Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

Autonomous

Academic Year 2020-2021

Course Structure For M.Sc.- II : Electronic Science

Semester	Paper Code	Title of Paper	No. of Credits
III	ELE4301	Advanced Communication Electronics	4
	ELE4302	Advanced Embedded Systems	4
	ELE4303	Digital Signal Processing	4
	ELE4304	Programmable Logic Controllers and Applications	4
	ELE4305	Practical Course –V	4
	ELE4306	Practical Course –VI	4
IV	ELE4401	Control Systems	4
	ELE4402	Advanced Power Electronics	4
	ELE4403	Mechatronics and Robotics	4
	ELE4404	Wireless Sensor Networks	4
	ELE4405	Project	8

ELE4301**: Advanced Communication Electronics (4 Credits)**

Objectives:

1. To learn analog modulation techniques
2. To study basics of information theory and digital communication
3. To study various data digital communication systems
4. To make students aware of various communication technologies.

Unit 1: Analog communication

Communication systems, Modulation, Bandwidth requirements, External and Internal noise, Theory of Amplitude modulation, Power distribution, Generation of AM, Suppression of carrier, suppression of unwanted side Bands, Extensions of SSB. Theory of frequency and Phase modulation, sidebands and modulation index, Noise andFrequency modulation, Generation of FM, FM receivers. Analog base band Transmission,

Unit 2: Digital Communication

Pulse modulation, Pulse amplitude modulation, pulse width modulation, pulse position modulation, Delta modulation, Adaptive delta modulation, Digital modulation techniques- ASK, FSK, PSK, QAM, M-ary digital modulation techniques. Digital base band transmission.

Coding Techniques- Introduction to the Coding, Alpha - Numeric coding, Parity Check Coding, Hamming Code, Concept of Systematic Code, RZ, NRZ, Manchester code, AMI, Error Detection and Error Correction.

Unit 3: Advanced Digital Communication Systems- 5

Satellite Communication, Telephone, Cellular Phones, Dual Tone Multi Frequency (DTMF) dialing, Integrated Services Digital Network (ISDN)., spread spectrum techniques, OFDM, 3G wireless, IP telephony, Bluetooth, IrDA, CDMA

Unit 4: Communication Technologies

Local Loop, PSTN, ISDN, digital exchanges, Principles of Telemetry, satellite communication and VSAT, GSM,

Text / Reference Books

1. Electronic Communication Systems, George Kennedy and Bernard Davis Publ. Tata McGraw Hill.
2. Electronic communications, Dennis Roddy and John Coolen, Pearson Publ.
3. Communication Electronics Principles and applications, Louis E. Frenzel, Tata McGraw Hill.
4. Digital data communication, Miller

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ELE4302: **Advanced Embedded Systems (4 Credits)**

Objectives:

1. To study the architecture of Advanced RISC machine (ARM7)
2. To learn assembly level programming of ARM-7 and interfacing hardware
3. To get acquainted to fundamentals of operating system
4. To get familiar with real time operating system (RTOS)
5. To introduce Raspberry pi.

Unit-1: Advanced Risc Machine (ARM-7)

ARM7 CPU Core,Processor Architecture (32-bit), ARM Programmer's Model, ARM Development Tools, Introduction to ARM families, ARM7TDMI Features,Pipelining, Exepections, Interrupt Vector Table, ARM Instruction Set, Thumb Instruction
System Peripherals: Bus Structure, Memory Map, Register Programming, PLL
User Peripherals: GPIO, PWM Modulator, RTC, Watchdog Timer, UART, I2C, SPI, ADC, DAC, CAN Overview of ARM Cortex M1, Cortex M2, Cortex M3

Unit-2 : Introduction to Operating Systems

Brief history of OS, Operating system basics and types of operating systems
The BIOS and Boot Process: BIOS Actions, Operating System, Boot Process System calls, files, processes, design and implementation of processes, communication between processes Memory Management: segmentation and paging Memories: virtual, cache etc.

Unit-3: Real Time Operating Systems (RTOS)

Operating System basics, Types of Operating Systems, Tasks, Process, Threads, Multiprocessing and Multi tasking, Task Scheduling, Threads-Processes-Scheduling putting them together, Task Communication, Task Synchronization, Device Drivers, How to choose an RTOS

Unit-4: Raspberry Pi with Python

Basic functionality of the Raspberry Pi board and its processor, setting and configuring the board, differentiating Raspberry pi from other platform like arduino, asus thinker etc., overlocking Component overview.Communication facilities on Raspberry pi(I2C,SPI,UART)working with RPil. GPIO library, interfacing of Sensors and Actuators.

Text / Reference Books:

1. “ARM System On Chip Architecture”, By Steve Furber, Pearson
2. ARM System Developer”s Guide Designing and Optimizing Systems Software, by Andrew Sloss, Elsevier
3. The insider”s guide to the PHILIPLS ARM7 based Microcontrollers, An Engineer Introduction LPC2100 Series, Trevor Martin, Hitex ltd
4. LPC 214x User Manual
5. Operating System Concepts and Techniques,M. Naghibzadeh.
6. Operating Systems Concept, Galvin, John Willey and Sons
7. .Raspberry Pi for Python Programmers Cookbook - Second Edition 2nd Edition, Kindle Edition
8. Raspberry Pi® User Guide, 4Eben Upton Gareth Halfacree

ELE4303: **Digital Signal Processing** Credit : 4

Objectives:

1. To get acquainted to fundamental aspects of Digital Signal Processing (DSP)
2. To become aware of mathematical background required for DSP
3. To learn design of digital filters and implementation on digital Signal Processor
4. To study DSP applications
5. To make the students able to apply digital filters according to known filter specifications
6. To provide the knowledge about the principles behind the discrete Fourier transform (DFT) and its fast computation
7. To be able to apply the MATLAB programme to digital processing problems and presentations

Unit-1: Signals and Systems

Overview: Classification of Signals and Systems: continuous time and discrete time, signal types, amplitude and phase spectrum, classification of systems. Real time DSP system and interfacing A-D conversion process, sampling, quantization and encoding, oversampling and antialiasing, Nyquist rate & aliasing problem, anti aliasing, Pulse Sampling, one bit ADC, DAC conversion process, oversampling

Unit-2: Mathematical Tools for DSP

Introduction to Fourier series, Fourier series Representation of periodic signals, Dirichlet Conditions, Evaluation of Fourier coefficients, Properties of Fourier Transform (FT), Discrete Fourier Transform (DFT) and its inverse DFT, Existence of DFT, properties of DFT, Circular convolution, sampling of continuous signal, Fast Fourier Transform (FFT) DIT, DIF algorithm and their comparison and its computational advantage. Inverse FFT, implementation of FFT, DIT and DIF algorithm

Unit-3: Digital Filter Design

Frame work of digital filter design: introduction, types – infinite impulse response (IIR), finite impulse response (FIR)

FIR filter: features, filter design steps, design, filter specifications, coefficient calculation methods, window method, optimal method, frequency sampling method, FIR filter design using Kaiser window, realization structure for FIR filter, finite word length effects, and implementation of FIR filters

IIR Filter: basic features, design steps, coefficient calculation, poles-zeros placement, impulse invariant method, bilinear transform, Matched z-transform, Nyquist effect, realization structure for IIR filter, finite word length effects, implementation of IIR filters

Unit-4: DSP Processor and Application Areas

Introduction to DSP processors, types of DSP processors and architecture, general purpose DSP processors; implementation of noise removal techniques, echo, chorus and flange effects introduced in music, implementation of DSP algorithm for FIR, IIR filtering

Text /Reference Books:

1. Digital Signal Processing: A Practical Approach, Emmanuel Ifeachor, Barrie Jervis, Prentice Hall.
2. Digital Signal Processing: S. Salivahan, A. Valuraj, C.Gnanapriya, Tata McGraw Hill, Pub. Co. Ltd. Edn. 2006.
3. Digital Signal Processing: A Hands on Approach: Charles Schuller, Mahesh Chugani, Tata McGraw Hill Pub. Co. Ltd. Edn. 2006.
4. Digital Signal Processing: - Principles, Algorithms and Applications: John G Proakis, Dimitris G Monolkis, and Pub. Person 2005.Operating Systems Concept, Galvin, John Willey and Sons.
5. Digital Signal Processing and Applications with the C6713 and C6416 DSK, Rulph Chassaing, a John Wiley & Sons, Inc.
6. The Scientist and Engineer's Guide toDigital Signal Processing, Steven W. Smith Second Edition California Technical Publishing.

ELE4304: **Programmable Logic Controllers- Programming and Applications**

Credit : 4

Objectives -

1. To make the students aware of programmable logic controller hardware
2. To introduce students to ladder diagram and PLC programming
3. To study some case studies using PLC

Unit 1: Introduction to PLC

PLC characteristics, operation, function, Types of PLC, Architecture Of PLC, Applications of PLC, PC v/s PLC, memory, Input/output module with reference to sink or source, output module relay, transistor, triac, power supply, signal conditioning, remote connections, networks, PLC product application range, selection of PLC, Examples of applications

AC mains interfaces, PLC wiring, device wiring, 24V DC input interfaces, sourcing devices, sinking devices, output interface configurations and wiring

Unit 2: PLC Programming

Programming methods- Logic control elements (NOT,AND,OR,NAND,NOR etc), ladder diagrams, function blocks, statement list, programming a PLC, programming terminals, ladder relay instructions, ladder relay programming (digital gates, boolean expression, mux-demux, flip flop)

Unit 3: Timers, Counters and Registers

Types of timers, programming timers, off-delay timers, pulse timers, programming examples, forms of counter, programming, up and down counting, timers with counters, sequencer, data handling: registers and bits, data handling, arithmetic functions, closed loop control shift registers, ladder programs.

Unit 4: Case studies

Program development, safe systems, commissioning, fault finding, system documentation

programs- temperature control, valve sequencing, conveyor belt control, control of a process, traffic lights controller, bottle filling control, alarm monitor program, car parking, vending machine, automatic stacking program, AC motor drive interface, elevator, water level controller.

Text /Reference Books:

1. John W. Webb and Ronald A. Reis, “Programmable Logic Controllers Principles and Applications“, Fifth Edition, Prentice Hall Publication, New Delhi, 2002.
2. L.A. Bryan, E.A. Bryan, “Proghrammable controllers theory and Implementations” second edition, An Industrial Text Company Publication.
3. W.Bolton, “Programmable Logic Controllers”, Fifth Edition, Elsevier Publication
4. Gary Dunning, “Introduction To Programmable Logic Controllers”, Third Edition.
5. John R. Hackworth, Frederick D. Hackworth, “Programmable Logic Controllers Programming Methods and Applications”, Pearson Publication.
6. Frank D. Petruzella, “Programmable Logic Controllers”, Third Edition, Tata McGraw Hill Education Private Limited, 2010.
7. John F. Kennedy “Programmable Controllers An engineer’s guide” 3rd Newnes Publications.

Semester-IV ELE4401: **Control System** Credit: 4

Objectives --

1. To make student familiar with basic concepts of control theory.
2. To understand the use of transfer function models for analysis physical systems and introduce the control system components.
3. To accord basic knowledge in obtaining the open loop and closed–loop frequency responses of systems.
4. To introduce stability analysis and design of compensators.
5. To make students familiar with latest trends in industrial control / production systems.

Unit-1: Basics of Control system

Elements of control system, concept of closed loop control and open-loop control, continuous and discrete state control, control strategies such as feedback and feed forward, mathematical models of systems, transfer function and its use, obtaining transfer function, block diagram reduction rules and signal flow graph, Mason's gain formula.

Unit-2: Stability and frequency response

Concept of stability, Routh stability criterion, Routh- Hurwitz criterion, Construction of Root locus, Bode plots- phase margin and gain margin, Lead, lag, lead-lag compensation using bode plot, Polar plot, Nyquist plots, process loop tuning, Open loop transient response method, Zeigler- Nichols method.

Unit-3: Analog and Digital Controllers

Classification of controllers, Controller terms Discontinuous controllers: On-OFF Controller, three position controller.

Continuous controllers: Proportional, Integral and Derivative control

Composite control modes: PI, PD and PID controllers. Derivative overrun and integral windup in PID control mode, concept of DCS, SCADA supervisory, Fuzzy logic, applications.

Unit-4: Control system components and system examples

Principle and characteristics of control values, synchro-servo motors, Solenoids, actuators, annunciators, alarms, recorders, Standard Graphics Symbols for Process Control and Instrumentation.

Control system examples: Speed control system, position control systems,temperature and level control systems, reel drives, tension control system for paper.

Text / Reference Books:

1. Process control: Principles and applications, Surekha Bhanot, Oxford University Press 2nd Edition.
2. Control Engineering Noel. M. Morris, 3rd Edition Mac Graw Hill.
3. Process control instrumentation technology, C. D Johanson, PHI.
4. Control system engineering, Nagrath and Gopal, New age international limited.
5. Control Systems, U.A. Bakshi and V. U. Bakshi, Technical Publications Pune.
6. Modern Control engineering, Ogata, Prentice Hall, EEE.
7. Control engineering theory and practice, N.M. Bandhopadhyay, PHI.

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ELE4402: **Advanced Power Electronics** Credit :4

Objectives:

1. To study the basic principles and applications of power electronics
2. To understand the solid-state devices required for power electronic circuits
3. To study and understand the power conversion and power transmission principles
4. To study the industrial and domestic applications

Unit-1: Introduction to Power Devices and Circuits

Overview of Power circuits, concept of load, Application areas, and Basic concepts of electrical and magnetic circuits. Construction, I-V characteristics, switching characteristics, types, Selection criteria and applications of Power diodes, Power BJT, MOSFET, IGBTs

Thyristors: SCR Characteristics, two-transistor model, turn-on and turn-off methods of SCR

Unit-2: Power Circuits

Rectifiers: single phase rectifiers performance parameters overview (half-wave and full wave)

Controlled rectifiers: Single phase and three phase R and RL load – half-wave, semi-full wave and dual converters, Single phase series converters, Powerfactor improvement techniques

AC voltage controllers: ON-OFF control, Concept of phase control, single phase Uni-directional and bidirectional controllers with resistive & inductive loads.

Cycloconverter: Introduction to cycloconverter, types of cycloconverter,Single Phase Cycloconverter, Mid point cycloconverter, Bridge type cycloconverter, step up cycloconverter. Reduction of output harmonics.

DC-DC converters: step-up and step-down converters, performance parameters, control strategies,

Unit-3: Applications of Power Electronics

DC power supplies: switch mode DC power supplies, flyback, forward, push pull, half bridge, full bridge-converters, resonant DC power supplies, resonant power supplies, bi- directional power supplies

AC Power supplies (UPS): switch mode AC Power supplies, resonant and bidirectional AC Power supplies

DC drives: Basic characteristics of DC motors, Operating modes, single phase and 3 phase drives, DC –DC converter Drives, Closed loop control of DC drives

AC drives: Induction motors drives-squirrel cage and wound rotor motor, Performance characteristics, control methods

Synchronous motor drives-cylindrical rotor, Reluctance, Permanent magnet, switched reluctance- motors, control methods, Brushless DC and AC Motors and Stepper Motor: types and Control

Unit-4: Practical Design Considerations

Snubber circuits, Turn-on and turn-off and over voltage snubbers, isolation methods, Control Circuits: Current mode and voltage mode PWM Cooling and heat sinks, reverse recovery transients, supply and load side transients, Selenium diodes and MOVs for voltage protections, Current protection methods, EMI standards, sources and shielding methods, Induction and capacitive heating, modern electric

welding

Text /Reference books:

1. Power Electronics: Circuits, Devices and Applications, Muhammad H. Rashid, 3rd Edition, Pearson.
2. Industrial and Power Electronics – Deodatta Shingare Electrotech publication,
3. Power Electronics: Converters, Applications, and Design, Ned Mohan, Tore M. Undeland, William P. Robbins, 3rd Edition, Wiley.
4. Power Electronics, P. C. Sen, Tata McGraw-Hill Education.
5. Power Electronics: A First Course, Ned Mohan, 2012.
6. Power Electronics Handbook, edited by Muhammad Rashid, Elsevier
7. Fundamentals of Power Electronics, Robert W. Erickson, Dragan Maksimovic, Springer
8. Power Electronics, Daniel Hart, Tata McGraw-Hill Education, 2011

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ELE4403: **Mechatronics and Robotics. (4 Credits)**

Objectives:

1. To introduce the students of Electronic Science to the subject of mechatronics
2. To review the concepts of sensors, transducers and actuators, with a view to use them in Mechatronic systems
3. Enable the learner to acquire basic knowledge of mechanical systems to be used with Electronic systems
4. To introduce robot dynamics and robot joint control systems.
5. To provide a quick overview of the Artificial intelligence and role of computer in Mechatronics and Robotics.

Unit-1: Introduction to Mechatronics, Sensors and Transducers

Introduction to Mechatronics: Introduction to Mechatronics, design Process, System, modeling of the system measurement systems, control systems, Open and closed loop systems, examples on mechatronics systems, Real Time Mechatronics systems, advantages and disadvantages of mechatronics systems, Applications of mechatronics systems .

Sensors and Transducers: Introduction to sensors and transducers, sensitivity analysis, measurement of motion, digital sensors for motion measurement of force, torque and tactile sensors, vibration- acceleration sensors, flow measurement, temperature sensors and devices, applications of sensors

Unit-2:Mechanical and Electrical Actuation Systems

Mechanical actuation systems: mechanisms and their role in mechatronic systems, Translational and rotational motion – degrees of freedom, kinematic chains – examples of links, toggle linkage, slider-crank etc. cams, gears – types, gear trains, gear ratios, uses of rotation-to-translational motion – rack and pinion, ball screw and links, Ratchet and pawl, belt and chain drives, bearings– types and uses, consideration of moment of inertia and torque for motor selection

Electrical actuation systems: Relays and applications with driver circuits, Solid state switches- diodes, thyristors, BJTs and MOSFETs and their applications as switches and driver circuits

DC Motor-: types, basic construction and working, DC motor driver circuits, and speed control AC motors- basic idea of single phase and three phase motors and their speed control

Stepper motors- types, construction, features, specifications, control of drives.

Unit-3: Robotics and system of a Robot.

Classification of robots, applications, Basic components of robot system, functions of robots, robot specifications. Mechanical systems: review of elementary mechanical concepts, motion conversion, modeling of mechanical systems, end effectors, resolution, repeatability, accuracy of manipulators.

Unit-4: Mechatronic system and case studies.

Artificial intelligence-basic ideas, meaning, perception and cognition, reasoning and learning Role of Computers in Robotics **-**Imaging, image representation, picture coding, object recognition and categorization, control-using computer

Mechatronic systems - Mechatronic designs and case studies

Text / Recommended Books:

1. Mechatronics by W.Bolton, 4th Edition, Pearson.
2. Mechatronics System Design, by DevdasShetty and Richard Kolk, 2nd Edition, Cengage Learning.
3. Robotics Engineering – An integrated approach. By Richard W. Klafter, Thomas A. Chmielewski and Michael Negin, PHI Learning Pvt. Ltd.

EEL 4404: **Wireless Sensor Networks (4 Credits)**

Objectives:

1. To familiarize with wireless sensor network.
2. To provide a background of single-node architecture and wireless networking protocols
3. To study currently available sensor platforms and tools

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Unit-1: Introduction and Overview of Wireless Sensor Networks

Introduction,background of sensor network technology, challenges and hurdlesExamples of WSN applications: home control, industrial automation, medical applications. Radio technology primer: propagation and propagation impairments, modulation, ISM band, Specifications of WSN devices

Unit-2: Architecture Considerations and Networking Sensors

Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes, Operating Systems and Execution Environments, Network Architecture - Sensor Network Scenarios, Optimization Goals and Figures of Merit, Gateway Concepts Physical Layer and Transceiver Design considerations, Introduction to protocols, Overview of Communication Protocols for Sensor Networks, wireless networking protocols (IEEE 802.11, 802.15, 802.16, GPRS, MAC protocol.

Unit-3: Infrastructure formation, Available Sensor Platforms and Tools

Introduction to the RF Modules, architecture of the Zigbee module, on-chip resources of the Zigbee Pro, programming the Zigbee, designing of WSN with Zigbee modules
Topology Control, Clustering, Time Synchronization, Localization.
Hardware platforms – Berkeley Motes or equivalent, Programming Challenges,
Introduction to Simulators: NS2, OPNET, OMNET, WSN Planner Tool etc.

Unit-4:Sensor Network Security

Network Security Requirements, Issues and Challenges in Security Provisioning, Network Security Attacks, Layer wise attacks in wireless sensor networks, possible solutions for jamming, tampering, black hole attack, flooding attack. Key Distribution and Management, Secure Routing – SPINS, reliability requirements in sensor networks.

Text / Recommended Books:

1. Kazem Sohraby, Daniel Minoli and Taieb Znati, “Wireless Sensor Networks Technology-
2. Protocols and Applications”, John Wiley & Sons, 2007.
3. Ananthram Swami, Qing Zhao, Yao-Win Hong, Lang Tong, “Wireless Sensor Networks-Signal Processing and Communications Perspectives” John Wiley & Sons,2009
4. Feng Zhao, Leonidas Guibas, “Wireless Sensor Networks”, ELSEVIER publications, 2005.
5. Kaveh Pahlavan and Prashant Krishnamurthy, “Principle of Wireless network- A unified approach”, Prentice Hall, 2006.
6. “Theoretical and algorithmic aspects of sensor, Ad Hoc Wireless and Peer to Peer Networks”, Edited by Jie Wu, Auerbach Publications.
7. Handbook of Sensor Networks: Compact Wireless and Wired Sensing Systems, CRC
8. PRESS Publication, Edited by Mohammad Ilyas and Imad Maugoub.

ELE4305: Practical course V

Laboratory Practicals: Any 10 Practicals from following sections

Communication Electronics

1. Design of AM/FM transmitter and receiver
2. Delta modulation
3. Design PCM encoder/ decoder system
4. Design of ASK / FSK transmitter and receiver
5. Time division Multiplexing
6. Telemetry Applications
7. Varactor diode characteristics and its application in FM

Control Systems and Process Instrumentation

1. Signal conditioning circuits for analog controller
2. Design and implement ON-OFF Controller
3. Design and implement P / PI / PID controller
4. To study the position / velocity control of dc servo motor
5. Flow control using solenoid valve
6. Study of optical position encoder

Advanced Power Electronics

1. DC motor speed /AC motor speed control/ Stepper motor control
2. Practical based on Inverter.
3. Measurement of transformer parameters
4. Design single phase on-off controller.
5. Study of thyristor its characteristics.
6. Study of Commutation method of SCR.

Mechatronics

1. Study of DC servo motor/BLDC motor.
2. Study of PMDC motor toque speed characteristics
3. Study of AC servo motor, its speed control/position control
4. Set up a flow control system using suitable flow sensor and actuator
5. study of actuators and their driving circuit (solenoids, motors etc.)
6. Study digital sensor

ELE4306**: Practical Course –VI (4 Credits)**

Computer - Microcontroller Laboratory: Any 10 Practicals from following sections

Group I- Advanced Embedded Systems

1. Interfacing Alphanumeric LCD to 16/32 bit microcontroller
2. Interfacing key board to 16/32 bit microcontroller
3. Programming ADC of 16/32 bit microcontroller
4. Programming DAC of 16/32 bit microcontroller
5. Programming UART of 16/32 bit microcontroller
6. Implementation of priority based execution of 3 task using RTOS
7. Blink an LED using Raspberry Pi and Python
8. Interfacing 16×2 LCD with Raspberry Pi
9. Controlling a DC Motor with Raspberry Pi

Group II- Digital Signal Processing

1. Generation of signals- Impulse, Step, Exponential and Ramp functions
2. Design of FIR filter, Design of IIR filter
3. Find DFT and IFT of given Example
4. Linear and circular convolution
5. To design low pass/ band pass filter using MATLAB.
6. To generate rectangular, hamming, hanning,blackman and kaiser window using MATLAB.
7. Implementation of Decimation Process / Interpolation Process

Group III:-Programmable Logic Controllers and Applications

1. Relay programming (all logic gates, boolean equation like multiplexer, demultiplexer, encoder, decoder, latch etc.)
2. Temperature controller
3. Conveyor belt control
4. Alarm monitor program
5. Vending machine
6. Water level controller

Group IV:- Wireless Sensor Networks

1. Study of 802.15.4-interfacing and configuration
2. Setting up communication between 2 zigbee nodes
3. Home automation- related experiments
4. Study of effect of various modes of Microcontrollers on Network performance.
5. Interfacing Bluetooth / wifi module

Group V:- Communication

Experiments using MATLAB

1. Phase shift keying (PSK)
2. Generation and reception of BPSK
3. Generation and reception of FSK
4. Generation and reception of QPSK
5. Continuous Phase FSK