Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar (Autonomous)

(Affiliated to Savitribai Phule Pune University, Pune)

Choice Based Credit System (CBCS)

Bachelor of Science (B. Sc.)

Syllabus of

T. Y. B. Sc. Electronic Science

Implemented from

Academic Year 2023 - 24

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar (Autonomous)

Board of Studies in Electronic Science

Sr. No.	Name	Designation
1.	Mr. D. K. Sonawane	Chairman
2.	Mrs. S. D. Shelke	Member
3.	Mr. D. S. Shelar	Member
4.	Dr. S. N. Helambe	Academic Council Nominee
5.	Mr. S. K. Shinde	Academic Council Nominee
6.	Dr. M. S. Zambare	Vice-Chancellor Nominee
7.	Mr. Bipinchandra Todmal	Alumni
8.	Mr. P. D. Nirmal	Industry Expert
9.	Prof. A. V. Mancharkar	Member (co-opt)
10.	Mrs. B. M. Danave	Member (co-opt)
11.	Mr. G. V. Avhale	Invitee

Programme Structure and Course Titles: (All academic years)

Sr. No.	Class	Semester	Course Code	Course Title	Credits
1.	F. Y. B. Sc.	I	BSC-ES 101 T	Principles of Analog Electronics	02
2.	F. Y. B. Sc.	I	BSC-ES 102 T	Principles of Digital Electronics	02
3.	F. Y. B. Sc.	I	BSC-ES 103 P	Practical Course - I	1.5
4.	F. Y. B. Sc.	II	BSC-ES 201 T	Analog Device Applications	02
5.	F. Y. B. Sc.	II	BSC-ES 202 T	Digital Circuits and Computer Organization	02
6.	F. Y. B. Sc.	II	BSC-ES 203 P	Practical Course - II	1.5
7.	S. Y. B. Sc.	III	BSC-ES 301 T	Communication Electronics	02
8.	S. Y. B. Sc.	III	BSC-ES 302 T	Digital System Design	02
9.	S. Y. B. Sc.	III	BSC-ES 303 P	Practical Course - I	02
10.	S. Y. B. Sc.	IV	BSC-ES 401 T	Analog Circuit Design	02
11.	S. Y. B. Sc.	IV	BSC-ES 402 T	Fundamentals of Embedded System Design	02
12.	S. Y. B. Sc.	IV	BSC-ES 403 P	Practical Course – II	02
13.	T. Y. B. Sc.	V	BSC-ES 501 T	Analog Circuit Design and Applications	02
14.	T. Y. B. Sc.	V	BSC-ES 502 T	Microcontrollers	02
15.	T. Y. B. Sc.	V	BSC-ES 503 T	Process Control Systems	02
16.	T. Y. B. Sc.	V	BSC-ES 504 T	‘C’ Programming	02
17.	T. Y. B. Sc.	V	BSC-ES 505 T	Fundamentals of Fiber Optic Communication	02
18.	T. Y. B. Sc.	V	BSC-ES 506 T	Electronic Product Design and Entrepreneurship	02
19.	T. Y. B. Sc.	V	BSC-ES 507 P	Practical Course – I	02
20.	T. Y. B. Sc.	V	BSC-ES 508 P	Practical Course – II	02
21.	T. Y. B. Sc.	V	BSC-ES 509 Pr	Project Course – I	02

22.	T. Y. B. Sc.	V	BSC-ES 510 T	Electronic Design Automation Tools	02
23.	T. Y. B. Sc.	V	BSC-ES 511 P	Practical Course – III	02
24.	T. Y. B. Sc.	VI	BSC-ES 601 T	Modern Communication Systems	02
25.	T. Y. B. Sc.	VI	BSC-ES 602 T	Embedded System Design	02
26.	T. Y. B. Sc.	VI	BSC-ES 603 T	Power Electronics	02
27.	T. Y. B. Sc.	VI	BSC-ES 604 T	Sensors and Systems	02
28.	T. Y. B. Sc.	VI	BSC-ES 605 T	Python Programming	02
29.	T. Y. B. Sc.	VI	BSC-ES 606 T	Digital System Design using Verilog	02
30.	T. Y. B. Sc.	VI	BSC-ES 607 P	Practical Course – IV	02
31.	T. Y. B. Sc.	VI	BSC-ES 608 P	Practical Course – V	02
32.	T. Y. B. Sc.	VI	BSC-ES 609 Pr	Project Course – II	02
33.	T. Y. B. Sc.	VI	BSC-ES 610 T	PLC and its Applications	02
34.	T. Y. B. Sc.	VI	BSC-ES 611 P	Practical Course – VI	02

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Semester – V	**Paper – I**
Course Code: BSC-ES 501 T	**Title of the Course: Analog Circuit Design and Applications**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

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

a. Understand the practical design aspects while using Op-amps.
b. Use op-amp for different applications.
c. Obtain information about different special purpose ICs and their applications.
d. Design analog electronic circuit for given specifications.

Detailed Syllabus:

Unit I: Fundamentals of Analog Circuit Design (04)

Op-Amp parameters: input offset voltage, input offset current, input bias current, differential input resistance, input capacitance, offset voltage adjustment range, input voltage range, common mode rejection ratio, slew rate, supply voltage rejection ratio. Selection of amplifier, unwanted signals, offset nullifying techniques.

Unit II: Nonlinear Circuits (08)

Design of basic and practical integrator and differentiator circuits, designing steps of practical integrator and differentiator circuit.

Active filters: 2nd and higher order, Design of LP, HP and BP filters.

Log and antilog amplifiers, Precision half wave rectifier, precise full wave rectifiers with equal resistor and one with high input impedance, peak detectors, sample and hold circuits.

Unit III: Basic Application Circuits using Linear ICs (10)

Signal generators: Phase shift oscillator, Wein bridge oscillator, Square wave generator, triangle wave generator, saw tooth wave generator, Function generators: ICL8038, Voltage controlled oscillator (IC 566).

Op-amp as a comparator IC (LM311), zero crossing detector, voltage level detector, Schmitt trigger, voltage to current converter, current to voltage converter, voltage to frequency converter, frequency to voltage converter.

Unit IV: Voltage Regulators and Phase Lock Loops (08)

Design of Power Supply: Voltage Regulator, Three terminal voltage regulators, Fixed and adjustable voltage regulators (78XX, 79XX, LM317, LM337), Dual power supply, Phase lock loop (PLL): Basic PLL, Components of PLL, Monolithic IC LM565, performance parameters, applications of PLL such as frequency multiplier and FSK.

Suggested Readings:

1. OP-AMP and Linear ICs, Ramakant A. Gayakwad, Prentice Hall / Pearson Education.
2. Operational Amplifiers and Linear Integrated Circuits, Robert F. Coughlin, Frederick F. Driscoll, PHI.
3. Operational Amplifiers, G. B. Clayton, Elsevie.
4. Design with operational Amplifiers and analog integrated circuits, Sergio Franco.

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Semester – V	**Paper – II**
Course Code: BSC-ES 502 T	**Title of the Course: Microcontrollers**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

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

a. Understand the microcontroller architecture and peripherals.
b. Program timer, serial port for different applications.
c. Understand the interrupt programming of 8051 and its importance.
d. Interface different I/O devices to 8051 and used them for different applications.

Detailed Syllabus:

Unit I: Microcontroller Architecture and Peripherals (05)

General architecture of microcontroller, introduction to CPU, memory and peripherals. Memory types used in microcontroller, peripherals – Timer and counter, serial port and interrupt, buses used in CPU. Roles of ALU, CPU registers, Instruction decoder and program counter. Introduction to Harvard and Princeton architecture. Comparison between CISC and RISC architecture. Concept of pipelining.

Unit II: The 8051 Timer Programming (07)

Timers and counters: introduction, architecture, SFR used, different modes of operation, steps to program for delay generation and counter application. Assembly programming for delay generation, waveform generation using timer and frequency counter using counter.

Unit III: The 8051 Serial Port and Interrupt Programming (10)

Serial Port programing – differences between serial and parallel communication, asynchronous and synchronous communication, simplex and duplex communication, architecture, SFR used, different modes of operation, steps and assembly programming for serial data transmission and reception.

Interrupt Programming – Polling vs Interrupt, interrupt vector table (IVT) and interrupt service routine (ISR). Interrupt structure of 8051, interrupt sources – Reset, timer, external and serial communication, SFR used and assembly programs.

Unit IV: Advanced I/O device interfacing and Case Studies (08)

Interfacing LCD – pin configurations, commands, programming for display message. Serial port programming - Send data to smartphone using Bluetooth module HC05 and control devices using smartphone. Interfacing ADC – pin configurations, programming for monitoring temperature using LM35 sensor. Waveform generation using DAC - square wave, Sawtooth, triangular and staircase. Bottle filling plant.

Suggested Readings:

1. Microcontrollers [Theory and Applications] Deshmukh - Ajay V. TMH.
2. Microcontrollers: Principles and Applications – Ajit Pal.
3. The 8051 Microcontroller and Embedded Systems using Assembly and C - Kenneth J. Ayala, Dhananjay V. Gadre.
4. The 8051 Microcontroller and Embedded Systems using Assembly and C - M.A. Mazidi, J.G. Mazidi, R.D. Mckinlay. Pearson Education.
5. The 8051 Microcontroller Architecture, Programming and application - Kenneth J. Ayala, Penram International.

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Semester – V	**Paper – III**
Course Code: BSC-ES 503 T	**Title of the Course: Process Control Systems**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

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

a. Familiar with different types of sensors and related systems.
b. Know different types of measurement systems.
c. Understand control parameters in process automation.
d. Understand different types of process control systems and their characteristics.

Detailed Syllabus:

Unit I: Process Measurements (06)

Block diagram of instrumentation system, Analog and Digital Modes of Operation, Null and Deflection Methods, Input Output configuration of Instruments and measuring systems.

Unit II: Process Performance Parameters (08)

Generalized measurement systems, zero-order System, First-order System, Second–order System, Dead-Time Element, Specifications and Testing of Dynamic Response.

Generalized Data Acquisition system- Elements of a data acquisition system, Single channel Data Acquisition system, Multichannel Data Acquisition system.

Unit III: Fundamentals of Process Control (06)

Process control principles, Continuous control, discrete state control, composite discrete/continuous control, Process Characteristics, Control system parameters, Architecture of Industrial Automation Systems, Advantages and limitations of Automation.

Unit IV: Process Control Systems (10)

Two position mode, Multi-position mode, floating control mode.

Continuous controller modes: Proportional control, Integral control, Derivative control Composite modes: Proportional-Integral, Proportional derivative, Proportional-integral – derivative (PID).

Suggested Readings:

1. Process Control Instrumentation Technology; Curtis Johnson, Pearson Publication.
2. Instrumentation Devices & Systems, C S Rangan, G R Sarma,V S Mani, TMH.
3. Measurement Systems Application and Design, Ernest O Doeblin, Dhanesh N Manik, Tata McGrawHill.
4. Elements of Electronic Instrumentation and Measurement, Joseph J. Carr, Pearson Education.
5. Modern control technology: components & systems, Kilian, Delmar.
6. Process software and digital networks, Bela G Liptak.
7. Computer-Based Industrial Control - Krishna Kant.

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Semester – V	**Paper – IV**
Course Code: BSC-ES 504 T	**Title of the Course: 'C' Programming**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

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

a. Understand fundamentals of C language.
b. Develop algorithm/flowcharts for problem solving and writing programs.
c. Learn to use functions, arrays, pointers and file handling in C language.
d. Understand different types of algorithm.

Detailed Syllabus:

Unit I: Fundamentals (10)

Introduction, character set, constants and variables, Key words, Symbolic constant, statements, entering and executing C program, input and output simple and formatted functions, operators and expressions, control structures and loops and programming examples.

Unit II: Functions, Arrays and Pointers (10)

Defining a function, Accessing a function, function prototype, passing argument, recursion. Defining and processing of an array, passing array to a function, Pointers declarations, passing pointers to a function, operations of Pointers, pointers as function parameters and programming examples.

Unit III: String and File handling (05)

Operations on string, string length, string size, string copy, string concatenation, string compare, Opening and closing of data file, read and write data file, processing data file and append data file.

Unit IV: Electronic Circuit Problems using C (05)

Write a program 1.To calculate the equivalent resistance of n resistors. (Parallel and series), 2.To converts binary number to decimal.

Develop a program to calculate frequency of 1. Astable multivibrator using 555 2. Wein bridge oscillator 3. Phase shift oscillator.

Suggested Readings:

1. J. Jayasri The 'C' Language Trainer with C Graphics and C++ WILEY.
2. Byron. S. Gottfried Schaum's Outline of Programming with C TMH.
3. E Balaguruswamy Programming in –C BPB.
4. Stephens Cochan Programming in C Prentice hall of India Ltd.
5. V. Rajaraman Computer Programming in C Prentice hall of India Ltd.
6. Madhusudan Mothe C for Beginner.

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Semester – V	**Paper – V**
Course Code: BSC-ES 505 T	**Title of the Course: Fundamentals of Fiber Optic Communication**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

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

a. Acquire Knowledge of optical fiber communication system.
b. Understand different parameters of optical fibers.
c. Learn essential optical components of Fiber Optic Communication.
d. Analyze and integrate fiber optical network components in variety of networking schemes.

Detailed Syllabus:

Unit I: Overview of Optics and Optical Fiber Communication (12)

History of fiber optic systems, block diagram, Fiber material, fiber cables and fiber fabrication, fiber joints, fiber connectors, splicer, Propagation of light in optical fiber, acceptance angle, numerical aperture, Types and specification of optical fiber, Advantages of optical fiber communication, applications.

Unit II: Transmission Characteristics of Optical Fiber (07)

Attenuation, absorption, linear and nonlinear scattering losses, bending losses, modal dispersion, waveguide dispersion and pulse broadening, Dispersion shifted and dispersion flattened fibers, Measurement of optical parameters, attenuation and dispersion.

Unit III: Optical Sources and Detectors (07)

Sources: Coherent and non-coherent sources, quantum efficiency, modulation capability of optical sources, Working principle and characteristics of - LEDs, Laser diodes, Detectors: PIN and APD.

Unit IV: Optical Networks **(04)**

Architecture of optical transport networks (OTNs), network topologies, Introduction to Synchronous optical networking (SONET) and synchronous digital hierarchy (SDH).

Suggested Readings:

1. Optical fiber communication – Principles and practice, J.M. Senior, PHI.
2. Fiber optics and Optoelectronics, R.P. Khare, Oxford University Press.
3. Optical fiber communication, G. Kaiser McGraw Hill.

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Semester - V	**Paper - VI**
Course Code: BSC-ES 506 T	**Title of the Course: Electronic Product Design and Entrepreneurship**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

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

a. Know of fundamental steps of electronic product design.
b. Know about product debugging and testing techniques.
c. Understand different types of documentation procedures required for product design.
d. Understand basic requirements for entrepreneurship.

Detailed Syllabus:

Unit I: Introduction to Electronic Product Design (05)

Stages in Product Design, Five elements of successful product design, Prototyping of Product, Ergonomics.

Unit II: Product Debugging and Testing (08)

Steps of debugging, Techniques of troubleshooting, characterization, Inspection and testing of components, Simulation and prototyping, Integration, Verification and validation, EMI and EMC issues.

Unit III: Entrepreneurship Development (09)

Definition, Characteristics of an Entrepreneur, Functions of Entrepreneur, types of Entrepreneur, Motivation factors to become Entrepreneur, Entrepreneurial competencies, Entrepreneur and economic Development.

Unit IV: Documentation (08)

Types of documentation, Presentation and preservation, Methods of documentation: Technical

presentations, Proposals, Visual Techniques, Layout of documentation, Bill of Materials (BOM).

Suggested Readings:

1. Electronic Product Design, V. S. Bagad, Technical Publications.
2. Entrepreneurship Development, E. Gordan and K. Natarajan, Himalaya Publishing House, New Delhi.
3. Electronic Product Design, R. G. Kaduskar, V. B. Baru Second edition Wiley India.
4. Development of Entrepreneurship, G. S. Batra, Deep and Deep Publications, New Delhi.

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Semester – V	**Paper – VII**
Course Code: BSC-ES 507 P	**Title of the Course: Practical Course - I**
Credits: 02	**Total Lectures: 60 Hrs.** (12 practicals)

Course Outcomes (COs):

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

a. Analyze different design and test procedures for analog circuits and systems.
b. Measure different parameters of optical fiber communication systems.
c. Develop electronic systems for given application.
d. Understand different process control systems.

Detailed Syllabus:

The practical course consists of **10** experiments and **1** activity equivalent to 2 experiments.

Group A: Practicals based on Analog Circuit Design and Applications (Any 4)

1. To design, build and test wave shaping circuits (Integrator / differentiator circuit).
2. To design, build and test voltage to current/current to voltage converter.
3. To design, build and test Log amplifier using Opamp.
4. To study gain bandwidth product of inverting/ non-inverting amplifier.
5. To design, build and test Regulated power supply using IC LM317 / IC 723.
6. Designing of Fixed voltage power supply using IC regulators using 78 series and 79 series.
7. To design, build and test Function generator using 8038/2206 or any equivalent IC.
8. To design, build and test second order Butterworth active Low Pass / High Pass / Band Pass / Band Reject Filter (any two).
9. To study PLL and measure lock range and capture range of PLL (IC565 / CD4046 / XR2211 or any equivalent IC).
10. To design, build and test peak detector.

Group B: Practicals based on Fundamentals of Fiber Optic Communication (Any 4)

1. To measure propagation loss in optical fibers.
2. To measure bending loss in optical fibers.
3. To set up fiber optic voice link.
4. To measure Numerical Aperture of given optical fiber.
5. To study different methods of optical fiber terminations and polishing.
6. To study fiber optic sensors and their applications.
7. To design, build and test fiber optic Transmitter.
8. To design, build and test of fiber optic Receiver.
9. Visit to telecom facility for observing splicing, alignment, fusing, OTDR operation, and types of connectors, couplers and cables.

Group C: Practicals based on Process Control Systems (Any 2)

1. Simulation of controller modes (P/PI/PD/PID).
2. Design and develop ON/OFF controller using microcontroller.
3. Study of process automation system using ladder diagram.
4. Design and Development of Data acquisition system.

Group D: Activity (Any 1)

Any one of the following activities will be considered as equivalent to 2 experiments

1. Any two additional experiments than specified from any Group.
2. Industrial / field Visit.
3. Hands on training Workshop.
4. Do it Yourself Open ended Project.

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Semester – V	**Paper – VIII**
Course Code: BSC-ES 508 P	**Title of the Course: Practical Course - II**
Credits: 02	**Total Lectures**: **60 Hrs.** (12 practicals)

Course Outcomes (COs):

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

a. Compose and execute basic C programs.
b. Write and execute assembly programs for 8051.
c. Interface different I/O device to the 8051.
d. Understand importance of product design and entrepreneurship.

Detailed Syllabus:

The practical course consists of **12** experiments.

Group A: Practicals based on Microcontrollers (Any 5)

All the practicals should be performed for 8051 microcontroller using assembly programming.

1. Send data using Bluetooth module HC05.
2. Control devices using smartphone.
3. Send / receive SMS using GSM module.
4. RFID reader (EM18) interfacing.
5. Interfacing ADC.
6. LCD interfacing.
7. DAC interfacing for waveform generation.
8. Event counter for Bottle filling plant.
9. Delay generation using Timer.
10. Interrupt programming – External / Timer.

Group B: Practicals based on 'C' Programming (Any 5)

1. Generate the Fibonacci series up to the given limit N and also print the number of elements in the series.

2. Calculate factorial of a given number.
3. Generate and print prime numbers up to an integer N.
4. Parallel equivalent resistance of n resistors.
5. Reactance of Inductor, Capacitor in Ω at given frequency.
6. To determine impedance of the series LR circuit.
7. Calculate frequency of i) Astable multivibrator using 555 ii) Wein bridge Oscillator.
8. Transient response of an RC circuit.
9. Program to determine current flowing in a diode accepting diode voltage, reverse saturation current and junction temperature in Kelvin.
10. Program for code conversion - binary to decimal / binary to gray.

Group C: Practicals based on Electronic Product Design and Entrepreneurship (Any 2)

1. Interview a successful entrepreneur.
2. Visit a small business - project report.
3. Writing business proposal.
4. Market Survey of electronic products.
5. Quality control test procedures in industry.
6. Study of methods from Prototype to product.
7. Study of manufacturing process of any identified product.

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Semester – V	**Paper – IX**
Course Code: BSC-ES 509 Pr	**Title of the Course: Project Course – I**
Credits: 02	**Total Lectures: 60 Hrs.**

Course Outcomes (COs):

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

a. Understand basic methodology of selection of topic for project.
b. Understand how to do literature review for selected topic for project.
c. Apply the knowledge for design and development of the selected project.
d. Use different software and hardware for testing, validation and verification of circuits for successful outcome of project.
e. Understand documentation process in the form of presentation and project report.
f. Understand process of systematic development of electronic system and development of skills for successful outcome.

Guidelines to conduct Project Course - I:

This Course should be conducted using following guidelines:

a) Student has to perform project in Semester V as well as Semester VI. It can be:
   i. Separate project for each semester OR
   ii. Can perform continuous project carrying sufficient weightage of marks per semester.
b) There should be internal continuous assessment of Project work in the form of Seminars/presentation and continuous monitoring of work.
c) After completion of project, student has to submit the Project Report in the following format.
   i. Title of Project.
   ii. Aim and objectives of project.
   iii. Literature or Reference work.

iv. Block diagram and its explanation in brief and/or algorithm of software required if any
v. Design and development of Circuit/system and Simulation required if any
vi. Circuit Diagram and its working and Program explanation if any
vii. Experimental Work and PCB Design/fabrication required if any
viii. Results and Discussion
ix. Applications
x. Future Scope
xi. References

d) There must be observations, interpretations, conclusions, results of the project work.
e) Algorithm, program strategy, module wise description of parts etc. be provided in case of projects related with development of computer software.
f) Applications, usefulness, student's contribution must be clearly specified.
g) Further extension work may be suggested for better outcome of the project.
h) It is recommended to present the projects in competitions / project exhibitions organized by various authorities.

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Semester – V	**Paper – X**
Course Code: BSC-ES 510 T	**Title of the Course: Electronic Design Automation Tools**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

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

a. Understand different EDA software tools
b. Simulate various analog and digital circuits using EDA software tools
c. Perform DC, AC, Transient and Fourier analysis of different electronic circuits

Detailed Syllabus:

Unit I: Introduction to EDA Tools (06)

Definition of Simulation, Need of Simulation, Brief introduction of various simulators, Description to simulator tool, Hands on practice on available library of components, wiring and schematic designing.

Unit II: Electronics Designing using LTSPICE (10)

Introduction to Simulator: Brief History, New Versions, Representing Components, Understanding the simulation Environment, Using Model Editor, designing a Circuit and drawing a schematic, Preparation for Simulation: Preparing schematic for simulation, Understand the sources for simulation, Use of different markers. DC, AC, Transient and Fourier analysis of circuit, Digital circuit Simulation.

Unit III: Introduction to Multisim (08)

Environment: Design Process, Setting environment preferences

The Multisim: Schematic capture of circuits, placing components, Wiring components, simulation and result display in MultiSim. Device modeling: Design of Half-Wave rectifier,

Bridge rectifier, clippers and clampers using diode, voltage regulator, AC voltage measurement, DC transfer curve analysis.

Unit IV: Introduction to Proteus (06)

Description of simulation software tools (Proteus), Schematic Description: Introduction, Input files, element values, Nodes, circuit elements, sources, output variables, format of circuit and output files, drawing the schematic, Design rule Check (DRC), Netlist details.

Types of analysis: DC, Transient and Frequency.

Suggested Readings:

1. Essential Electronic Design Automation (EDA), by Mark D. Birnbaum,Pearson, ISBN: 0131828290.
2. Electronic Design Automation for Integrated Circuits Handbook – 2, Scheffer Lavagno Scheffer Martin.
3. LTspice,https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html
4. PCB Design and Circuit Simulator Software – Proteus, https://www.labcenter.com/
5. Multisim, https://www.multisim.com/

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Semester – V	**Paper – XI**
Course Code: BSC-ES 511 P	**Title of the Course: Practical Course – III**
Credits: 02	**Total Lectures: 60 Hrs. (12 Practicals)**

Course Outcomes (COs):

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

a. Design the electronics circuits using EDA software tools.
b. Simulate various analog and digital circuits using EDA software tools.
c. Plot various waveforms. Simulate basic electronic system blocks.

Detailed Syllabus:

The practical course consists of 12 experiments.

Group A: Practicals based on LTSpice (Any 4)

1. Simulation of clipper/clamper circuit/passive filter circuits.
2. Design and simulation the inverting and non-inverting amplifier using an Op-Amp of given gain.
3. Design and simulation of op-amp as integrator and differentiator.
4. Simulation of Half wave, Full Wave and Bridge Rectifier circuit.
5. Design and Simulation of Active second order low pass/high pass/band pass/band stop filter of given cutoff frequency.
6. Design and Simulation of a Wein`s Bridge oscillator of given frequency.
7. Design and Simulation of phase shift oscillator.
8. Design and Simulation of Simulation of peak detector.

Group B: Practicals based on Multisim (Any 4)

1. Power Supply design with regulators, LM7805, LM7812
2. Simulation Study of I-V characteristics of SCR
3. Simulation Study of I-V characteristics of MOSFET
4. Simulation Study of I-V characteristics of IGBT
5. To design, build and test Half wave/Full Wave controlled rectifier.

6. Design and simulation of light dimmer circuit.
7. Design and Simulation AM Modulator and Demodulator
8. Design and Simulation FM Modulator and Demodulator

Group C: Practicals based on Proteus (Any 4)

1. Design and Simulation Amplitude Shift Keying (ASK)
2. Design and Simulation Frequency Shift Keying (FSK)
3. Design and Simulation Phase Shift Keying (PSK)
4. LED array interfacing (display 3 different patterns on LED) to microcontroller.
5. Seven segments display interfacing to microcontroller.
6. Stepper motor interfacing (Clockwise and anticlockwise rotation) to microcontroller.
7. DC motor interfacing (Clockwise and anticlockwise rotation to microcontroller.
8. LCD interfacing to microcontroller.

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Semester – VI	**Paper – I**
Course Code: BSC-ES 601 T	**Title of the Course: Modern Communication Systems**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

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

a. Understand the digital modulation techniques.
b. Understand different types of pulse modulation techniques.
c. Describe the evolution and importance of Mobile communication and cellular communication.
d. Know the basics of satellite communication systems.

Detailed Syllabus:

UNIT 1: Basics of Digital Communication (06)

Introduction, digital trans receiver, Information capacity, bits, bit rate, baud rate and m-ary coding, Amplitude Shift Keying, Frequency Shift Keying, Binary Phase Shift Keying, Quadrature amplitude modulation, Block diagram of MODEM.

UNIT 2: Digital Modulation (08)

Definition of PCM, PCM Sampling, Signal to quantization noise, PCM Methods, Delta modulation and adaptive delta modulation and generation methods, Time Division Multiplexing, Frequency Division Multiplexing.

UNIT 3: Mobile and Cellular Communication (08)

Introduction, mobile telephone service, cellular phone, frequency reuse, cell splitting, sectoring, segmentation and dualization, cellular telephone topology, roaming and handoffs, network components and call processing, comparative study of GSM and CDMA, 2G, 3G, 4G and 5G concepts.

UNIT 4: Satellite Communication (08)

Introduction to satellite, geosynchronous satellites, spacing and frequency allocation, satellite system link models, system parameters, FDM satellite systems: Set-Top Box, channel capacity, satellite radio navigation, FDMA, TDMA, Satellite data communication: VSAT.

Suggested Readings:

1. Electronic Communication Systems Fundamentals through advanced, Wayne TomaPearson Education Press.
2. Wireless communications, Andrea Goldsmith, Cambridge University Press.
3. Fundamentals of Wireless Communication, D. Tse and P. Viswanathan, Cambridge University Press.
4. Modern Wireless Communication, Haykin S. and Moher M., Pearson.
5. Wireless and Mobile Network Architectures, Yi-Bing Lin Wiley.
6. WEB resources: http://nptel.ac.in/courses/

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Semester – VI	**Paper – II**
Course Code: BSC-ES 602 T	**Title of the Course: Embedded System Design**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

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

a. Understand debugging and error handling techniques.
b. Understand features, architecture and memory organization of PIC microcontroller.
c. Program AVR and PIC microcontroller using C.
d. Interface different peripherals with PIC and AVR microcontroller.

Detailed Syllabus:

Unit I: Microcontroller Programming using Embedded C (06)

Assembly language vs C language, advantages of microcontroller programming using embedded C. Data types, operators, control statements, loops and functions. Software development tools used for programming and debugging, debugging and error handling techniques.

Unit II: Introduction to PIC Microcontroller and its Programming using C (09)

Introduction to PIC, families, features of PIC18, architecture, memory organization, I/O port structure. Programming PIC using C – available compilers and IDE, data types, operators, structure of program, library files, I/O Bit Manipulation, delay generation. Simple programs for performing arithmetic and logical operations, I/O programming and data conversion.

Unit III: Introduction to AVR Microcontroller and its Programming using C (09)

Introduction to AVR, families, features of ATMega16, architecture of AVR, memory organization, I/O port structure. Programming AVR using C – available compilers and IDE, data types, operators, structure of program, library files, I/O Bit Manipulation, delay

generation. Simple programs for performing Arithmetic and Logical operations, I/O programming and data conversion.

Unit IV: Peripheral Interfacing to PIC / AVR and Case Studies (06)

Interfacing LED, push button, buzzer, SSD, stepper motor, Interfacing LCD – pin configurations, commands, programming for display message on both lines, security system using PIR sensor, waveform generation using DAC - square wave, Sawtooth, triangular and staircase. Automatic car parking system.

Suggested Readings:

1. The AVR microcontroller and embedded systems using Assembly and C, Muhamad ali Mazidi, Sarmad Naimi, Sepehr Naimi, PHI publications.
2. PIC microcontroller and embedded system, Muhammad Mazidi, Mackanly, Danny Causy Pearson Education Press.
3. Embedded System Design, Rajkamal, Pearson Education Press.
4. Introduction to Embedded Systems, K. V. Shibu, TMH publication.

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Semester – VI	**Paper – III**
Course Code: BSC-ES 603 T	**Title of the Course: Power Electronics**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

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

a. Understand basics of semiconductor power devices.
b. Analyze basic power electronics circuits.
c. Understand the Electric Vehicle (EV) systems.

Detailed Syllabus:

Unit I: Introduction to Power Electronics **(06)**

Comparative study of power devices (Diodes, Transistors, DIAC, TRIAC, Thyristors / SCR), Protection of power semiconductor devices.

Unit II: Power Circuits **(10)**

Concept of three phase, Controller Rectifiers: Half wave and Full Wave (R Load and R/L load) Inverters: Half bridge and full bridge, Cyclo converters.

Concept of Switched Mode Power Supplies (SMPS), various schemes of SMPS, Design aspects of SMPS, UPS.

High frequency heating:

Induction Heating - Basic Principle, Factors Governing the process, applications, merits and demerits over other systems.

Di-electric heating - Basic Principle, Factors governing the process, applications, merits and demerits over other systems.

Unit III: Motor Control **(06)**

Classification of motors, DC motor, single phase SCR drive, Speed control of DC motor, AC motor and Induction motor.

Unit IV: Electric Vehicle (EV) Systems (08)

Advantages of Electric Vehicles. Comparative study of EV and Hybrid Vehicles, Types of EVs: Battery Electric Vehicle (BEV), Plug in Hybrid Electric Vehicle (PHEV), Hybrid Electric Vehicle (HEV), Fuel Cell Vehicles, Electric Vehicle Batteries.

Suggested Readings:

1. Power Electronics: Circuits, Devices and Applications, Mohammad Rashid, Pearson publication.
2. Power Electronics, P.C. Sen TMH, New Delhi.
3. Power Electronics and Its Applications, Alok Jain Penram India.
4. Power Electronics, M D Singh, K B Khanchandani McGraw Hill, New Delhi.
5. https://nptel.ac.in/courses/108/103/108103009/
6. https://pluginbc.ca/wp/wp-content/uploads/2014/07/EV-Beginners-Guide_Final_Sept2_2014.pdf

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Semester – VI	**Paper – IV**
Course Code: BSC-ES 604 T	**Title of the Course: Sensors and Systems**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

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

a. Understand basic principles and types of different sensors.
b. Know basic principles and types of actuators.
c. Understand about signal conditioning systems for sensors.
d. Know applications of sensors.

Detailed Syllabus:

Unit I: Fundamentals of Sensors **(10)**

Definition, Classification and types of sensors, Sensors: Temperature, stress and strain, light, chemical sensors, gas sensors, vibration sensors, smart sensors.

Specification and performance parameters: Accuracy, Resolution, Threshold, impedance, noise, Sensitivity, Hysteresis, Linearity, Range, Reliability, Selectivity, bandwidth.

Unit II: Introduction to Sensor Systems **(08)**

Sensor systems: Sensor characteristics, signal conditioning circuits, power supply, data acquisition and readout, measurement issues and criteria.

Bridge amplifiers, Precision op-amps characteristics for amplifiers, instrumentation amplifiers, isolation amplifiers.

Unit III: Actuators **(06)**

Actuators-Principle, construction and specifications,

Pressure controller, flow control actuators (Valves), Power control devices, magnetic control device - Relay, Solenoid, Electromechanical: servo, DC motor, AC motor, Stepper motor

Unit IV: Applications of Sensors **(06)**

Healthcare, biosensors and biomedical applications, automobile, applications in building management system, industry, security and surveillance, marine, military and space.

Suggested Readings:

1. Sensor technology handbook John Wilson, Elsevier.
2. Fundamentals of industrial instrumentation and process control, William C. Dunn, McGaw Hill Publication.
3. Sensors and Transducers, D Patranabis, Prentice Hall Publication.
4. Sensors and Transducers, Dr. A.D. Shaligram, Chintan Publication.
5. Sensors and Transducers, Principles and Applications, R.Y. Borse, Adhyan Publishers and Distributers, New Delhi.

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Semester – VI	**Paper – V**
Course Code: BSC-ES 605 T	**Title of the Course: Python Programming**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

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

a. Understand basics of python programming.
b. Use different data types of python programming.
c. Write simple python programs.
d. Understand the use of Classes and Objects.

Detailed Syllabus:

Unit I: Introduction to Python **(08)**

Importance, features and overview of Python, Comments, Identifiers, Reserved Keywords, Variables, Standard Data Types, Operators, Statement and Expression, String Operations, Boolean Expressions. Getting Started with Programming. Applications of Python, software tools used for Python programming.

Unit II: Python data types **(06)**

Strings and Lists, Tuples and Dictionaries, Files and Exceptions - Text Files, Directories, Exceptions, User-Defined Exceptions. Applications and simple programs to understand each data type.

Unit III: Control statements and Functions **(10)**

Control Statements, Iteration – while Statement, for statement, input-output. Functions - Built-in Functions, Composition of Functions, User Defined Functions, Parameters and Arguments, Function Calls, The return Statement, Python Recursive Function, The Anonymous Functions, Writing Python Scripts. Simple programs using Control Statements and functions.

Unit IV: Classes and Objects **(06)**

Overview of OOP (Object-Oriented Programming), Class Definition, Creating Objects, Objects as Arguments, Objects as Return Values, Built-in Class Attributes, Inheritance, Data Encapsulation and Data Hiding. Applications and programs.

Suggested Readings:

1. Think Python, Allen Downey, O'Reilly, 2012.
2. Introduction to Computing and Problem Solving using Python - E. Balagurusamy.
3. Python 3 for Absolute Beginners - Tim Hall and J-P Stacey.
4. Hands-on Python Tutorial - Dr. Andrew N. Harrington.

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Semester –VI	**Paper – VI**
Course Code: BSC-ES 606 T	**Title of the Course: Digital System Design using Verilog**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

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

a. Know and understand structure of HDL and Verilog.
b. Understand different modeling styles in Verilog.
c. Use Verilog effectively for simulation, verification and synthesis of digital system.
d. Understand basics of programmable logic devices.

Detailed Syllabus:

Unit I: Introduction to Verilog (10)

A Brief History of HDL, Structure of HDL Module, Comparison of VHDL and Verilog, Introduction to Simulation and Synthesis Tools, Test Benches, Verilog Modules, Delays, data flow style, behavioral style, structural style, mixed design style, simulating design.

Introduction to Language Elements: Keywords, Identifiers, White Space Characters, Comments, Format, Integers, Reals and Strings, Logic Values, Data Types-net types, undeclared nets, scalars and vector nets, Register type, Parameters, Expressions, Operands, Operators, types of Expressions.

Unit II: Modeling Styles (10)

Data flow Modeling: Continuous assignment, net declaration assignments, delays, net delays. Behavioral Modeling: Procedural constructs, timing controls, block statement, procedural assignments, conditional statement, loop statement, procedural continuous assignment. Gate level modeling: Introduction, built in Primitive Gates, multiple input gates, Tri-state gates,

MOS switches, bidirectional switches, gate delay, array instances, implicit nets, Examples (both combinational and sequential logic circuits).

Unit III: Logic synthesis with Verilog **(05)**

Concept of logic synthesis, Synthesis design flow, Synthesis of combinational logic for two bit magnitude comparator, Synthesis of Sequential Logic with Flip-Flops.

Unit IV: Introduction to Programmable Logic Devices **(05)**

Introduction of Programmable Logic Array (PLA), Programmable Array Logic (PAL), Programmability of PLDs, Complex PLDs (CPLDs), Field-Programmable Gate Arrays.

Suggested Readings:

1. Verilog HDL: A Guide to Digital Design & Synthesis, Samir Palnitkar, SunSoft Press, ISBN: 978-81-775-8918-4.
2. Digital Fundamentals, Floyd and Jain, Pearson Education, ISBN: 8177587633.
3. Fundamental digital logic with Verilog design by Stephen Brown and Zvonka Vrenesic, Mc Graw Hill Publication, ISBN 0-07-282315-1 ISBN 0-07-121322-8 (ISE).

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Semester – VI	**Paper – VII**
Course Code: BSC-ES 607 P	**Title of the Course: Practical Course - IV**
Credits: 02	**Total Lectures: 60 Hrs.** (12 practicals)

Course Outcomes (COs):

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

a. Demonstrate power electronic circuits.
b. Demonstrate different types of digital communication systems.
c. Design and develop sensor systems for different applications.
d. Understand working principles of different power devices and their characteristics.

Detailed Syllabus:

The practical course consists of **10** experiments and **1** activity equivalent to 2 experiments.

Group A: Modern Communication Systems (Any 3)

1. Study of PCM.
2. Study of Delta / Adaptive Delta modulation.
3. Study of Satellite communication system.
4. Comparative study of GSM, CDMA. 2G, 3G and 4G methods.
5. Study of architecture of mobile communication system.
6. Study QAM /QPSK techniques.
7. Study of BPSK MODEM.

Group B: Practicals based on Power Electronics (Any 3)

1. To study Characteristics of power devices like BJT/MOSFET/IGBT/Triac.
2. To design, build and test light dimmer circuit.
3. To design, build and test DC motor speed controller.
4. To design, build and test half wave / Full Wave controlled rectifier.
5. SMPS.
6. Emergency light.

7. Study of UPS.
8. Analog/Digital Inverter.
9. BLDC motor driver.

Group C: Practicals based on Sensors and Systems (Any 4)

1. Design, develop and test bridge amplifier for thermistor.
2. Design, develop and test Instrumentation amplifier for temperature measurement.
3. Design, develop and test signal conditioning circuit for optical sensors (LDR/Photodiode/Phototransistor).
4. Smoke detector.
5. Soil moisture measurement.
6. Burglar alarm.
7. Study of Smart sensors.
8. Design, develop and test controller for servo motor / DC motor / AC motor / Stepper motor.
9. Specification and performance parameters analysis of any sensor.

Group D: Activity (Any 1)

Any one of the following activities will be considered as equivalent to 2 experiments -

1. Any two additional experiments than specified from any Group.
2. Industrial / field Visit.
3. Hands on Training Workshop.
4. Do it Yourself Open ended Project.

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Semester – VI	**Paper – VIII**
Course Code: BSC-ES 608 P	**Title of the Course: Practical Course - V**
Credits: 02	**Total Lectures: 60 Hrs.** (12 practicals)

Course Outcomes (COs):

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

a. Develop and simulate design digital systems using Verilog.
b. Design and develop microcontroller based systems.
c. Inculcate basic skills required for design and development of embedded Systems.
d. Write and execute python programs.

Detailed Syllabus:

The practical course consists of **12** experiments.

Group A: Practicals based on Embedded System Design (Any 4)

All the practicals should be performed for PIC / AVR microcontroller using C programming.

1. To get familiarize with PIC and AVR target board, understand the use of software development tools and perform necessary installation procedure and perform basic exercises.
2. LED array interfacing (display 3 different patterns on LED).
3. LCD interfacing.
4. Seven segments display interfacing.
5. Stepper motor interfacing (Clockwise and anticlockwise rotation).
6. Security system using PIR sensor.
7. Waveform generation using DAC - square wave, Sawtooth / triangular / staircase.
8. Automatic car parking system.
9. To read push-button and turn ON/OFF Buzzer as per the status of push-button.

Group B: Practicals based on Python Programming (Any 4)

1. Enter the number from the user and depending on whether the number is even or odd, print out an appropriate message to the user.
2. Write a program to generate the Fibonacci series.
3. Python program to swap two elements in a list.
4. Python program to print the factorial for a given number.
5. Program to find sum of array.
6. Python Program to find largest element in a list.
7. Calculate frequency of Phase Shift Oscillator.
8. Reverse words in a given String in Python.
9. Python program to print even numbers in a list.
10. Python Program to check Armstrong Number

Group C: Practicals based on Digital System Design using Verilog (Any 4)

1. 2:1 Multiplexer and 1: 2 De-multiplexer.
2. Magnitude comparator.
3. Code converters.
4. Binary Adder (Ripple Adder and carry look ahead adder).
5. Up / down counter.
6. Stepper motor sequence generator.
7. Design 2-4 / 3-8 decoder.
8. Four bit ALU design.
9. Designing of Traffic light Controller.
10. Encoder - 8 to 3 encoder.

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Semester – VI	**Paper – IX**
Course Code: BSC-ES 609 Pr	**Title of the Course: Project Course – II**
Credits: 02	**Total Lectures: 60 Hrs.**

Course Outcomes (COs):

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

a. Understand basic methodology of selection of topic for project.
b. Understand how to do literature review for selected topic for project.
c. Apply the knowledge for design and development of the selected project.
d. Use different software and hardware for testing, validation and verification of circuits for successful outcome of project.
e. Understand documentation process in the form of presentation and project report.
f. Understand process of systematic development of electronic system and development of skills for successful outcome.

Guidelines to conduct Project Course - II:

This Course should be conducted using following guidelines:

a) Student has to perform project in Semester V as well as Semester VI. It can be:
   i. Separate project for each semester OR
   ii. Can perform continuous project carrying sufficient weightage of marks per semester.
b) There should be internal continuous assessment of Project work in the form of Seminars/presentation and continuous monitoring of work.
c) After completion of project, student has to submit the Project Report in the following format.
   i. Title of Project
   ii. Aim and objectives of project.
   iii. Literature or Reference work

iv. Block diagram and its explanation in brief and/or algorithm of software required if any
v. Design and development of Circuit/system and Simulation required if any
vi. Circuit Diagram and its working and Program explanation if any
vii. Experimental Work and PCB Design/fabrication required if any
viii. Results and Discussion
ix. Applications
x. Future Scope
xi. References

d) There must be observations, interpretations, conclusions, results of the project work.
e) Algorithm, program strategy, module wise description of parts etc. be provided in case of projects related with development of computer software.
f) Applications, usefulness, student's contribution must be clearly specified.
g) Further extension work may be suggested for better outcome of the project.
h) It is recommended to present the projects in competitions / project exhibitions organized by various authorities.

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Semester – VI	**Paper – X**
Course Code: BSC-ES 610 T	**Title of the Course: PLC and its Applications**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

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

a. Know about the basics of programmable logic controllers and their components.
b. Understand basics of Programmable Logic Controllers, their working and their programming.
c. Develop PLC based systems by programming different components in PLC.

Detailed Syllabus:

Unit I: Programmable Logic Controller (PLC) (09)

Introduction, Concept of PLC, Building blocks of PLC, Building blocks of PLC, Functions of various blocks, limitations of relays. Advantages of PLCs over electromagnetic relays. Different programming languages, PLC manufacturer etc.

Working of PLC - Basic operation and principles of PLC, Scan Cycle, Memory structures, I/O structure, Programming terminal, power supply.

Unit II: Basics of PLC Programming (09)

PLC Programming Languages, Basic instructions like latch, master control self-holding relays. Timer instruction like retentive timers, resetting of timers. Counter instructions like up counter, down counter, resetting of counters. Arithmetic Instructions (ADD, SUB, DIV, MUL etc.) MOV instruction, RTC (Real Time Clock), Watch Dug Timer, Comparison instructions like equal, not equal, greater, greater than equal, less than, less than equal.

Unit III: Ladder Diagram Programming (07)

Programming based on basic instructions, timer instructions, counter instructions, data compare instructions, arithmetic Instructions using ladder program.

Unit IV: PLC Programming Applications (05)

Applications of PLCs: Object counter, On-off control , Car parking , Sequential starting of motors, Traffic light control, Bottle filling plant.

Suggested Readings:

1. Programmable Logic Controllers Programming Methods and Applications, John R. Hackworth and Fredrick D. Hackworth, Jr., Pearson Education.
2. Programmable Logic Controller by Job Dan Otter; P.H. International, Inc, USA.
3. Programmable Logic Controllers, W. Bolton.
4. Programmable Logic Controllers, Frank D. Petruzella, Third Edition, Tata McGraw Hill Education Private Limited.
5. Module on PLCs and their Applications by Rajesh Kumar, NITTTR Chandigarh.

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Semester – VI	**Paper – XI**
Course Code: BSC-ES 611 P	**Title of the Course: Practical Course – VI**
Credits: 02	**Total Lectures: 60 Hrs. (12 experiments)**

Course Outcomes (COs):

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

a. Understand basics of Programmable Logic Controllers and its programming
b. Understand basic ladder diagram programming.
c. Develop PLC programs different applications using ladder diagram.

Detailed Syllabus:

The practical course consists of 12 experiments.

1. To Identify Components/sub-components of a PLC, Learning functions of different modules of a PLC system available in laboratory.
2. To understand programming a PLC (a) using a Hand held programmer (b) using computer interface.
3. Ladder Programming for basic and derived logic gates.
4. PLC Program to Convert Binary to Gray Code and Gray code to Binary.
5. PLC Program to Implement 2-bit Magnitude Comparator.
6. PLC Program to Implement 4:1 Multiplexer and 1:4 Demultiplexer.
7. PLC Program to Implement SR Flip-Flop.
8. PLC Program to Implement D Flip Flop.
9. Study of timer instructions.
10. Study of counter instructions.
11. Study of comparison instructions.
12. PLC Program for Burglar Alarm Security System.
13. Ladder Programming for bottle filling plant.
14. Ladder Programming for traffic light control.

15. Ladder Programming for Object counter - On-off control.
16. Ladder Programming for Car parking.
17. Ladder Programming for Sequence control system e.g. in lifting a device for packaging and counting.
18. Ladder Programming for Sequential starting of motors.
19. PLC Program to Control Motor in Forward and Reverse Direction.
20. PLC Program to Count and Pack Parts from Conveyor.