:** Variable-threshold-voltage CMOS (VTCMOS) approach, Multi-threshold-voltage CMOS (MTCMOS) approach, Power gating, , Transistor stacking Dual-Vt assignment approach (DTCMOS)	22

Text Books:

- Sung Mo Kang, Yusuf Leblebici, CMOS Digital Integrated Circuits, Tata Mcgrag Hill.
- Neil H. E. Weste and K. Eshraghian, Principles of CMOS VLSI Design, 2nd Edition, Addison Wesley (Indian reprint).
- Bellamour, and M. I. Elmasri, Low Power VLSI CMOS Circuit Design, Kluwer Academic Press, 1995.
- Anantha P. Chandrakasan and Robert W. Brodersen, Low Power Digital CMOS Design, Kluwer Academic Publishers, 1995.

Reference Books:

- Kaushik Roy and Sharat C. Prasad, Low-Power CMOS VLSI Design,Wiley-Interscience, 2000.

Course Outcomes: After successfully completing the course students will be able to

CO 1:- Understand the basic fundamental concepts of CMOS circuits, SRAMs/ DRAMs, power minimization approaches including device feature size scaling, multi-Vdd Circuits, architectural level approaches.

CO 2:- Explain the Short Channel Effects and switched capacitance minimization.

CO 3:-Analyze the performance of architectural approaches and scaling of CMOS integrated circuits with reference to speed and power dissipation.

CO 4:- Apply the power minimization techniques to reduce the power dissipation.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3, PO4 /PSO2, PSO3
CO4	PO1,PO2, PO3, PO4 /PSO2, PSO3

BECE0207: LOW-POWER VLSI CIRCUITS AND SYSTEMS

Objectives:

- Get knowledge about various types of power dissipation in CMOS circuits.
- Analyze the different supply voltage scaling approaches.
- Analyze the various power reduction techniques.
- Design and implementation of power reduction techniques to minimize the power dissipation.

L–T–P: 3–0–0

Module No.	Contents	Teaching Hours
I	**Fundamentals:** Need for Low Power Circuit Design, Sources of Power Dissipation: Switching Power Dissipation, Short Circuit Power Dissipation, Leakage Power Dissipation, Glitching Power Dissipation **Supply Voltage Scaling Approaches:** Device feature size scaling, Multi-Vdd Circuits, Architectural level approaches: Parallelism, Pipelining, Voltage scaling using high-level transformations, Dynamic voltage scaling, Power Management	23
II	**Switched Capacitance Minimization Approaches:** Hardware Software Tradeoff, Bus Encoding, Two's complement Vs Sign Magnitude, Architectural optimization, Clock Gating, Logic styles **Leakage Power minimization Approaches:** Variable-threshold-voltage CMOS (VTCMOS) approach, Multi-threshold-voltage CMOS (MTCMOS) approach, Power gating, , Transistor stacking Dual-Vt assignment approach (DTCMOS)	22

Text Books:

- Sung Mo Kang, Yusuf Leblebici, CMOS Digital Integrated Circuits, Tata Mcgrag Hill.
- Neil H. E. Weste and K. Eshraghian, Principles of CMOS VLSI Design, 2nd Edition, Addison Wesley (Indian reprint).
- Bellamour, and M. I. Elmasri, Low Power VLSI CMOS Circuit Design, Kluwer Academic Press, 1995.
- Anantha P. Chandrakasan and Robert W. Brodersen, Low Power Digital CMOS Design, Kluwer Academic Publishers, 1995.

Reference Books:

- Kaushik Roy and Sharat C. Prasad, Low-Power CMOS VLSI Design,Wiley-Interscience, 2000.

Course Outcomes: After successfully completing the course students will be able to

CO 1:- Understand the basic fundamental concepts of CMOS circuits, SRAMs/ DRAMs, power minimization approaches including device feature size scaling, multi-Vdd Circuits, architectural level approaches.

CO 2:- Explain the Short Channel Effects and switched capacitance minimization.

CO 3:-Analyze the performance of architectural approaches and scaling of CMOS integrated circuits with reference to speed and power dissipation.

CO 4:- Apply the power minimization techniques to reduce the power dissipation.

CO 5:- Design of SRAM cell for Low power applications.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3, PO4, PO5 /PSO2, PSO3
CO4	PO1,PO2, PO3, PO4, PO5 /PSO2, PSO3
CO5	PO1,PO2, PO3, PO4, PO5,PO9 /PSO2, PSO3

BECE 0272: LOW POWER VLSI CIRCUITS AND SYSTEMS LAB

Credits: 1 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
I	PART A Draw the Layout, do circuit partitioning, placement and routing, circuit compaction, check DRC , Circuit extraction and finally post layout simulation for different combinational and sequential circuits.	
II	PART B Use the feature of automation test program generation, multilevel logic synthesis for design smaller application chips like multi bit parallel adder priority encoder, gereral purpose register, ALU, microcontroller/ dsp processor/ traffic light controller /sequential adder etc.	

Outcomes: *After completion of Lab, student will be able to:*

1. *Implement and simulate Write HDL code for basic as well as advanced digital integrated circuits.*
2. *Design and Analysis of Digital Blocks using EDA tools.*

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4, PO5 /PSO1, PSO2, PSO3

BECE0287: LOW-POWER VLSI CIRCUITS AND SYSTEMS PROJECT

Projects List:

VLSIL01 Low Power Dual Edge Triggered FLIP-FLOP

In the research of low power and low voltage VLSI circuits, the use and implementationof dual edge triggered flip flop (DETFF) has gained more attention at the gate level design. The main advantage of using DETFF is that it allows one to maintain a constantthroughput while operating at only half the clock frequency.Forthe performance evaluation of DETFF, the optimal delay, power consumption, and energy has to determine as the primary figures of merit.

VLSIL02 Implement of Full Adder of Cells Using 90nm Technology

The most widely used arithmetic operation in digital applications is addition.Full adder is the most important building block in digital signal processors and controllers as it is used in arithmetic logic circuit (ALU), in the floating point unit and in case of cache or memory access address generation. Asdensity of IC chip increases, power consumption also increases. Hence low power design is the primary requirement in the VLSI field.Reducing delay of a digital circuit is an important topic in logic design for efficient implementation of adder.

VLSIL03 Performance Analysis of Power Gating Designs in Low Power VLSI Circuits

The growing market of mobile, battery powered electronic systems (e.g., cellular phones, personal digital assistants, etc.) demands the design of microelectronic circuits with low power dissipation. As density and complexity of the chips continue to increase, the difficulty in providing power dissipation might limit the functionality of the computing systems. Especially, at nanometer level the power dissipation consumes about 35% of the chip power. The purpose of this project is to analyse the performance of one of the most trustful approaches to low power design called as "Power Gating".

VLSIL04 Design of Sequential Elements For Low Power Clocking System

Power consumption is a major bottleneck of system performance and is listed as one of the top three challenges in International Technology Roadmap for Semiconductor 2008. In practice, a large portion of the on chip power is consumed by the clock system which ismade of the clock distribution network and flop-flops. In this project Low Power Clocking System withLowPower Techniques will be implemented and analyzed.

VLSIL05 Energy Efficient Adiabatic Logic For Low Power VLSI Applications

The power dissipation has become a major design issue in VLSI circuits. As the system size is shrinking gradually it has become one of the prime concerns for the designers. The power dissipation can be reduced by introducing different design techniques. The power dissipation in adiabatic circuits can be minimized more than 90% as compared to conventional CMOS logic. In adiabatic circuit the charge stored in load capacitor is recovered while in conventional CMOS it is transferred to ground which causes wastage of energy. In this project Adiabatic Logic Circuits has to be implementing and analyze for Low Power VLSI Applications.

Course Outcomes: After successfully completing the course students will be able to

CO 1:-Identify the challenges in low power VLSI circuits.

CO 2:-Design a project based on power minimization techniques.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4, PO5, PO9 /PSO1, PSO2, PSO3

BECE0208: FUNDAMENTALS OF RF INTEGRATED CIRCUITS

Objectives:

To provide students with RF circuit fundamentals for designing key building blocks in a typical RF transceiver.

Credits: 04 **L–T–P: 3–1–0**

Module No.	Contents	Teaching Hours
I	Introduction; Advantages and challenges of high frequency design, S-Parameters, dB Units , Resonance in LC circuits, BW and Quality factor, Impedance transformations and matching; L-matches, Noise and Distortion: Harmonics and Intermodulation, Noise in RF Circuits, Resistor thermal noise , Noise in MOSFET: MOSFET Thermal noise , Flicker Noise.Transmitter Architectures: Transmitter versus Receiver metrics, Transmitter Architectures- Direct Conversion Transmitter, Power Amplifier Pulling and its different solutions, Heterodyne Transmitter, Issues in transmitter	21
II	Direct-Conversion Receiver, DC offset Problem and its solution, Heterodyne Receiver, Image frequency problem, Image reject filters ,Introduction to Low Noise Amplifier (LNA), Common Source LNA with inductive degeneration Mixer: Metrics , Single balanced and double balanced Mixers, Square law Mixer, Switching Mixers, , GilbertMixer,Voltage Controlled Oscillators, RC and LC oscillators, Power Amplifiers, linear versus constant envelope type power amplifiers	22

Text Books:

- RF Microelectronics by Behzad Razavi, Second Edition, Pearson.

Reference books:

- The Design of CMOS Radio-Frequency Integrated Circuits by Thomas H. Lee. Cambridge University Press, 2006.
- VLSI for Wireless Communication by Bosco Leung (Publisher: Prentice Hall - Electronics and VLSI Series)

Course Outcomes: After successfully completing the course students will be able to

1. Understand the basic principle, tradeoffs and design issues of radio frequency circuits.
2. Analyze typical transceiver architectures including direct conversion & heterodyne.
3. Design key building blocks of RF transceivers, including standard matching circuits, low-noise amplifiers, mixers, power amplifiers and RF oscillators.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/ PSOs
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3, PO4 /PSO2, PSO3
CO4	PO1,PO2, PO3, PO4 /PSO2, PSO3

BECE0209: RF INTEGRATED CIRCUITS

Objectives: To provide students with RF circuit fundamentals for designing key building blocks in a typical RF transceiver using CMOS technology.

Credits: 04 **L–T–P: 4–0–0**

Module No.	Contents	Teaching Hours
I	Parallel and Series RLC Resonant Networks, Impedance matching , L Match-Low pass and High pass , T and Pi-match networks, RF Concepts: Non-linearity, Time variant, Harmonics, Gain Compression, Desensitization and Blocking, Cross-modulation, Intermodulation, Two tone test, Noise in RF circuits, Noise figure, Cascaded noise Figure, Transmitter : Cartesian and Polar Representation, Homodyne and Heterodyne architecture, Transmitter design issues: PA Pulling, Emission mask, Adjacent Channel Power, Spurs, noise	21
II	Direct conversionReceiver, Issues-DC offset, LO Self mixing, Interference leakage, 1/f noise, LO Pulling, Even order distortion I/Q mismatch, Heterodyne Receiver, low side and high side injection, IF frequency selection, Issues-Image Problem, Image reject filters, Image Reject Receivers-Hartley and Weaver Architectures, Low noise amplifier (LNA), LNA Topologies, Mixers, Two-port and Three port mixers, Gilbert Mixer, Sources of non-linearity and noise in Gilbert Mixers, ,Oscillators , RC and LC oscillators , Cross-coupled LC Oscillators ,Power Amplifiers-Linear and Switching type Power Amplifiers	22

Text Books:

- RF Microelectronics by BehzadRazavi. Pearson, 2012.

Reference Books:

- The Design of CMOS Radio-Frequency Integrated Circuits by Thomas H. Lee. Cambridge University Press, 2006.

Course Outcomes: After successfully completing the course students will be able to

1. Understand the principle, tradeoffs and design issues of radio frequency circuits.
2. Analyze typical transceiver architectures including direct conversion & heterodyne, Image reject
3. Design key building blocks of RF transceivers, including standard matching circuits, low-noise amplifiers, mixers, power amplifiers and RF oscillators.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/ PSOs
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 /PSO1, PSO2
CO3	PO1,PO2, PO3, PO4, PO5 /PSO2, PSO3
CO4	PO1,PO2, PO3, PO4, PO5 /PSO2, PSO3

BECE 0273: RF INTEGRATED CIRCUITS LAB

Credits: 01 **L–T–P: 0–0–2**

Objective:

- To perform the experiment *design and simulate the key building blocks of a typical RF Transceiver system.*

Module	Content	Teaching Hours
I	Design and Simulation of Different type of impedance matching networks(L, T and Pi)	24
	Design and Simulation of Low Noise Amplifier.	
	Design and Simulation of RF Mixer	
	Design and Simulation of Voltage Controlled Oscillator (VCO)	
	Design and Simulation of Phase Locked Loop (PLL)	
	Design and Simulation of Power Amplifier	

Outcomes: After successful completion of this course, student are able todesign and simulate

CO 1: Design and simulate L, Pi and T type impedance matching networks using high frequency simulation software environment including ADS, Cadence virtuoso

CO 2: Analyze the performance in terms of matching, linearity, noise of Low noise amplifiers, Mixer, Voltage Controlled Oscillator, Phase locked loop and power amplifiers using high frequency simulation software environment including ADS, Cadence virtuoso.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 /PSO1, PSO2, PSO3
CO2	PO1,PO2, PO3, PO4, PO5 /PSO1, PSO2, PSO3

BECE0288: RF Integrated Circuits Project

Projects on RF Integrated circuits:

RF Integrated Circuits course focus on design of RF module of a wireless transceiver system

1. Design low noise amplifier for transceiver system for a specific wireless standard.
2. Design of power amplifier for transceiver system for a specific wireless standard.
3. Design of switch for transceiver system for a specific wireless standard.
4. Design of mixerfor transceiver system for a specific wireless standard.
5. Design of voltage controlled oscillator for transceiver system for a specific wireless standard.
6. Design of filterfor transceiversystem for a specific wireless standard.

Technologies:

- Silicon CMOS
- GaN-Suitable for power amplifiers

Popular Wireless Standards:

- Cellular networks: 5G
- Wireless Personal Area Networks:IEEE Std 802.15.4™-2015, WiMedia,BT/BLE
- Wireless Local Area Networks: IEEE 802.11/a/b/g/n/VHT
- Internet of Things (IOT):ZigBee, LTE-M, NB-IOT

References:

I. Razavi B. RF Microelectronics. Pearson Education International Upper Saddle River NJ; 2012
II. RFIC Design and Testing for Wireless Communications, A PragaTI(TI India Technical University) Course, July 18, 21, 22, 2008 by Vishwani D. Agrawal and Foster Dai, 200 Broun Hall, Auburn University Auburn, AL 36849-5201, USA

Outcomes: - After successful completion of this course, students are able to

1. Identify the design specifications of the components of RF transceiver blocks including LNA, mixer, oscillators, PLL and power amplifier for a specified wireless standard.
2. Design and simulate the any one the component of RF transceiver including LNA, mixer, oscillators, PLL and power amplifier for a specified wireless standard

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4, PO5, PO9 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4, PO5, PO9 /PSO2, PSO3

BECE0210: MICRO AND NANO DEVICES

Credits: 03 **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours
I	Recapitulation of MOS scaling laws, Short channel effects, MOSFET models,Nano CMOS, Effects of gate oxide tunneling, Concept of EOT, high-k dielectrics, Effects of nanoscaling on MOSFET characteristics and performance, Technology trend, Advanced CMOS structures, SOI. Semiconductor heterojunctions; compound semiconductor and silicon-germanium heterostuctures, superlattice, HBTs, PETs, MESFETs, advanced solar cell structures.	21
II	Fundamental concepts of quantum structures and tunneling junctions, Nanotubes, Devices based on quantum wells, quantum wires/nanotubes and quantum dots – HEMTs, RTDs, CNT MOSFETs, SETs, Terahertz devices, advanced optoelectronic devices.Outline of nanofabrication – nanolithography, MBE, MOVPE; Introduction to molecular electronics.	21

Text Books:

- Yuan Taur, Tak H. Ning, Fundamentals of Modern VLSI devices, Cambridge University press
- B.R.Nag, Physics of Quantum well Devices, Springer Netherlands
- S. M. Sze, "VLSI Technology", 2nd Edition, McGraw –Hill Publication.

Course Outcomes:

1. Understanding of basic concepts related to CMOS devices.
2. Analysis of effects of nano-scaling on MOSFET characteristics.
3. Study of advanced solar cell structure
4. Explain the various unit-processes in micro/nano fabrication

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3 /PSO1, PSO2
CO2	PO1,PO2, PO3 /PSO1, PSO2, PSO3
CO3	PO1,PO2, PO3 /PSO1, PSO2, PSO3
CO4	PO1,PO2, PO3 /PSO1, PSO2, PSO3

BECE 0211: FUNDAMENTALS OF MEMORY DESIGN AND TESTING

Objectives:

- Get complete knowledge regarding different types of memories and their architectural techniques of memories.
- Analyze different parameters that lead malfunctioning of memories.
- Design reliable memories with efficient architecture to improve processes times and power.
- Design memory circuits with low power dissipation.

Credits: 04 **L–T–P: 4–0–0**

Module No:	Content	Teaching Hours
I	Introduction to SRAM, SRAM Architecture, SRAM Design Issues and Challenges, SRAM Bit-cell Topologies, Design Metrics of SRAM Bit-cell, Standard 6T SRAM Bit-cell: An Overview, Other SRAM Bit-cell Stability Metrics, Bit-line Measurement Design Metrics, Dynamic Stability Analysis, Single-Ended SRAM Bit-cell Design, Single-Ended 6T SRAM (SE-SRAM) Bit-cell, Read Stability and Write Ability Margins, Performance and Power Dissipation,	14
II	Tunneling Transistors Development of TFETs Behavioural Model, NBTI and Its Effect on SRAM, The Physics of Negative Bias Temperature Instability NBTI Model SRAM Bitcells Under NBTI Effect of NBTI Under Process Variation Dynamic Random Access Memories (DRAMs):DRAM Technology Development-CMOS DRAMs- DRAMs Cell Theory and Advanced Cell Strucutures-BiCMOS DRAMs-Soft Error Failures in DRAMs-Advanced DRAM Designs and Architecture-Application Specific DRAMs. Memory Fault Modeling, Testing, And Memory Design For Testability And Fault Tolerance RAM Fault Modeling,	14

Text/ References books:

- Jawar Singh, Saraju P. Mohanty, Dhiraj K. Pradhan"Robust SRAM Designs and Analysis"by, ISBN 978-1-4614-0817-8, Springer New York Heidelberg Dordrecht London
- A.K Sharma, " Semiconductor Memories Technology, Testing and Reliability", IEEE Press.:
- Luecke Mize Care, " Semiconductor Memory design & application", Mc-Graw Hill.

Outcomes:

- Analysis the different types of SRAM designs.
- Analysis the different RAM architecture.
- Analysis about design and characterization technique.
- Identification of new developments in semiconductor memorydesign.

BECE 0212: Design of Analog/ Mixed Mode VLSI Circuits

Credits: 04 **L–T–P-J: 3–1–0-0**

Module No.	Contents	Teaching Hours
I	Basic CMOS Circuit Techniques, Continuous Time And Low voltage Signal Processing: Mixed-Signal VLSI Chips-Basic CMOS Circuits-Basic Gain Stage-Gain Boosting Techniques-Super MOS Transistor-Primitive Analog Cells-Linear VoltageCurrent Converters-MOS Multipliers and Resistors-CMOS, Bipolar and Low-Voltage BiCMOS Op-Amp Design-Instrumentation Amplifier Design-Low Voltage Filters. Basic BiCMOS Circuit Techniques, Current -Mode Signal Processing: ContinuousTime Signal Processing-Sampled-Data Signal Processing-Switched-Current Data Converters. Sampled-Data Analog Filters, Over Sampled A/D Converters And Analog Integrated Sensors: First-order and Second SC Circuits-Bilinear Transformation - Cascade Design-Switched-Capacitor Ladder Filter-Synthesis of Switched-Current FilterNyquist rate A/D Converters-Modulators for Over sampled A/D Conversion-First and Second Order and Multibit Sigma-Delta Modulators-Interpolative Modulators – Cascaded Architecture-Decimation Filters-mechanical, Thermal, Humidity and Magnetic Sensors-Sensor Interfaces.	20
II	Analog VLSI Interconnects: Physics of Interconnects in VLSI-Scaling of Interconnects-A Model for Estimating Wiring Density-A Configurable Architecture for Prototyping analog Circuits. Statistical Modeling And Simulation, Analog Computer-Aided Design And Analog And Mixed Analog-Digital Layout: Review of Statistical Concepts - Statistical Device Modeling- Statistical Circuit Simulation-Automation Analog Circuit Design-automatic Analog Layout-CMOS Transistor Layout-Resistor Layout-Capacitor Layout-Analog Cell Layout-Mixed Analog -Digital Layout.	21

Text /Reference Book:

1. Paul R. Gray and Robert G.Meyer, “ Analysis and Design of Analog Integrated Circuits”, John Wiley & Sons.
2. Mohammed Ismail, Terri Fiez, " Analog VLSI signal and Information Processing ", 1994, McGraw-Hill International Editons.
3. Behzad Razavi, “ Design of Analog CMOS Integrated Circuits”, Tata Mc-Graw Hill.
4. Y. Tsividis, “ Mixed Analog-Digital Devices and Technology”, Mc-Graw Hill.
5. Alan B. Gnebene, “ Bipolar and MOS analog integrated circuit design“,John Wiley & Sons.
6. Mohammed I. Elmasy,” Digital Bipolar circuits “, John Wiley & Sons.
7. Greogorian & Tames, “ Analog Integrated Circuit For Switched Capacitor Circuit “

BECE0213: ADVANCED DIGITAL DESIGN USING VERILOG

Credits: 04 **L–T–P-J: 3–1–0-0**

Advanced Digital Design Using Verilog

Module No.	Content	Teaching Hours
I	**Review of logic gates, Boolean Logic and Combinational circuits.** **Analysis of clocked synchronous sequential circuits and modeling**- State diagram, state table, state table assignment and reduction-Design of synchronous sequential circuits design of iterative circuits-ASM chart and realization using ASM. **Analysis of asynchronous sequential circuit** – flow table reduction-races-state assignment-transition table and problems in transition table- design of asynchronous sequential circuit-Static, dynamic and essential hazards – data synchronizers – mixed operating mode asynchronous circuits – designing vending machine controller **Programming logic device families** – Designing a synchronous sequential circuit using PLA/PAL – Realization of finite state machine using PLD – FPGA – Xilinx FPGA-Xilinx 4000	21
II	**Verilog** : Introduction, Lexical conventions, Data types and Operators, All types of Modeling, Memories, FSM, UDP, Task and Function, System Task, Timing delays and Checks **Synthesis and Simulation**: Introduction to HDL simulation and Synthesis, Synthesis of Verilog and VHDL constructs, Verilog and VHDL coding guidelines, Optimization and Pipelining, Low power Synthesis, Reset synchronizer **Digital System Design:** Flip-flop, Shift register, SRAM, A bit-counting circuit, ASM-Chart-Implied Timing Information, Shift-and-Add Multiplier, Divider Arithmetic Mean, Sort Operation **Clock Synchronization**: Clock Skew, Flip-Flop Timing Parameter, Asynchronous Inputs to Flip-Flops, Switch Debouncing	22

Text Book:

1. Stephen D Brown, “Fundamentals of digital logic”, TMH publication, 2007.
2. Charles H.Roth Jr “Fundamentals of Logic Design”, Thomson Learning 2004
3. Stephen D Brown, “Fundamentals of digital logic”, TMH publication, 2007.
4. Balabanian, “Digital Logic Design Principles”, Wiley publication, 2007.
5. Stalling, “Computer Organization & Architecture”, Pearson Education India, 2008.
6. Verilog HDL: A Guide to Digital Design and Synthesis, Second Edition By Samir Palnitkar

Reference Books:

1. M. Morris Mano and M. D. Ciletti, “*Digital Design*” 4th Edition, Pearson Education.

BECE 0274: ADVANCED DIGITAL SYSTEM DESIGN USING VERILOG LAB

Credits:

Course Objectives:

1. Analyze the designing of various combinational and sequential circuits.
2. Design of synchronous and asynchronous sequential circuits using FSM
3. Understand the various primitives of Verilog.
4. Implement the digital logic circuits using HDL on Xilinx.

Module No.	Content	Teaching Hours
I	1. Write HDL code to realize all the logic gates 2. Write a HDL program for the following combinational designs a. 2 to 4 decoder b. 8 to 3 (encoder without priority & with priority) c. 8 to 1 multiplexer d. 4 bit binary to gray converter e. Multiplexer, de-multiplexer, comparator. 3. Write a HDL code to describe the functions of a Full Adder Using three modeling styles. 4. Develop the HDL code for the following flip-flops, SR, D, JK, T. 5. Design 4 bit binary, BCD counters (Synchronous reset and Asynchronous reset) and "any sequence" counters 5. Write a model for 32 bit ALU • ALU should use combinational logic to calculate an output based on the four bit op-code input. • ALU should pass the result to the out bus when enable line in high, and tri-state the out bus when the enable line is low.	
	INTERFACING (at least four of the following must be covered using VHDL/Verilog) 1. Write HDL code to display messages on the given seven segment display and LCD and accepting Hex key pad input data. 2. Write HDL code to control speed, direction of DC and Stepper motor. 3. Write HDL code to accept 8 channel Analog signal, Temperature sensors and display the data on LCD panel or Seven segment display. 4. Write HDL code to generate different waveforms (Sine, Square, Triangle, Ramp etc.,) using DAC change the frequency and amplitude. 5. Write HDL code to simulate Elevator operations 6. Write HDL code to control external lights using relays.	

Text Book:

2. Verilog HDL: A Guide to Digital Design and Synthesis, Second Edition By Samir Palnitkar

Reference Books:

3. M. Morris Mano and M. D. Ciletti, "*Digital Design*" 4th Edition, Pearson Education.

BECE 0207: FPGA PROTOTYPING USING SYSTEM VERILOG

Credits: 04 **L–T–P-J: 3–1–0-0**

Module No.	Contents	Teaching Hours
I	Introduction to System Verilog, Gate-Level Design Using System Verilog, Hierarchical Design, Constants and Multi-Bit Signals, Dataflow in System Verilog. Behavioural System Verilog Models for Combinational Logic and Sequential Logic Blocks , Memories:- Register File Design and Multi-Ported Register File Design using System Verilog, Larger Memories, Read-Only Memories (ROM) Writing Test Benches, Basic Test benches (Clock Generation, Reset and Other Deterministic Signals, Monitoring Responses, Dumping Responses, Test Vectors from a File) ,Test bench Structure, Constrained Random Stimulus Generation, Object-Oriented Programming, Randomization ,Assertion-Based Verification	20
II	FSM:- A Simple State Machine - A Sequence Recognizer, A Continuous ’011’ Detector - Moore Version and Mealy Version, Finite State Machine Example - Car Wash Controller , Resetting State Machines State Machine Design using System Verilog:- System Verilog Features for Coding State Machines, The 2-Always Block State Machine Coding Style, Enumerated Types for Symbolic State Names, The always comb IFL/OFL Block, State Machine Coding Styles Field Programmable Gate Arrays- An Introduction:- Lookup Tables - Universal Function Generators , FPGA Logic Elements, Global FPGA Architecture ,Configuring an FPGA Device ,More Advanced FPGA Architectures, FPGA vs. ASIC Technology Case Studies:- LFSR, Debouncing Switches , Detecting edges, Sequential Parity Detector, Vending Machine, Design of a UART, A Simple Microprocessor	21

Text Book:

- Designing Digital Systems With System Verilog v2.1 by Dr. Brent E. Nelson
- Digital System Design with System Verilog by Mark Zwolinski, Prentice Hall
- RTL Modeling with SystemVerilog for Simulation and Synthesis using SystemVerilog for ASIC and FPGA design by Stuart Sutherland
- FPGA PROTOTYPING BY SYSTEMVERILOG EXAMPLES Xilinx MicroBlaze MCS SoC Edition by Pong P. Chu, Wiley

BECE 0272: FPGA PROTOTYPING USING SYSTEM VERILOG LAB

Credits: 01 **L–T–P: 0–0–2**

Module No.	Contents	Teaching Hours
I	Designing of system verilog code for the followings and implementation of the same on a suitable FPGA: four bit full adder, 4:1 MUX, 4:1 MUX using 2:1 MUX, binary to gray converter, 3:8 decoder, full adder design using 3:8 decoder, BCD to seven segment display. System verilog code for the SR-flipflop, JK-flipflop, D-flipflop, T-flipflop, Serial-in to Serial-out (SISO) register, Serial-in to Parallel-out (SIPO) register, Parallel-in to Serial-out (PISO), Parallel-in to Parallel-out (PIPO) register, 8-bit up-down counter, and peak detector. Designing of vending machine for the case of both Mealy and Moore, Traffic light controller, Automatic car wash controller, Sequence detector using both Mealy and Moore: for all these modules designing of system verilog code and implementation of the same on a suitable FPGA.	24

Text /Reference Book:

- Designing Digital Systems With System Verilog v2.1 by Dr. Brent E. Nelson
- Digital System Design with System Verilog by Mark Zwolinski, Prentice Hall
- RTL Modeling with SystemVerilog for Simulation and Synthesis using SystemVerilog for ASIC and FPGA design by Stuart Sutherland
- FPGA PROTOTYPING BY SYSTEMVERILOG EXAMPLES Xilinx MicroBlaze MCS SoC Edition by Pong P. Chu, Wiley

BECE 0214: HARDWARE VERIFICATION USING SYSTEM VERILOG AND UVM (UNIVERSAL VERIFICATION METHODOLOGY)

Credits: 04 **L–T–P-J: 3–1–0-0**

Module No.	Contents	Teaching Hours
I	System Verilog: Introduction to HDL and HVL, Data Types and Operators, Object Oriented programming, Randomization and Its constrained, Inter Process communication and Synchronization, Code and Functional coverage, Assertions, Test bench Environment	20
II	UVM class library, UVM objects, UVM Components, TLM ports, UVM phases and Factory concept, UVM Report Mechanism, UVM testbench Environment Introduction to basic protocol of Industry, Latest technologies based on these protocols, Practical exposure of different protocols	21

Text Book:

- FPGA-Based System Design Wayne Wolf, Verlag: Prentice Hall
- Modern VLSI Design: System-on-Chip Design (3rd Edition) Wayne Wolf, Verlag

BCSG0001: PYTHON PROGRAMMING

Objective: *This course introduces the solving of mathematical problems using Python programming using OO concepts and its connectivity with database.*

Credits:03 **L-T-P-J:3-0-0-0**

Module No.	Content	Teaching Hours
I	Introduction to Python: Introduction and Basics; Setting up path Python Data Variables & Operators: Data Variables and its types, id () and type () functions, Coding Standards; **Control Structures:** if-else, elif, Nested if, Iteration Control structures, Break, Continue & Pass; **String Manipulation:** Accessing Strings, Basic Operations, String slices Function and Methods. **Lists:** Introduction, accessing list, Operations, Working with lists, Function and Methods. **Tuple:** Introduction, accessing tuples, Operations, Working, Functions and Methods. **Dictionaries:** Introduction, accessing values in dictionaries, Working with dictionaries, Properties, Functions.	22
II	**Functions:** Defining & Calling a function, Passing arguments to functions – Mutable & Immutable Data Types, Different types of arguments, Recursion, Scope of variables; **Modules and Packages:** User-defined modules and Standard Library: random, numpy, scipy, sys, Math Module, String Module, List Module, Date & Time Module, Regular Expressions: match, search, replace; **Input-Output:** Printing on screen, reading data from keyboard, Opening and closing file, Reading and writing files, Functions. **Exception Handling:** Exception, Exception Handling, except clause, try? finally clause, User Defined Exceptions. Basics of Python for Data Analysis, Introduction to series and data frames& Python using Pandas.	22

Text Books:

- Paul Barry: "Head First Python "O'Reilly Media, Inc.", 2010.

Reference Books:

- Bret Slatkin: "Effective Python: 59 Specific ways to write better Python", Addison Wesley, 2015.

Outcome: After completion of course, the student will be able to:

- CO1: Understand the basics of Python Programming.
- CO2: Apply the concepts of control structures and string manipulations of python programming.
- CO3: Understand the use of data structures available in PythonList, Tuple and Dictionary.
- CO4: Experiment user-defined functions and access built-in functions.
- CO5: Experiment user-defined modules and access built-in modules- math, random, string, date, time, datetime.
- CO6: Develop the programs using the concept of File Handling.
- CO7: Develop programs based on Exceptional Handling.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO2/PSO4
CO2	PO4/PSO1
CO3	PO5/PSO4
CO4	PO5,PO7/PSO1
CO5	PO2,PO8/PSO4
CO6	PO3,PO10/PSO2
CO7	PO5,PO9/PSO1

BCSC0002: OBJECT ORIENTED PROGRAMMING

OBJECTIVE: *This course introduces the Object-Oriented programming paradigm to students. It also teaches a student how to think objectively and model a Java program for solving real-world problems.*

CREDITS: 3 **L-T-P-J:3-0-0-0**

Module No.	Content	Teaching Hours
I	**Object-Oriented Programming:** Features of Object-Oriented Programming, Introduction to Object-Oriented Java Programming. **g Java Technology & Environment:** Understanding the compilation process of the JVM, JVM vs JDK vs JRE, Key Features of Java, Structure of a simple Java program. **Working with Java Primitive Data Types:** Strongly Typed nature of Java, Primitive Data Types in Java, The new 'var' keyword, Scope of a variable. **Accepting User Input in Java Programs:** using the Scanner class, using command line arguments. **Programming Constructs:** Sequence, Selection, Iteration & Transfer Statements, For-Each Loop. **Working with Java Arrays**: Declaring and Initializing One-Dimensional and Two-Dimensional Arrays in Java, Introduction to java. util. Arrays class. **The String API:** String Data Type, commonly used methods from the String API, String Tokenizer, String Builder & String Buffer. **Creating and Using Methods:** Signature of a method, Types of Methods, Overloading methods in a class, Static and Non-Static Methods. **Describing and Using Objects & Classes:** Declare the structure of a Java class, declaring members of a class (fields and methods), declaring and using Java Objects, lifecycle of an Object (creation, assignment, dereferencing and garbage collection), Constructors of a class, Overloading Constructors, Constructor chaining using 'this' and 'super' keyword. **Using Java Packages:** create and import Java packages and static imports, abstracting program logic to packages, creating executable main class, running the executable class inside a package. **Applying Encapsulation**: Using access modifiers with/in a class, principles of encapsulation. **Programming Abstractly Through Interfaces:** create and implement Interfaces for programs, private and default methods in Interfaces, declaring Abstract Classes, Constructors in Abstract Classes. Marker Interface, Functional Interfaces,	20
II	**Reusing Implementations using Inheritance:** Declaring Subclasses and Superclasses, extend Abstract Classes, implementing Interfaces, exploring polymorphic behaviour by overriding methods, Object Types vs Reference Types, differentiate overloading, overriding and hiding. **Exception Handling:** Exception Hierarchy, Need of Exception Handling, Checked Exceptions, Unchecked Exceptions and Errors, Try-Catch Blocks, Finally, Throw & Throws Keywords, creating and handling Custom Exceptions. **Threads in Java:** Life Cycle of a Thread, creating threads using Runnable and Thread, 'sleep ()', Thread Priorities. **Using Wrapper Classes:** Wrapper Classes in Java, Boxing-Unboxing-Auto Boxing-Auto Unboxing. **Generics & Collections:** Creating Generic classes, Generic Methods, Diamond Notation, Wildcards, Type Erasure, Collection Hierarchy, Base Interfaces, Lists, Sets and Maps. **The Stream API:** Introduction to the Stream API, using lambda expressions in Streams. **Regular Expressions:** Pattern and Matcher Class. **JDBC:** JDBC Drivers, Connecting to a MySQL Database, Driver Manager, Connection Interface, Statement Interface, Result Set Interface, Prepared Statements.	18

Text Book:

- Herbert Schildt, "The Complete Reference, Java Eleventh Edition", Oracle Press.2019.

Reference Book:

- Cay S Hosrtmann, "Core Java Volume I—Fundamentals, Eleventh Edition", Pearson,2018.
- Rogers Cadenhead, "Sams Teach Yourself Java in 21 Days (Covers Java 11/12), 8th Edition", Pearson,2020.

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

- CO1: Understand the basics of Object-Oriented Programming paradigm.
- CO2: Construct the logical flow of programs by using the sequence ,selection ,iterations and transfer statements.
- CO3: Apply the concepts of Object-Oriented Programming to model programs in Classes, Abstract Classes, Interfaces and Enums, and simplify program function by dissecting it into methods.
- CO4: Understand accessibility of members in a program unit and create packages to prevent namespace collisions.
- CO5: Predict run-time errors in a program by examining program functioning.
- CO6: Show the parallel processing capabilities of a program using a multithreading concept.
- CO7: Experiment with the predefined classes and interfaces defined in the Collections Framework.
- CO8: Develop a program using JDBC connectivity to demonstrate data persistence.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO1,PO3/PSO1,PSO2
CO2	PO1,PO3/PSO1,PSO2
CO3	PO1,PO2/PSO1,PSO2
CO4	PO1/PSO2,PSO4
CO5	PO1,PO2,PO4/PSO4
CO6	PO1,PO2, PO3/PSO2
CO7	PO1,PO2,PO11/PSO2
CO8	PO1,PO2,PO3/PSO1,PSO2

BCSC0003: DATABASE MANAGEMENT SYSTEM

Objective: *The objective of the course is to enable students to understand and use a relational database& NoSQL system. Students learn how to design and create a good database.*

Credits: 03 **L-T-P-J: 3-0-0-0**

Module No.	Content	Teaching Hours
I	Introduction**:** An Overview of Database Management System, Database System Vs File System, Database System Concept and Architecture, Data Model Schema and Instances, Data Independence, Database Language and Interfaces (DDL, DML, DCL), Database Development Life Cycle (DDLC) with Case Studies. Data Modeling Using the Entity-Relationship Model**:** ER Model Concepts, Notation for ER Diagram, Mapping Constraints, Keys, Specialization, Generalization, Aggregation, Reduction of an ER Diagram to Tables, Extended ER Model. Relational Data Model and Language**:** Relational Data Model Concepts, Integrity Constraints, Entity Integrity, Referential Integrity, Keys Constraints, Domain Constraints, Relational Algebra **Database Design & Normalization I:** Functional Dependencies, Primary Key, Foreign Key, Candidate Key, Super Key, Normal Forms, First, Second, Third Normal Forms, BCNF, Non-Redundant Cover, Canonical Cover	20
II	**Database Design & Normalization II:** 4th Normal Form, 5th Normal Form, Lossless Join Decompositions, MVD and JDs, Inclusion Dependence. **File Organization:** Indexing, Structure of Index files and Types, Dense and Sparse Indexing **Transaction Processing Concept:** Transaction System, Testing of Serializability, Serializability of Schedules, Conflict & View Serializable Schedule, Recoverability, Recovery from Transaction Failures, Log Based Recovery, Deadlock Handling. **Concurrency Control Techniques:** Concurrency Control, Locking Techniques for Concurrency Control, 2PL, Time Stamping Protocols for Concurrency Control, Validation Based Protocol. **Distributed Database:** Introduction of Distributed Database, Data Fragmentation and Replication.	20

Text Books:

- Elmasri and Navathe, "Fundamentals of Database Systems", 6th Edition, Addison Wesley,2010.
- Sadalage, P. &Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", Pearson Education,2012.

References Books:

- Date C J," An Introduction to Database Systems", 8th Edition, Addison Wesley.
- Korth, Silbertz and Sudarshan, "Database Concepts", 5th Edition, TMH,1998.
- Redmond, E. & Wilson, "Seven Databases in Seven Weeks: A Guide to Modern Databases and the NoSQL Movement", 1st Edition.

Outcome: After the completion of the course, the student will:

- CO1: Understand the concept of database management systems and Relational database.
- CO2: Identify the various data model used in database design.
- CO3: Design conceptual models of a database using ER modeling for real life applications and construct queries in Relational Algebra.
- CO4: Create and populate a RDBMS for a real life application, with constraints and keys,using SQL.
- CO5: Selectthe information from a database by formulating complex queries in SQL.
- CO6: Analyze the existing design of a database schema and apply concepts of normalization to design an optimal database.
- CO7: Discuss indexing mechanisms for efficient retrieval of information from a database.
- CO8: Discuss recovery system and be familiar with introduction to web database, distributed databases.

Mapping of Course Outcomes (COs) withProgram Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO1 /PSO1
CO2	PO2, PO3/ PSO2
CO3	PO2,PO3,PO6,PO11/PSO1,PSO2,PSO4
CO4	PO1,PO3/PSO1
CO5	PO1,PO5/PSO1
CO6	PO2,PO3,PO9/ PSO2
CO7	PO1,PO11 /PSO1
CO8	PO1,PO3,PO12/ PSO2

BCSC0004: OPERATING SYSTEMS

Objective: *This course aims to introducing the concept of computer organization. In particular, it focuses on basic hardware architectural issues that affect the nature and performance of software.*

Credits:03 **L-T-P-J:3-0-0-0**

Module No.	Content	Teaching Hours
I	**Introduction:** Operating System and its Classification - Batch, Interactive, Multiprogramming, Time sharing, Real Time System, Multiprocessor Systems, Multithreaded Systems, System Protection, System Calls, Reentrant Kernels, Operating System Structure- Layered structure, Monolithic and Microkernel Systems, Operating System Components, Operating System Functions and Services. **Processes:** Process Concept, Process States, Process State Transition Diagram, Process Control Block (PCB), Process Scheduling Concepts, Threads and their management. **CPU Scheduling:** Scheduling Concepts, Performance Criteria, Scheduling Algorithms, Multiprocessor Scheduling. **Process Synchronization:** Principle of Concurrency, Implementation of concurrency through fork/join and parbegin/parend, Inter Process Communication models and Schemes, Producer / Consumer Problem, Critical Section Problem, Dekker's solution, Peterson's solution, Semaphores, Synchronization Hardware. **Classical Problem in Concurrency:** Dining Philosopher Problem, Readers Writers Problem.	20
II	**Deadlock:** System model, Deadlock characterization, Prevention, Avoidance and detection, Recovery from deadlock, Combined Approach. **Memory Management:** Multiprogramming with fixed partitions, Multiprogramming with variable partitions, Paging, Segmentation, Paged segmentation. **Virtual memory concepts:** Demand paging, Performance of demand paging, Page replacement algorithms, Thrashing, Locality of reference. **I/O Management and Disk Scheduling:** I/O devices, I/O subsystems, I/O buffering, Disk storage and disk scheduling. **File System:** File concept, File organization and access mechanism, File directories, File allocation methods, Free space management.	20

Text Books:

- Silberschatz, Galvin and Gagne, "Operating Systems Concepts",9th Edition, Wiley, 2012.

Reference Books:

- SibsankarHalder and Alex a Aravind," Operating Systems", 6th Edition, Pearson Education, 2009.
- Harvey M Dietel, "An Introduction to Operating System", 2nd Edition, Pearson Education, 2002.
- D M Dhamdhere, "Operating Systems: A Concept Based Approach", 2nd Edition, 2006.
- M. J. Bach, "Design of the Unix Operating System", PHI, 1986.

Outcome: After completion of course, the student will be able to:

- CO1: Understand the classification of operating system environment.
- CO2: Understand the basic of process management.
- CO3: Apply the concept of CPU process scheduling for the given scenarios.
- CO4: Illustrate theprocess synchronization and concurrency process in operating system.
- CO5: Analyze the occurrence of deadlock in operating system.
- CO6: Describe and analyze the memory management and its allocation policies.
- CO7: Understand the concepts of disk scheduling.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO1,PO2,PO7/PSO1
CO2	PO1,PO2 /PSO1
CO3	PO1,PO4/PSO1,POS3
CO4	PO3,PO4,PO6/PSO3,PSO4
CO5	PO1,PO4/PSO1,PSO3
CO6	PO1,PO2/PSO1,PSO3
CO7	PO1,PO2,PO7/PSO1,PSO3

BCSC0005: COMPUTER ORGANIZATION

Objective: *This course aims to introducing the concept of computer organization. In particular, it focuses on basic hardware architectural issues that affect the nature and performance of software.*

Credits: 03 **L–T–P-J: 3–0–0-0**

Module No.	Content	Teaching Hours
I	**PREAMBLE:** Subject Introduction, Basic organization of the computer and block level description of the functional units, Number Representation, Fixed and floating-point Number Representation-Arithmetic Addition/subtraction, overflow, IEEE standard for floating point representation, **Basic Organization:** Introduction to combinational circuit - Half Adder, Full Adder, carry look ahead adder, Multiplexor/ De multiplexer and Decoder/Encoder, Introduction to sequential circuit- Flip-Flops, Synchronous and Asynchronous Counters, Register, Bus and memory Transfer Language. **Arithmetic Operations:** Addition and subtraction of signed numbers, Hardware implementation of Method, Multiplication: Signed operand multiplication, Booths algorithm, Hardware implementation of Algorithms, Array Multiplier. **Processor Organization:** General register organization, Single Accumulator and Stack organization, Addressing Modes, Types of Computer Instructions – one, two, three & four address, Instruction Cycle, Instruction Formats.	20
II	**Micro-operations:** Arithmetic, Logical & Shift Micro operations with some applications. **Multiprogramming and Multiprocessing:** Introduction to pipelined operation. **Hardwired & Microprogrammed Unit:** Execution of a complete instruction & Branch Instructions, Hardwired control Unit, Micro programmed control Unit, Micro-Instructions, Microinstruction with Next Address field, Pre-Fetching Microinstructions, Concept of Horizontal and Vertical Microprogramming. **Memory:** Basic concept and Hierarchy, RAM memories, 2D, 2 & 1/2D Memory Organization, ROM Memories, Cache Memories: Concept and Design issues performance, Address mapping and Replacement, Auxiliary memories: Magnetic disk, Magnetic tape and Optical disks, Virtual memory: Concept and Implementation. Input/Output: Peripheral Devices, I/O interface, I/O ports. **Interrupts:** Interrupt hardware, Types of Interrupts and Exceptions, Buses, Bus architecture, Types of Buses and Bus Arbitration. Modes of Data Transfer: Programmed I/O, Interrupt initiated I/O, Direct Memory Access, I/O channels and Processors, Standard communication interfaces.	**20**

Text Books:

- M. Mano, "Computer System Architecture", 3rd Edition, PHI,1996

Reference Books:

- D.W. Patterson, "Computer Organization and Design", 4th **Edition**, Elsevier Publication, 2008.
- William Stalling, "Computer Organization",8th Edition, PHI, 2011.
- V. CarlHamacher, Zaky, "Computer Organization",4th International Edition, TMH, 1996.
- John P Hays, "Computer Organization", 2nd Edition, TMH.
- Tannenbaum , "Structured Computer Organization", 5thEdition, PHI, 2005.

- P Pal Chaudhry, "Computer Organization & Design", 2nd Edition, PHI, 2002.

Outcome: After completion of the course, the student will be able to:

- CO1: Understand the basics of digital computer system.
- CO2: Demonstrate the principle of arithmetic operations on unsigned, signed integers and floating point numbers.
- CO3: Understand the concepts of Combinational and Sequential circuits and their applications.
- CO4: Understand the CPU architecture and organization.
- CO5: Explain the basic concepts of pipelining.
- CO6: Design the steps for the execution of the complete instruction for hardwired and micro-programmed control unit.
- CO7: Explain the function of memory hierarchy.
- CO8: Determine the interface of CPU with input/output devices and their modes of transfer.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO1,PO3/PSO1
CO2	PO1,PO3/PSO1
CO3	PO2,PO3,PO5/PSO2
CO4	PO2,PO3,PO4/PSO1,PSO3
CO5	PO2,PO3,PO4/PSO2
CO6	PO1,PO2,PO3/PSO1,PSO3
CO7	PO2,PO3,PO5/PSO2,PSO3
CO8	PO3,PO4/PSO1

BCSC0006: DATA STRUCTURES AND ALGORITHMS

Objective: *The objective of this course is that students will construct and application of various data structures and abstract data types including lists, stacks, queues, trees and graphs*.

Credits: 04 **L–T–P-J: 3–1–0-0**

Module No.	Content	Teaching Hours
I	**Introduction:** Basic Terminology, Elementary Data Organization, Properties of an Algorithm, Efficiency of an Algorithm, Time and Space Complexity, Asymptotic Notations – Big-Oh; Operations on Data Structure, Abstract Data Types (ADT). **Linked Lists:** Implementation of Singly Linked Lists, Doubly Linked List, Circular Linked List, Operations on a Linked List - Insertion, Deletion, Traversal; Generalized Linked List, Polynomial Representation and Addition. **Stacks:** Primitive Stack Operations - Push & Pop, Array and Linked Implementation of Stack in C, Application of Stack: Prefix and Postfix Expressions, Evaluation of Postfix Expression, conversion of Infix to Postfix expression, Recursion, Principles of Recursion, Tail Recursion, Removal of Recursion, use of stack in Recursion, Tower of Hanoi Problem. **Queues:** Operations on Queue - Add, Delete operations, Implementation of Queue Using Array and Linked List, Circular Queues, Deque and Priority Queue. **Trees:** Basic Terminology, Array Representation and Dynamic Representation; Complete Binary Tree, Algebraic Expressions, Extended Binary Trees, Tree Traversal Algorithms - Inorder, Preorder and Postorder; Threaded Binary Trees, Traversing Threaded Binary Trees.	20
II	**Search Trees:** Binary Search Trees (BST), Insertion and Deletion in BST, AVL Trees, Introduction to M-Way Search Trees, B Trees. **Searching:** Sequential Search, Binary Search. **Sorting:** Bubble Sort, Selection Sort, Insertion Sort, Quick Sort, Two Way Merge Sort, and Heap Sort. **Graphs:** Terminology, Adjacency Matrices, Adjacency List, Graph Traversal - Depth First Search and Breadth First Search; Spanning Trees, Minimum Cost Spanning Trees – Prim's and Kruskal's Algorithm; Shortest Path Algorithm – Bellman-Ford and Dijkstra's Algorithm. **Hashing & Indexing:** Hash Function, Collision Resolution Strategies. Primary Indices, Secondary Indices, Indexing and Hashing Comparisons.	20

Text Book:

- Aaron M. Tanenbaum, YedidyahLangsam and Moshe J. Augenstein, "Data Structures Using C and C++", 2nd Edition, PHI, 2009.

Reference Books:

- Horowitz and Sahani, "Fundamentals of Data Structures", 3rd Edition, W H Freeman & Co, 2004-05.
- Jean Paul Trembley and Paul G. Sorenson, "An Introduction to Data Structures with Applications", 2nd Edition, TMH, 2007.
- R. Kruse, "Data Structures and Program Design in C", 2nd Edition, Pearson Education, 2004.
- LipschutzSchaum's Outline Series, "Data Structures", 12th Reprint, TMH, 2010.
- G A V Pai, "Data Structures and Algorithms", TMH, 2009.

Outcome: After completion of course, student will be able to:

- CO1: Understand the basic concepts of the data structure and algorithms.
- CO2: Understand the complexity representation in terms of Big Oh, Theta and Omega notations.
- CO3: Apply the associated operations in linear data structure like stack, Queue and link list.
- CO4: Apply the associated operations in Binary Search Tree, AVL Tree and M- Way Search Tree.
- CO5: Understand the basic algorithms such as heap sort, graph traversal, quick sort, AVL trees, and hashing.
- CO6: Select the appropriate data structure to solve the problem.
- CO7: Apply the shortest path algorithm to solve real life problem.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO1/PSO1,PSO2
CO2	PO1, PO2/PSO1,PSO2
CO3	PO1/PSO1
CO4	PO1,PO4/PSO1
CO5	PO1,PO4/PSO3
CO6	PO2/PSO4
CO7	PO2/PSO4

BCSC 0008: Computer Networks

Objective: *The objective is to understand fundamental underlying principles of computer networking, details and functionality of layered network architecture.*

Credits: 04 **Semester - IV** **L–T–P-J: 3–1–0-0**

Module No.	Content	Teaching Hours
I	**Introduction Concepts**: Goals and Applications of Networks, Network structure and architecture, The OSI reference model, services, Network Topology Design, Physical Layer Transmission Media, Line coding scheme, switching methods (circuit switching, Packet switching), TDM. **Medium Access sub layer**: Medium Access sub layer - Channel Allocations, LAN protocols - ALOHA protocols, CSMA, CSMA/CD, Overview of IEEE standards. **Data Link Layer**: Error detection and correction, Flow control (sliding window protocol)	20
II	**Network Layer**: Network Layer –IP addressing, subnet, CIDR, VLSM, Internetworking, Address mapping, routing. Connecting devices. **Transport Layer**: Transport Layer - Design issues, connection management, Flow control, TCP window management, congestion control-slow start algorithm. **Application Layer**: Data compression, Data Encryption, File Transfer, DNS, HTTP, SMTP, TELNET **Introduction to IPv6, transition from IPv4 to IPv6.**	20

Text Books:

- Forouzan B. A. , "Data Communication and Networking", 4th Edition, McGrawHill,2004.

References:

- Kurose, J.F. and Ross K.W., "Computer Networking: A Top-Down Approach Featuring the Internet", 3rd Edition, Addison-Wesley,2005.
- A.S. Tanenbaum, "Computer Networks", 2nd Edition, Prentice Hall India,2006.

Outcome**:** After the completion of the course, the student will be able to:

- CO1: Understand the concept of OSI and TCP/IP reference model.
- CO2: Understand the basics of data transmission at physical layer.
- CO3: Understand the channel allocation using ALOHA, CSMA and CSMA/CD.
- CO4: Apply error detection and correction technique to eliminate transmission error.
- CO5: Analyze the fixed and variable length address (IPv4) subneting for the given scenarios.
- CO6: Understand the design issues of the transport layer.
- CO7: Understand the mechanism of protocols at application layer such as FTP, HTTP, Telnet, DNS.
- CO8: Understand IPv6 addressing and differentiate it from IPv4.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO1,PO3,PO12/PSO1
CO2	PO1/PSO2
CO3	PO1,PO4/PSO1,PSO4
CO4	PO1,PO3/PSO1
CO5	PO1,PO3,PO4,PO6/PSO3
CO6	PO2,PO4/PSO1
CO7	PO5,PO12/PSO2
CO8	PO4,PO7/PSO4

BCSC0009: SOFTWARE ENGINEERING

Objective: *Be employed in industry, government, or entrepreneurial endeavors to demonstrate professional advancement through significant technical achievements and expanded leadership responsibility.*

L–T–P-J: 3–0–0-0

Credits: 03

Module No.	Content	Teaching Hours
I	**Introductory Concepts**: The evolving role of software – characteristics, components and applications. **Process Models:** Waterfall Model, Prototyping, Incremental, Spiral. **Agile software Development**: Introduction to Agile, Agile software development framework. **Software Requirement Specification**: Requirement Process, SRS Components, Requirement Specifications with Use Cases Diagram. **Software Project Planning:** Project Planning Objectives. **Software Metrics:** Size, Function Point, Staffing, Project Estimation Methods–COCOMO Model. **Function-Oriented Design**: Problem Partitioning, Abstraction, Top Down and Bottom Up Design. **Module-Level Concepts:** Coupling, Cohesion, Design Notation and Specification - Structure Charts; Structured Design Methodology - Data Flow Diagram, Sequence Diagram.	20
II	**OO Analysis and OO Design:** OO Concepts, Introduction to UML Design Patterns: Class Diagram, Activity Diagram, State Chart Diagram. **Coding**: Coding Process, Verification – Code Inspections, Software Metrics. **Testing Fundamentals**: Test Case Design, Black Box Testing Strategies, White Box Testing, Unit Testing, Integration Testing, System Testing. **Introduction to Automation Testing and Testing Tools:** Automated Testing Process, Framework for Automation Testing, Introduction to Automation Testing Tool. **Software Quality:** Models, ISO 9000 Certification for Software Industry, SEI Capability Maturity Model. **Software Maintenance**: Models Cost of Maintenance, Re-engineering, Reverse Engineering.	18

Text Books:

- R. S. Pressman , "Software Engineering: A Practitioners Approach", 7thEdition, McGraw Hill,2010.

Reference Books:

- K. K. Aggarwal and Yogesh Singh , "Software Engineering", 3rd Edition, New Age International Publishers,2008.
- Rajib Mall , "Fundamentals of Software Engineering", 3rd Edition, PHI Publication,2009.
- R.E Fairley , "Software Engineering", McGraw Hill,2004.
- Sommerville, "Software Engineering", 9th Edition, Pearson Education,2010.

Outcome: After the completion of the course, the student will be able to:

- CO1: Understand the basic concepts of software engineering.
- CO2: Apply software processes to solve real world problems.
- CO3: Estimate the cost, effort and schedule of software using COCOMO Model.
- CO4: Analyze the software design techniques (structure chart, SDM, sequence diagram).
- CO5: Understand the basic concepts of OO analysis and design.
- CO6: Develop the test cases to validate the software.
- CO7: Understand the basic models of software Quality and maintenance.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO1,PO7/PSO1
CO2	PO2,PO3/PSO4
CO3	PO2,PO11/PSO3
CO4	PO3,PO10/PSO4
CO5	PO3,PO7/PSO1
CO6	PO5,PO12/PSO2
CO7	PO4,PO9,PO12/PSO1

BCSE0105: MACHINE LEARNING

Objective*:*

Credits: 03 L–T–P-J: 3–0–0-0

Module No.	Content	Teaching Hours
I	**Introduction:** Machine Learning basics, Hypothesis space and inductive bias, training and test set, and cross-validation. **Introduction to Statistical Learning:** Bayesian Method. **Machine Learning:** Supervised (Regression, Classification) vs. Unsupervised (Clustering) Learning. **Data Preprocessing:** Imputation, Outlier management, One hot encoding, Dimensionality Reduction- feature extraction, Principal Component Analysis (PCA), Singular Value Decomposition **Supervised Learning:** Regression- Linear regression, Polynomial regression, Classification- Logistic regression, k-nearest neighbor classifier,	20
II	**Supervised Learning:** Decision tree classifier, Naïve Bayes classifier Support Vector Machine (SVM)Classifier, **Unsupervised Learning:** k-means clustering, Hierarchical clustering **Underfitting vs Overfitting:** Regularization and Bias/Variance. **Ensemble methods:** Bagging, Boosting, Improving classification with Ada-Boost algorithm.	20

Text Book:

- Tom M. Mitchell, Machine Learning. Tata McGraw-Hill Education, 2013.
- Alpaydin, E. . Introduction to machine learning. MIT press, 2009.

Reference Books:

- Harrington, P. , " Machine learning in action", Shelter Island, NY: Manning Publications Co, 2012.
- Bishop, C. M. . Pattern recognition and machine learning (information science and statistics) springer-verlag new york. Inc. Secaucus, NJ, USA. 2006

Outcome: After completion of Lab, student will be able to:

- CO1: Apply the basic concepts of machine learning.
- CO2: Apply the concepts of regression and re-sampling methods.
- CO3: Design supervised and re-enforcement learning based solution.
- CO4: Apply the ensemble methods for improving classification.
- CO5: Identify the ways of feature extraction, reduction and selection.
- CO6: Design the applications of machine learning algorithms.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO1,PO2/PSO3,PSO4
CO2	PO1,PO2/PSO1,PSO3
CO3	PO1,PO3,PO5/PSO1,PSO3
CO4	PO1 /PSO1
CO5	PO2/PSO3
CO6	PO1,PO2,PO3/PSO1,PSO2,PSO4

BCSE0157: INTRODUCTION TO BIG DATA ANALYTICS

Objective:

Credits: 03 **L-T–P-J: 3–0–0-0**

Module No.	Content	Teaching Hours
I	**Big Data Technology Landscape**: Types of Digital Data (Structured, Semi-Structured, Unstructured), Concept, importance and characteristics of data, Challenges with big data, Big data stack, Big Data 1.0, 2.0 and 3.0, Traditional BI vs. Big Data Environment, NoSQL Databases, NoSQL Vs. RDBMS, New SQL, Introduction to Data Science/Scientist **HADOOP 1.0:** Introducing Hadoop 1.0, Limitations of RDBMS, Hadoop Components, High Level Architecture of Hadoop, History of Hadoop, Special Features of Hadoop, Introduction to HDFS 1.0, Architecture, Daemons, working with HDFS Command, Introduction to Map-Reduce 1.0, Architecture, Daemons **HADOOP 2.0:** Introducing Hadoop 2.0, Limitations of 1.0, Introduction to HDFS 2.0, Architecture, Daemons, Introduction to Map-Reduce 2.0, YARN, Architecture, Daemons, Word Count Example using Java, Introduction to Hadoop 3.0, Difference among Hadoop1.0, Hadoop2.0, Hadoop3.0 **Introduction to Mongo DB**: RDBMS vs. MongoDB, JSON, Unique Key, Dynamic Queries, Sharding, Replication, MongoDB QL: Create, Drop Database and Collections, CRUD: Create, Insert, Find, Update, Delete, Map Reduce Programming, Aggregations	20
II	**Introduction to Cassandra DB**: Features of Cassandra, CQL Data Types, CQLSH: CRUD, Counter, TTL, List, Set, Map, Tracing, Import Export csv files **HADOOP Ecosystem and Flume:** Introduction to Hadoop Ecosystem, Sqoop, Zookeeper, Plug-in Components: Impala, Hue, Flume: Introduction, Application, Advantage, Features. **Introduction to HIVE:** Hive Architecture, Hive Data types, Hive Collection Types, Hive File Formats, Hive Query Language, Hive Partitions, Bucketing, Views, RCFile Implementation, Hive User Defined Function, SerDe, UDF **Introduction to Pig:** History and Anatomy of Pig, Pig on Hadoop, Use Case for Pig, Pig Primitive Data Types, Pig Latin Overview, Execution Modes of Pig, Field, Tuple, Bag, User Defined Function, Parameters in Pig, Piggy Bank, Word count example using Pig, Pig vs Hive, When to use Pig.	20

Text Book:

- Seema Acharya and SubhashiniChellappan, “Big Data and Analytics”, 1st Edition, 2015, Wiley, India.
- Jure Leskovec, AnandRajaraman, Jeff Ullman, “Mining of Massive Datasets”, 2nd Edition, 2014, Cambridge University Press.

Reference Books:

- Chuck Lam, “Hadoop in Action”, 2nd Edition, 2014, Manning Publications.

Outcome: At the end of the course, student will be able to

- CO 1: Understand the concepts and challenges of big data.
- CO 2: Apply existing technology to collect, manage, store, query, and analyze the big data.
- CO 3: Apply job scheduling of various applications and resource management using Hadoop and Yarn.
- CO 4: Apply the data summarization, query, and analysis of big data using pig and hive.
- CO 5: Design the regression model, cluster and decision tree of big data.
- CO 6: Experiment with hands-on experience in large-scale analytics tools to solve big data problems.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO5/PSO5
CO2	PO3/PSO4
CO3	PO3,PO5/PSO4
CO4	PO3,PO5/PSO4
CO5	PO3/PSO2
CO6	PO2/PSO4

BCSG0800: PYTHON PROGRAMMING LAB

Objective: *This course introduces the solving of problems using Python programming using OO concepts and its connectivity with database.*

Credits:01 **L-T-P-J:0-0-2-0**

Module No.	Content	Lab Hours
I & II	Programs based on the concepts of: • Building Python Modules • Obtaining user Data • Printing desired output Programs based on the concepts of: • Conditional if statements • Nested if statements • Using else if and elif Programs based on the concepts of Iteration using different kinds of loops Usage of Data Structures • Strings • Lists • Tuples • Sets • Dictionary Program based on the concepts of User-defined modules and Standard Library (random, numpy, scipy, sys, Math Module, String Module, List Module). Program based on Input Output. Program based on exception Handling. Program based on Simple Data analysis. Program based on Pandas.	26

Text Books:

- Paul Barry: "Head First Python "O'Reilly Media, Inc.", 2010.

Reference Books:

- Bret Slatkin: "Effective Python: 59 Specific ways to write better Python", Addison Wesley, 2015.

Outcome: By the end of the course, students will learn to:

- CO1: Apply OO concepts using Python programming.
- CO2: Apply in-built packages defined in Python.
- CO3: Apply front-end as Python Programming to connect with any back-end.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO2/PSO1
CO2	PO3/PSO4
CO3	PO5/PSO2

BCSC0801: OBJECT ORIENTED PROGRAMMING LAB

Objective: *The objective of this course is that students will study and learn Object Oriented Modeling and programming.*

Credits:01 **L-T-P-J:0-0-2-0**

Module No.	Content	Teaching Hours
I& II	Programs in Java and python based on the concepts of: • Classes, Constructors, Polymorphism and Keyword Static. Programs based on the concepts of: • Inheritance, Multithreading Using Thread Class & Interface Runnable, String Handling, Generic Classes. Programs based on the concepts of: • Handling Database Connectivity. • Implementation of Collection Framework. Programs based on the concepts of: • Database Connectivity. • Retrieving Data from Database. • Parameters Passing, Execute many Method. • Cursor Attributes. • Invoke Stored Procedures. • Invoke Stored Functions.	24

Reference Books:

- Naughton, Schildt, "The Complete Reference JAVA2", 9th Edition, Oracle Press.
- Bhave&Patekar, "Programming with Java", Pearson Education
- Bret Slatkin: "Effective Python: 59 Specific ways to write better Python", Addison Wesley, 2015.

Outcome: After completion of course, the student will be able to:

- CO1: Implement object oriented language features.
- CO2: Design GUIs and Graphical programming.
- CO3: Design object oriented solutions for small systems involving database and event handling concepts.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO1,PO2/PSO1
CO2	PO3,PO5/PSO2
CO3	PO3,PO5/PSO4

BCSC0802: DATABASE MANAGEMENT SYSTEM LAB

Objective: *The lab aims to develop an understanding of different applications and constructs of SQL, PL/SQL.*

Credits:01 **L-T-P-J:0-0-2-0**

Module No.	Content	Teaching Hours
I & II	◦ Write the SQL queries for data definition and data manipulation language. ◦ To implement various operations on a table. ◦ To implement various functions in SQL. ◦ To implement restrictions on the table. ◦ To implement the concept of the grouping of Data. ◦ To implement the concept of Joins in SQL. ◦ To implement the concept of sub-queries. ◦ To implement the concept of views, sequence. ◦ To implement the concept of PL/SQL using a cursor. ◦ To implement the concept of Procedure function and Triggers.	24

References Books:

- Date C J," An Introduction to Database Systems", 8th Edition, Addison Wesley.
- Korth, Silbertz and Sudarshan, "Database Concepts", 5th Edition, TMH, 1998.
- Majumdar& Bhattacharya, "Database Management System", TMH

Outcome: After the completion of the course, the student will be able to:

- CO1: Apply SQL queries for DML and DDL.
- CO2: Develop the SQL queries for real life scenarios.
- CO3: Implement the procedural language (PL/SQL) and Triggers.

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Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO1,PO2/PSO1,PSO4
CO2	PO1,PO2/PSO1,PSO4
CO3	PO2,PO3,PO5/PSO2,PSO3

BCSC0803: OPERATING SYSTEMS LAB

Objective: *The lab aims to develop understanding the operation of UNIX operating system.*

Credits:01 **L-T-P-J:0-0-2-0**

Module No.	Content	Teaching Hours
I & II	• Implement the following basic commands (with options) used in UNIX/LINUX OS. • Write and implement the basic vi editor commands. • Shell scripts that use simple commands. • Decision based Shell scripts. • Shell scripts related to strings. • Shell scripts using pipes. • Shell scripts with loop statements. • Demonstration and solution for race condition. • Demonstration and use of System Calls. • Implement the basics of IPC in UNIX.	24

Reference Books:

- SibsankarHalder and Alex a Aravind," Operating Systems", 6th Edition, Pearson Education, 2009.
- Harvey M Dietel, "An Introduction to Operating System", 2nd Edition, Pearson Education, 2002.
- D M Dhamdhere, "Operating Systems: A Concept Based Approach", 2nd Edition, 2006.
- M. J. Bach. , "Design of the Unix Operating System", PHI, 1986.

Outcome: After completion of course, the student will be able to:

- CO1: Implement the basic operations on UNIX operating systems.
- CO2: Demonstrate the working of systems calls.
- CO3: Demonstrate message passing in Unix operating system.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO1,PO3,PO4/PSO1
CO2	PO1,PO2/PSO1
CO3	PO1,PO4,PO5/PSO1,PSO2

BCSC0804: COMPUTER ORGANIZATION LAB

Objective: *The aim of the lab is to better understand the design of sequential Circuits such as Flip-Flops, Registers, and Counters.*

Credits: 01 **L–T–P-J: 0–0–2-0**

Module No.	Content	Lab Hours
I & II	◦ Bread Board Implementation of Flip-Flops. ◦ Experiments with clocked Flip-Flops. ◦ Design of Counters. ◦ Bread Board implementation of Counters &Shift Registers. ◦ Implementation of Arithmetic Algorithms. ◦ Bread Board implementation of Adder/Subtraction (Half, Full). ◦ Bread Board implementation of Binary Adder. ◦ Bread Board implementation of Seven Segment Display. ◦ Small Project based on combinational and sequential circuit.	24

Reference Books:

- D.W. Patterson , "Computer Organization and Design", 4th **Edition**, Elsevier Publication, 2008.
- William Stalling , "Computer Organization",8th Edition, PHI, 2011.
- M. Mano , "Computer System Architecture", 3rd Edition, PHI.

Outcome: After the completion of the course, the student will be able to:

- CO1: Implement the Combinational and Sequential Circuit.
- CO2: Demonstrate the working of counter and shift register.
- CO3: Demonstrate the working of ALU and seven segment displays.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO2,PO3,PO5/PSO2
CO2	PO3,PO4/PSO2
CO3	PO3,PO5/PSO1,PSO2

BCSC0805: DATA STRUCTURES & ALGORITHMS LAB

***Objective*:** *The objective of this course is that students will understand and implement simple data structures, able demonstrate different sorting and searching techniques. and will be familiar with graphs and their applications.*

Credits:01 **L-T-P-J:0-0-2-0**

Module	Content	Lab
I &II	◦ Program to implement various operations in a singly linked list. ◦ Program to implement insertion, deletion and traversal in a doubly linked List. ◦ Program to implement polynomial addition using linked list. ◦ Program to demonstrate the various operations on stack. ◦ Program to convert an infix expression into postfix expression. ◦ Program to evaluate a given postfix expression. ◦ Program to implement Tower of Hanoi problem using Recursion. ◦ Program to demonstrate the implementation of various operations on linear and circular queue. ◦ Program to demonstrate the implementation of insertion and traversals on a binary search tree. ◦ Program to implement Dijkstra's Algorithm to find the shortest path between source and destination. ◦ Program to search a given element as entered by the user using sequential and binary search to search a given element as entered by the user. ◦ Implementation of various sorting algorithms like Selection Sort, Bubble Sort, Insertion Sort, Merge Sort, Quick Sort and Heap Sort.	24

Note: All Code must be done in Java as well as Python

Outcome: After completion of course, student will be able to:

- CO1: Demonstrate the associated operations in linear data structure like stack, Queue and link list.
- CO2: Demonstrate the associated operations in Binary Search Tree and Dijkstra's Algorithm.
- CO3: Implementation the sorting algorithms like Selection Sort, Bubble Sort, Insertion Sort, Merge Sort, Quick Sort and Heap Sort.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO1/PSO1
CO2	PO4/PSO1,PSO3
CO3	PO2/PSO3,PSO4

BCSE0133: MACHINE LEARNING LAB

Credits: 01 **L–T–P-J: 0–0-2-0**

Objective*:*

S.No	PROGRAM
1	Estimate parameters of a model based on Linear Regression method using a given set of training data set.
2	Estimate parameters of a model based on maximum likelihood estimation method using a given set of training data set.
3	Compute weights of ANN based on back propagation method using a given training dataset.
4	Compute probability of a person to be diabetic based on a given dataset of diabetic persons using Naïve Bayesian classifier.
5	Classify a person as male or female based on a given dataset using naïve Bayesian Classifier, and calculate accuracy, precision, and recall for your data set.
6	Write a program to implement *k*-Nearest Neighbour method to classify the iris data set. Print both correct and wrong predictions. Use Java/Python ML library classes
7	Predicts whether the bank should approve the loan of an applicant, based on his profile using Ensemble learning method.
8	Apply Ensemble learning to cluster a set of data stored in a .CSV file. Use the same dataset for clustering using *k*-Means method. Compare the results of these two algorithms and comment on the quality of clustering. You can add Java/Python ML library classes/API in the program.
9	The stock prediction data is used to predict, whether the stock will go up or down. Perform the task of feature selection with the help of wrapper method.
10	Identify principal components of Big Mart sales data using Principal component analysis (PCA). Also plot the result of PCA, and give inferences.

Outcome: After studying the subject, the students will be able to:

- CO1: Applythe machine learning algorithms in the area of text, audio and image processing.
- CO2: Apply classification algorithms to design complex problems.
- CO3: Design solution to societal issues using machine learning algorithms.
- CO4: Analyze the view problem in the perspective of machine learning.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

CO	PO/PSO
CO1	PO3,PO5/PSO4
CO2	PO1,PO5/PSO1,PSO3,PSO4
CO3	PO3 /PSO1,PSO2,PSO4
CO4	PO2,PO3/PSO1,PSO2,PSO4

BCSE0183: BIG DATA AND ANALYTICS LAB

Objective: *This course introduces students to R, a widely used statistical programming language. Students will learn to manipulate data objects, produce graphics, analyse data using common statistical methods, and generate reproducible statistical reports. Student will also learn data mangling*.

Credits: 01 **L-T–P-J: 0–0–2-0**

Module No.	Content	Lab Hours
I	**Module 1: Introduction to R** • Introduction and installation of R and RStudio • Data types, vectors, multidimensional array. • Functions and their use • Visualization using ggplot2. • Word-Count program using Java	24
II	**Module 2: Hands-On MongoDB, Cassandra** • Installation of VM-Ware and Cloudera • Hands-On Mongo DB: CRUD, Where, Aggregation • Hands-On Mongo DB: Projection, Aggregation • Hands-On Cassandra DB: CRUD, Projection	
III	**Module 3: Hands-On PIG & HIVE** • Hands-On PIG • Hands-On HIVE • Twitter Data Fetching using Flume	

Reference Books:

- Paul Teetor. R Cookbook: Proven recipes for data analysis, statistics, and graphics. O'Reilly Media, Inc.,2011.
- Norman Matloff. Theart of R programming: A tour of statistical software design. No Starch Press, 2011.
- Winston Chang. R graphics cookbook. O'Reilly Media, Inc., 2012.
- Hadley Wickham and Garrett Grolemund. R for data science. 2016.
- Phil Spector. Data manipulation with R. Springer Science& Business Media, 2008.

Outcome: At the end of the course, student is able to:

- CO1: Apply R-Studio, read R documentation, and write R scripts.
- CO2: Analyse the data using data analytics latest tools based on HDFS like Pig, Hive.
- CO3: Implement the aggregation projection on data set using Cassandra, MongoDB.
- CO4: Implement the concept of PIG & HIVE Using QVERIESON real world data

Mapping of Course Outcomes (COs) withProgram Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO2,PO5/PSO4
CO2	PO1,PO5/PSO3
CO3	PO2,PO5/PSO3
CO4	PO5/PSO4

BECJ0950: MINI PROJECT-I

Outcomes: *After completion of this course student will able to:*

CO 1:-Acquire practical knowledge within the chosen area of technology for project development.

CO 2:- Design and simulate the basic modules in chosen area of technology.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 PO9 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 PO9 /PSO2, PSO3

BECJ0951: MINI PROJECT-II

Outcomes: *After completion of this course student will able to:*

CO 1:-Acquire practical knowledge within the chosen area of technology for project development.

CO 2:- Design and simulate the basic modules in chosen area of technology.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 PO9 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 PO9 /PSO2, PSO3

BECJ0952: MINI PROJECT-III

Outcomes: *After completion of this course student will able to:*

CO 1:-Acquire practical knowledge within the chosen area of technology for project development.

CO 2:- Design and simulate the basic modules in chosen area of technology.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 PO9 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO4 PO9 /PSO2, PSO3

BECJ0971: PROJECT-I

Course Outcomes: After completing this course, students will able to:

CO1: Identify and Finalize problem statement by surveying variety of domains.
CO2: Perform requirement analysis and identify design methodologies
CO3: Apply advanced programming techniques
CO4: Present technical report by applying different visualization tools and Evaluation metrics.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO5 PO9 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO5 PO9 /PSO2, PSO3
CO3	PO1,PO2, PO3, PO5 PO9 /PSO2, PSO3
CO4	PO1,PO2, PO3, PO5 PO9 /PSO2, PSO3

BECJ0972: PROJECT-II

Outcomes: After completing this course, students will able to:

CO1: Review the literature and develop solutions for framed problem statement.
CO2: Implement hardware and/or software techniques for identified problems.
CO3: Test and analyze the modules of planned project.
CO4: Write technical report and deliver presentation.
CO5: Apply engineering and management principles to achieve project goal.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 PO9 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO5 PO9 /PSO2, PSO3
CO3	PO1,PO2, PO3, PO5 PO9 /PSO2, PSO3
CO4	PO1,PO2, PO3, PO5 PO9 /PSO2, PSO3
CO5	PO1,PO2, PO3, PO5 PO9 /PSO2, PSO3

BECJ0991: IDUSTRIAL TRAINING

Outcomes: After completing this course, students will able to:

1. Identify, formulate and model problems and find engineering solution based on a systems approach.
2. Develop and deliver a learning portfolio for presenting learning experiences and outcomes.
3. Demonstrate the awareness of the practical contexts in engineering.
4. Appreciate the work of others in an industrial or engineering sector.
5. Demonstrate good working practices to show a developing maturity and sense of responsibility

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs/ PSOs**
CO1	PO1,PO2, PO3, PO4 PO9 /PSO1, PSO2
CO2	PO1,PO2, PO3, PO5 PO9 /PSO2, PSO3
CO3	PO1,PO2, PO3, PO5 PO9 /PSO2, PSO3
CO4	PO1,PO2, PO3, PO5 PO9 /PSO2, PSO3
CO5	PO1,PO2, PO3, PO5 PO9 /PSO2, PSO3