LINEAR INTEGRATED CIRCUITS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	14XXX42	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to:

- Define and Describe basic concepts of Op-AMPs, characteristics and specifications.
- Develop and Apply Op-AMP applications to signal conditioning for amplifiers, filters and oscillators.
- Develop and Apply Op-AMP applications for comparators and data conversions.
- Develop, Apply and Analyze the use of Op-AMPs for advanced applications such as PLL, VCOs, V-I Converters, I-V Converters, AGC, AVC, Analog multipliers.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1		
Introduction to Operational Amplifiers and Characteristics Introduction, Block diagram, characteristics and equivalent circuits of an ideal op-amp, various types of Operational Amplifiers and their applications, Power supply configurations for OP-AMP applications, inverting and non-inverting amplifier configurations. Relevant Problems. **The Practical op-amp** Introduction, Input offset voltage, offset current, thermal drift, Effect of variation in Power supply voltage, common-mode rejection ratio, Slew rate and its Effect, PSRR and gain – bandwidth product, frequency limitations and compensations, transient response, Interpretation of OP-AMP LM741 & TL082 datasheet. Relevant Problems.	**10 Hours**	**L1, L2**
Module -2		
Amplifiers and Oscillators Summing amplifier, Integrators and differentiators, Instrumentation amplifier, Differential input and differential output amplifier, Voltage-series feedback amplifier, Voltage-shunt feedback amplifier, Log/ Antilog amplifier, isolation amplifiers, Triangular/rectangular wave generator, phase-shift oscillators bridge oscillator, analog multiplier (MPY634) VCO. Relevant Problems.	**10 Hours**	**L3, L4**
Module -3		
Active Filters Characteristics of filters, Classification of filters, magnitude and frequency response, Butterworth 1st and 2nd low pass, high pass and band pass filters, Chebyshev filter characteristics, Band reject filters, Notch filter, All pass filters and self tuned filters. Relevant Problems.	**10 Hours**	**L3, L4**
Module -4		

Comparators and Converters Comparator, Zero Crossing Detector, Monostable and Astable Multivibrator, Schmitt Trigger, Voltage limiters, Clipper and clampers, Absolute value output circuit, Peak detector, Sample and hold Circuit, Precision rectifiers, Voltage-to-current converter, Current-to-voltage converter. Relevant Problems.	**10 Hours**	**L2, L3**
Module -5		
Advanced Applications Applications as Frequency Divider, PLL, AGC, AVC using op-AMP and analog multipliers, Amplitude modulation using analog multiplier, Frequency Shift Keying, simple OP-AMP Voltage regulator, Fixed and Adjustable Voltage Regulators, Dual Power supply, Basic Switching Regulator and characteristics of standard regulator ICs – TPS40200, TPS40210. Relevant Problems.	**10 Hours**	**L3, L4, L5**

Course outcomes:

After studying this course, students will be able to:

- Acquire knowledge of
  - Operational amplifiers and characteristics as well as various types of op-amps.
  - Functioning of PLL, VCO, V-I, I-V converters, AGC, AVC and analog multipliers.
  - Active Filters, Comparators and Convertors.
- Analyse the performance of
  - Op-amps and Various Applications.
  - Instrumentation Amplifiers, Isolation Amplifiers, Wave Generators and Oscillators.
- Interpretation of Performance Characteristics of Practical Op-amps.
- Apply the knowledge gained in the design of practical circuits for amplifiers, filters oscillators and electronic systems.

Graduate Attributes (as per NBA)

- Engineering Knowledge
- Problem Analysis
- Design / development of solutions (partly)

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Ramakant A Gayakwad, "Op-Amps and Linear Integrated Circuits," Pearson, 4th Ed, 2015.

Reference Books:

1. B Somanathan Nair, "Linear Integrated Circuits: Analysis, Design & Applications," Wiley India, 1st Edition, 2015.

2. Data Sheet: http://www.ti.com/lit/ds/symlink/tl082.pdf.

4. Application Note: http://www.ti.com/lit/an/sloa020a/sloa020a.pdf.

5. MPY634 Data Sheet: http://www.ti.com/lit/ds/symlink/mpy634.pdf.

6. Application Note: http://www.ti.com/lit/an/sbfa006/sbfa006.pdf.
7. ASLK Pro Manual: ASLK Manual.

NETWORK ANALYSIS AND CONTROL SYSTEMS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	14XXX45	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to:

- Describe, Apply and Analyze basic network concepts emphasizing Series and Parallel Combination of Passive Components, Source Transformation and Shifting.
- Describe, Apply and Analyze use of mesh and nodal techniques for Formulating the Transfer Function of Networks.
- Apply and Analyze various network theorems in solving the problems related to Electrical Circuits.
- Describe and Analyze two-port networks and methods of analysing the Electrical Networks.
- Describe Open and Closed Loop Control Systems, Analysis of Control Systems Using Block Diagram Reduction and Signal Flow Graph Techniques.
- Determine the time domain response of first and second order systems to Various types of Inputs.
- Define and Describe stability in control systems, Analysis of stability using Routh-Hurwitz Criterion and Evaluate stability of systems using Root-Locus technique.

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1		
Basic Network Concepts Series and Parallel combination of Resistors, Inductances and Capacitors. Star-Delta Transformation. Source Transformation and Source Shifting. Relevant Problems. **Mesh and Node Analysis** Kirchhoff's Laws. Mesh Analysis and Super mesh Analysis. Node Analysis and Super node Analysis. Relevant Problems.	**10 Hours**	**L2, L3, L4**
Module -2		
Network Theorems and Two Port Networks Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem. Relationship of Two-Port Variables, Open Circuit Impedance Parameters, Short Circuit Admittance Parameters, Transmission Parameters, Hybrid Parameters, Relationships between the parameter sets. Relevant Problems.	**10 Hours**	**L2, L3, L4**
Module -3		

Introduction to Control Systems Introduction, Definitions, Open Loop Control Systems, Closed Loop (Feedback) Control Systems, Automatic Tank Level Control System, Position Control System, Merits and Demerits of Feedback. Transfer Function Concept, Properties of Transfer Function, Unity Feedback Systems. Relevant Problems. **Mathematical Modeling of Systems** Translation Systems, Rotational Systems, Electrical Analog of Mechanical Systems. Relevant Problems. Block Diagram Reduction, Signal Flow Graph, Masson's Gain Formula. Relevant Problems.	**10 Hours**	**L1, L2, L3**
Module -4		
Transient Response Analysis Introduction, Typical Test Input Signals, First Order Systems: Unit-Step, Unit-Ramp, Unit-Impulse Response of First Order Systems. Relevant Problems. Second-Order Position Control System, Unit-Step Response of Second-Order Systems, Performance Indices (No Derivation), Steady State Error: Unit Step Input, Unit Ramp Input, Unit Parabolic Input, Steady State Error in terms of Closed Loop Transfer Function for Unit Step and Unit Ramp Input. Relevant Problems.	**10 Hours**	**L2, L3, L4**
Module -5		
Routh Stability Introduction, Stability, Necessary Conditions for Stability, Routh Array, Special Cases, Application of Routh-Hurwitz Stability Criterion, Relative Stability. Relevant Problems. **Root-Locus Technique** Root-Loci for Second Order System, Basic Conditions of Root-Loci, Rules for the Construction of Root-Loci. Relevant Problems.	**10 Hours**	**L1, L2, L3**

Course outcomes:

After studying this course, students will be able to:

- Acquire knowledge of
  - Series and Parallel combination of Passive Components, Source Transformation and Source Shifting.
  - Network Theorems and Electrical laws to reduce circuit complexities and to arrive at feasible solutions.
  - Various Two-Port Parameters and their Relationship for finding Network Solutions.
  - Basic Concepts of Control Systems, Stability Concepts of Linear Systems.
- Analyse the Performance of
  - Various Types of Networks Using different concepts and principles.
  - Behavior of control systems with respect to simplification and determining stability of complex systems
- Interpretation of Performance Characteristics of Networks and control systems.
- Apply the knowledge gained in the analysis and design of electrical and electronic

circuits.

Graduating Attributes (as per NBA)

- Engineering Knowledge
- Problem Analysis
- Design / development of solutions (partly)
- Investigations

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 16 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. M. E. Van Valkenburg, "Network Analysis", Pearson, 3rd Edition, 2015**.** ISBN: 9789332550131.
2. Ravish R. Singh, "Network Analysis and Synthesis", McGraw Hill, 2013. ISBN: 9781259062957.
3. D. Roy Choudhury, "Modern Control Engineering", PHI, 2015. ISBN: 9788120321960.

Reference Books:

1. D. Roy Choudhury, "Networks and Systems", New Age International.
2. B. C. Kuo, "Automatic Control Systems", Wiley India.

MICROCONTROLLERS FOR EMBEDDED SYSTEMS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	14XXX44	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to:

- Recall and Describe the basic architecture of 16-bit microcontrollers.
- Describe the hardware-interfacing concepts and Apply to connect digital as well as analog sensors while ensuring low power considerations.
- Apply the protocols used by microcontroller to Develop to communicate with external sensors and actuators in real world.
- Describe IoT and architecture, and Develop a Wi-Fi Connectivity in a Smart Electric Meter.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1		
Fundamentals of microcontrollers for Embedded Systems Embedded system overview, applications, features and architecture considerations - ROM, RAM, timers, data and address bus, I/O interfacing concepts, and memory mapped I/O. CISC Vs RISC design philosophy, Von-Neumann Vs Harvard architecture. MSP430x5x series block diagram, address space, on-chip peripherals (analog and digital), and Register sets. Instruction set, instruction formats, and various addressing modes of 16-bit microcontroller; MSP430 specifics. Variants of the MSP430 family viz. MSP430x2x, MSP430x4x, MSP430x5x and their targeted applications, Sample embedded system on MSP430 microcontroller.	**10 Hours**	**L1, L2**
Module -2		
Peripherals and programming for Microcontroller Memory Mapped Peripherals, programming System registers, I/O pin multiplexing, pull up/down registers, GPIO control. Interrupts and interrupt programming. Watchdog timer. System clocks. Low Power aspects of MSP430: low power modes, Active vs Standby current consumption, FRAM vs Flash for low power & reliability. **Case Study**: MSP430 based embedded system application bringing up the salient features of GPIO, Watchdog timer, low power, FRAM Energy and power consumption estimation for embedded board	**10 Hours**	**L2, L3, L4**
Module -3		
Timer & Real Time Clock (RTC), PWM control, timing generation and measurements. Analog interfacing and	**10 Hours**	**L2, L3**

data acquisition: ADC and Comparator in MSP430, data transfer using DMA. Power considerations: Programming for optimal power consumption while using peripherals, Using MSP430 peripheral intelligence in power management Case Study: MSP430 based embedded system application using ADC & PWM demonstrating peripheral intelligence. "Remote Controller of Air Conditioner Using MSP430.		
Module -4		
Serial communication basics, Synchronous/Asynchronous interfaces (like UART, USB, SPI, and I2C). UART protocol, I2C protocol, SPI protocol. Implementing devices. Case Study: MSP430 based embedded system application using the interface protocols for communication with external devices: "A Low-Power Battery less Wireless Temperature and Humidity Sensor with Passive Low Frequency RFID.	**10 Hours**	**L2, L3**
Module -5		
IoT overview and architecture, Overview of wireless sensor networks and design examples, Various wireless connectivity: NFC, ZigBee, Bluetooth, Bluetooth Low Energy, Wi-Fi. Adding Wi-Fi capability to the Microcontroller, Embedded Wi-Fi, User APIs for Wireless and Networking applications, Building IoT applications using CC3100 user API for connecting sensors. Case Study: MSP430 based Embedded Networking Application: "Implementing Wi-Fi Connectivity in a Smart Electric Meter.	**10 Hours**	**L3, L4, L6**

Course outcomes:

After studying this course, students will be able to:

- Learn 16-bit architecture and its programming.
- Acquire the ability to design software using C for embedded systems applications.
- Understand and program various digital and analog Sensor Interfaces specific to Microcontroller.
- Design and understand various use cases and projects in the domain of Embedded Systems, Internet of Things, and will be able to implement the same.

Graduate Attributes (as per NBA)

- Engineering Knowledge
- Problem Analysis
- Design / development of solutions (partly)
- Modern Tool Usage
- Project Management and Finance (partly).

Question paper pattern:

- The question paper will have ten questions.
- Each full question consisting of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. John H. Davis, “MSP430 Microcontroller Basics”, Elsevier, 2012.

Reference Books:

1.http://processors.wiki.ti.com/index.php/MSP430_LaunchPad_Low_Power_Mode

2.http://processors.wiki.ti.com/index.php/MSP430_16Bit_UltraLow_Power_MCU_Training

ENGINEERING ELECTROMAGNETICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	14XXX44	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to:

- Define and Describe Coluomb's law and electric field intensity.
- Define and Explain electric flux density, Gauss's law and divergence.
- Describe energy and potential along with concepts of current and conductors.
- Describe Poisson's and Laplace's Equations, and Uniqueness Theorem.
- Define and Describe basic concepts of Magnetostatics by studying the various laws, Stoke's Theorem and scalar and vector magnetic flux density.
- Explain Magnetic Forces, Materials and Inductance.
- Describe the concepts of time varying fields and Develop Maxwell's equations in Point and Integral Forms.
- Describe and Compare different Types of Wave Propagation.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **a. Coluomb's Law and Electric Field Intensity** Experimental law of Coulomb, Electric field intensity, Field due to continuous volume charge distribution, Field of a line charge. Relevant Problems. **b. Electric flux density, Gauss's law and divergence** Electric flux density, Gauss' law, Divergence. Maxwell's First equation (Electrostactics), Vector Operator ▼ and divergence theorem. Relevant Problems.	**10 Hours**	**L1, L2**
Module -2		
Energy and potential Energy expended in moving a point charge in an electric field, The line integral, Definition of potential difference and potential, The potential field of point charge, Energy density in the electrostatic field. Relevant Problems. **Conductors, dielectrics and capacitance** Current and current density, Continuity of current, Metallic conductors, Conductor properties and boundary conditions, boundary conditions for perfect Dielectrics, Capacitance and examples. Relevant Problems.	**10 Hours**	**L1, L2**
Module -3		
Poisson's and Laplace's Equations Derivation of Poisson's and Laplace's Equations, Uniqueness theorem, Examples of the solution of	**10 Hours**	**L1, L2**

Laplace's equation, Examples of the solution of Poisson's equation, Relevant Problems. **The Steady Magnetic Field** Biot-Savart Law, Ampere's circuital law, Curl, Stokes' theorem, Magnetic flux and magnetic flux density, Scalar and Vector Magnetic Potentials. Relevant Problems.		
Module -4		
Magnetic Forces Force on a moving charge, differential current elements, Force between differential current elements. Force and Torque on a closed circuit. Relevant Problems. **Magnetic Materials and Inductance** Magnetisation and permeability, Magnetic boundary conditions, Magnetic circuit, Potential Energy and forces on magnetic materials, Inductance and mutual inductance. Relevant Problems.	**10 Hours**	
Module -5		
Time-varying fields and Maxwell's equations Farday's law, displacement current, Maxwell's equations in point form, Maxwell's equations in integral form, the retarded potential. Relevant Problems. **Uniform Plane Wave** Wave propagation in free space, Wave propagation in dielectrics, Poynting's theorem and wave power, Propagation in good conductors: Skin Effect. Relevant Problems.	**10 Hours**	**L1, L2, L5**

Course outcomes:

After studying this course, students will be able to:

- Acquire knowledge of
  - Basic Concepts of Electric Fields, Magnetic Fields and Electromagnetic Waves.
  - Basic Concepts to Solve Complex Problems in Electric Fields, Magnetic Fields and Electromagnetic Waves.
  - Time-varying fields and Maxwell's equations.
  - Wave propagation in free space and dielectrics.
- Analyse
  - Different Charge and Current Configurations to derive Electromagnetic Field Equations.
  - Poisson's and Laplace's Equations, Uniqueness theorem, and solution of Laplace's equation.
  - Time-varying fields, Maxwell's equations, wave propagation in free space and dielectrics.
- Interpretation of
  - Gradient, Divergence and Curl Operators.
  - Maxwell's Equations in differential and integral forms.
  - Wave propagation in free space and dielectrics.
- Apply the knowledge gained in the design of Electric and Electronic Circuits, Electrical Machines and Antenna's and Communication Systems.

Graduate Attributes (as per NBA)

- Engineering Knowledge

- Problem Analysis
- Design / development of solutions (partly)**.**

Question paper pattern:

- The question paper will have ten questions.
- Each full question consisting of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. W.H. Hayt, J.A. Buck and M. Jaleel Akhtar, "Engineering Electromagnetics", 8th Edition, McGraw-Hill, 2015, 9789339203276.
2. Mathew N.O. Sadiku and S.V. Kulkarni, "Principles of Electromagnetics", 6th Edition, Oxford University Press, 2015, 9780199461851.

Reference Books:

1. John Krauss and Daniel A Fleisch, " Electromagnetics with applications", Mc Graw-Hill.
2. N. Narayana Rao, "Fundamentals of Electromagnetics for Engineering", Pearson.

VIRTUAL INSTRUMENTATION (Elective)

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	14XXX461	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives: This course will enable students to:

- Discriminate between traditional instrumentation and virtual instrumentation.
- Describe the concepts of virtual instrumentation.
- Demonstrate the use of LabView as a Virtual Instrument.
- Illustrate and Analyze data acquisition, processing and plotting of data.
- Describe and Use instrument control and motion control.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module – 1		
Graphical System Design (GSD) and Modular programming: Introduction, GSD model, Design flow with GSD, Virtual Instrumentation, Virtual Instrument and traditional instrument, hardware and software in Virtual Instrumentation, Graphical programming and Textual programming. GSD using LabView: Introduction, Advantages of LabView, Software environment, Creating and saving a VI, Front panel toolbar, Block diagram toolbar, Palettes, Property dialog box, Front panel control and indicators, Block diagram, data types, data flow program. Introduction and Modular programming in LabView, Build a VI front panel and Block diagram, Icons, Building a connector pane, Displaying SUBVI's, Opening and editing SUBVI's.	**8 hrs**	**L2, L3**
Module -2		
Repetition and Loops, Arrays and Clusters : For loops, While loops, Shift registers, Control timing, Local variables , Global variables. Arrays in LabView, 1D array, 2D arrays, array initialization, array functions. Creating cluster control & Indicators, Cluster operations, Assembling Clusters, Conversion between Arrays & clusters, Error Handling , Error cluster.	**08 Hours**	**L2, L3**
Module -3		
Structures, Strings and File I/O: Case structure, Sequence structure , Timed structure, Formula Nodes, Event structure, Labview Mathscript Creating String controls and Indicators, String	**08 Hours**	**L1, L2**

Functions, Editing , Formatting and Parsing strings, Configuring String controls & Indicators Basics of File Input/Output, Choosing a File I/O Format , File I/O VI's		
Module -4		
Data Acquisition, Plotting Data: Introduction, Transducers, Signals, Signal conditioning, DAQ hardware configuration, DAQ hardware, Analog inputs, Analog outputs, Counters, Digital I/O, Selecting and Configuring a data acquisition device- Signal sources , Measurement systems, Types of data ,Waveform graphs ,Waveform charts , Waveform data , Digital waveform graphs, Customizing graphs and charts, Configuring a graph or chart	**08 Hours**	**L3, L4**
Module -5		
Instrument control, Motion Control: Introduction, GPIB communication, Hardware specifications, software architecture, instrument I/O assistant, VISA, instrument drivers, serial port communications. Components of a motion control system, Software for configuration, prototyping and development, Motion controller, Move types, Motor amplifiers and drives, Feedback devices and motion I/O. **Requirement : LabView Software from National Instruments**	**08 Hours**	**L2, L3**

Course outcomes:

After studying this course, students will be able to:

- Acquire knowledge of
  - graphical system design and modular programming
  - Repetition, Loops, Arrays and Clusters
  - Structures, Strings and File I/O
  - Data Acquisition, Plotting Data
  - Instrument control, Motion Control
- Understand and apply LabView software.
- Apply the knowledge gained in the design of practical virtual instrumentation systems.

Graduate Attributes (as per NBA)

- Engineering Knowledge
- Problem Analysis
- Modern Tool Usage

Question paper pattern:

- The question paper will have ten questions.
- Each full question consisting of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Jovitha Jerome, “Virtual Instrumentation using LabView”, PHI Learning, 2015, ISBN: 9788120340305.

Reference Books:

1. S.Sumathi, P.Surekha, “LabView based Advanced Instrumentation Systems”, Springer.
2. Gary Jhonson, “Labview Graphical Programming, Second Edition”, McGraw Hill.

ELECTRONICS ENGINEERING MATERIALS (Elective) [As per Choice Based Credit System (CBCS) scheme] SEMESTER – IV			
Subject Code	14XXX462	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03
CREDITS – 03			

Course objectives: This course will enable students to:

- Recall and Describe the scope of electrical and electronic materials, Requirement of Engineering materials, Operational requirements of electrical and electronic materials.
- Recall and Describe concepts of dielectric materials, classification of dielectric materials, Dielectric constant, Dielectric strength and Dielectric loss and, Polarization and its different facets.
- Recall and Describe solid insulating materials and their applications, and various insulating materials.
- Recall and Describe manufacturing method of a resistor, basic classification, construction details of different kinds of fixed resistors, specifications of resistors and thermistors.
- Recall and Describe characteristics and classification of capacitors, constructional details of fixed value capacitors, specifications of capacitors and identification of capacitors.
- Describe and Analyze types of PCBs, manufacturing process, layout and design of a PCB, manufacturing process of single-sided and double-sided PCBs.

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module – 1		
Introduction to Electrical and Electronic Materials: Importance of materials, Classification of electrical and electronic materials, Scope of electrical and electronic materials, Requirement of Engineering materials, Operational requirements of electrical and electronic materials, Classification of solids on the basis of energy gap, Products – working principle and materials, Types of engineering materials, Levels of material structure. Spintronics and Spintronic materials, Ferromagnetic semiconductors, Left handed materials. Relevant Problems.	**08 Hours**	**L1, L2**
Module -2		
Dielectric Materials: Properties and Behavior: Introduction to dielectric materials, classification of dielectric materials, Dielectric constant, Dielectric	**08 Hours**	**L1, L2**

strength and Dielectric loss. Polarization, Mechanisms of polarization, Comparison of different polarization process, Factors affecting polarization, Spontaneous polarization, Behavior of polarization under impulse and frequency switching, Decay and build-up of polarization under ac field, Complex dielectric constant. **Dielectric Materials: Types and Applications:** Solid Insulating Materials and their Applications, Polymeric Insulating Materials, Natural and Synthetic Rubber as Insulating Material, Paper as a Fibrous Insulating Material, Choices of Solid Insulating Material for Different Applications. Relevant Problems.		
Module -3		
Passive Components (Resistors): Passive and Active components, Introduction to Resistors, Manufacturing Method of a Resistor, Basic Classification of Resistor, Construction Details of Different Kinds of Fixed Resistors, Comparison Among Different Types of Fixed Resistors, Specifications Resistors, Variable Resistors, Non-Linear Resistors, Thermistors. Relevant Problems.	**08 Hours**	**L1, L2**
Module -4		
Passive Components (Capacitors): Capacitor: an Introduction, Characteristics of Capacitors, Classification of Capacitors, Forms and Materials of Common Types of Capacitors, Constructional details of Fixed Value Capacitors, Plastic Film Capacitors, Ceramic Dielectric Capacitors, Electrolytic Capacitors, Tantalum Electrolytic Capacitors, Air Capacitor, Polarized and Non-Polarized Capacitors, Variable Capacitors, Specifications of Capacitors, Identification of Capacitors. Relevant Problems.	**08 Hours**	**L1, L2**
Module -5		
Printed Circuit Board (PCB) Fabrication: Printed Circuit Board, Types of PCBs, Types of PCB Substrates, Manufacturing Process of Copper Cladded Laminate, Layout and Design of a PCB, Manufacturing Process of PCB, Manufacturing Process of Single-Sided PCBs, Manufacturing Process of Double-Sided PCBs. Relevant Problems.	**08 Hours**	**L1, L2, L3**
Course outcomes: After studying this course, students will be able to: • Acquire knowledge of o Electrical and electronic materials, Requirement of Engineering materials. o Concepts of dielectric materials, classification of dielectric materials, Polarization. o Solid Insulating Materials and their Applications and various Insulating Materials. o Manufacturing Method of a Resistor, Construction Details of Different Kinds of		

Fixed Resistors.
  - Characteristics and Classification of Capacitors, Construction and Specifications of Capacitors and Identification of Capacitors.
  - Types of PCBs, Manufacturing Process, Layout and Design of a PCB, Manufacturing Process of Single-Sided and Double-Sided PCBs.
- Apply the knowledge gained in the analysis and design of electrical and electronic circuits.

Graduating Attributes (as per NBA)

- Engineering Knowledge
- Design / development of solutions (partly)

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 16 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. K.M. Gupta and Nishu Gupta “Advanced Electrical and Electronics Materials”, Wiley, 2015. ISBN: 9788126555987.

Reference Books:

1. C. S. Indulkar and S. Thiruvengadam, “Electrical Engineering Materials,” S. Chand.

BUSINESS COMMUNICATION (Elective)

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	14XXX463	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives: This course will enable students to:

- Recall and Describe the principal concepts of communication, Communication process and its elements and universal elements in communication.
- Demonstrate and Apply the importance of oral communication, the key skills of oral communication, Develop use of oral communication skills to new communication technologies.
- Demonstrate, Apply and Develop different purposes of writing, the essential principles of effective written communication, and different formats of e-mails.
- Demonstrate, Apply and Develop the importance of presentation skills, how to design a presentation, The chief principles of delivering an effective presentation and to handle questions.
- Demonstrate, Apply and Develop writing an effective CV, the art of handling the interviews and to be an effective participant in group discussion.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module - 1		
The Nature and Process of Communication The role of communication. ▪ An instance of unclear communication Defining Communication, Classification of Communication, The purpose of Communication, The process of Communication, The elements of Communication, The major difficulties in communication, Barriers to communication, Condition for successful communication, The seven C's of communication, Universal elements in communication. ▪ How sentence structure affects meaning Communication and electronic media, communication social media. Summary. Case: Communication failures	**8 Hours**	**L2, L3**
Module -2		
Oral Communication What is oral communication?, Importance of oral communication ills, Choosing the form of communication, Principles of successful oral communication, Guidelines for effective oral	**8 Hours**	**L2, L3, L4**

communication, Barriers to effective oral communication. Three aspects of oral communication- Conversing, Listening and Body language. Intercultural oral communication ▪ Intercultural communication oral communication electronic media: Phones, Voice Mail, Conference call, cell phone, Video conferencing Summary. Case: Dealing with outsourcing backlash.		
Module -3		
Written Business Communication The art of writing, Skills required in written communication ▪ Informatory Writing The purpose of writing ▪ Persuasive writing ▪ Examples of clear and unclear writing Principles of effective writing ▪ Rewriting a letter Summary. Case: On writing well. ▪ Writing e-mails, A series of e-mails Summary. Case: A reply sent to an erring customer.	**08 Hours**	**L2, L3, L4**
Module -4		
Presentation Skills Introduction, What is a presentation: Essential characteristics of a good presentation, The difference between a presentation and a lecture, The difference between a presentation and written report, ▪ Preparing a presentation Identify the purpose of presentation, Analyse the audience and identify their needs, Design and organize the information, Decide on the medium of presentation and visual aids, Time the presentation, Become familiar with location of presentation. ▪ Delivering the presentation Rehearsal, Body language, Handling question and debate, Tips to fight to stage fright Summary Case: The presentation effect	**8 Hours**	**L2, L3, L4**
Module -5		
CV's, personal interviews and group discussion Applying for job, Writing a CV, The relationship between the resume and application letter, The resume of recent graduate, Guidelines for preparing a good CV Drafting an Application Letter, Interviews. Participating in a group discussion. Summary Case: An employment interview.	**8 Hours**	**L2, L3**

Course outcomes:

After studying this course, students will be able to:

- Apply reasoning by the contextual knowledge to assess legal and cultural issues and the consequent responsibilities relevant to the profession engineering practice
- Apply ethical principles and commit to professional ethics and responsibilities, and norms of the engineering practice.
- Function effectively as an individual and as a member or leader in divers technical teams
- Communicate effectively on complex engineering activities such as, being able to write effective reports and make effective presentation
- The need for, and the ability to engage in independent lifelong learning in specialized technologies.
- Engineering management principles and use them to manage projects in multidisciplinary environments.

Graduating Attributes (as per NBA)

- The Engineer and Society
- Ethics
- Individual and Teamwork
- Communication
- Lifelong learning
- Project Management and Finance

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 16 marks
- There will be **2** full questions (with a **maximum** of **four** sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer **5** full questions, selecting one full question from each module.

Text Books:

1. P. D. Chaturvedi and Mukesh Chaturvedi, "Business Communication," Pearson, 2012, ISBN: 9788131765036.
2. Meenakshi Raman and Sangeeta Sharma, "Technical Communication", Oxford University Press, Third Edition, 2015, ISBN: 9780199457496.

Reference Books:

1. Hory Sankar Mukerjee, "Business Communication," Oxford University Press.
2. K.Alex, "Soft Skills", S.Chand.

MEMS AND MICROSYSTEMS (Elective)

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	14XXX464	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives: This course will enable students to:

- Recall and Describe the basics of MEMS and Microsystems.
- Use of microsystems in various fields.
- Recall and Describe working principles of Microsystems.
- Recall and Describe operating principles of Microsensors.
- Recall and Describe the importance of materials used in MEMS and Microsystems.
- Recall and Describe the fabrication processes of a Microsystem.
- Recall and Describe Microsystem packaging involving general considerations in packaging design, interfaces and technologies.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1		
Overview of MEMS & Microsystems: MEMS & Microsystems, Typical MEMS and Micro system products, Evolution of Microfabrication, Microsystems and Microelectronics, the multidisciplinary nature of Microsystem design and Manufacture, Microsystems and Miniaturisation, Applications of Microsystems in automotive industry, Applications of Microsystems in other industries.	**08 Hours**	**L1, L2, L3**
Module -2		
Working Principles of Microsystems Introduction, Microsensors, Microactuation, MEMS with Microactuators, Microaccelerometers, Microfiuids	**08 Hours**	**L1, L2**
Module -3		
Materials for MEMS and Microsystems Introduction, Substrates and Wafers, Active Substrate Materials, Silicon as a Substrate Material, Silicon Compounds, Silicon Piezoresistors, Gallium Arsenide, Quartz, Piezoelectric Crystals, Polymers, Packaging Materials	**08 Hours**	**L1, L2**
Module -4		
Microsystem Fabrication Processes Introduction, Photolithography, Ion Implantation, Diffusion, Oxidation, Chemical Vapor Deposition, Physical Vapor Deposition- Sputtering, Depositon by Epitaxy, Etching, Summary of Microfabrication	**08 Hours**	**L1, L2**
Module -5		

Micro system packaging Introduction, Over view of mechanical packaging of micro electronics Microsystem packaging, Interfaces in Microsystem packaging, Essential Packaging technologies.	**08 Hours**	**L1, L2**

Course outcomes:

After studying this course, students will be able to:

- Acquire knowledge of
  - MEMS & Microsystems, the multidisciplinary nature of Microsystem design and Manufacture, Microsystems and Miniaturisation, Applications of Microsystems in automotive various industries.
  - Working principles of Microsystems that involve Microsensors, Microactuation, Microactuators, Microaccelerometers and Microfiuids.
  - Materials for MEMS and Microsystems.
  - Fabrication processes that involve Photolithography, Ion Implantation, Diffusion, Oxidation, Chemical Vapor Deposition, Physical Vapor Deposition-Sputtering, Deposition by Epitaxy, and Etching.
  - Over view of mechanical packaging of micro electronics Microsystem packaging, Interfaces in Microsystem packaging, Essential Packaging technologies
- Analyse the performance of
  - Various MEMS and Microsystem components, fabrication processes and applications.
- Apply the knowledge gained in the design of practical MEMS and Microsystems for various applications.

Graduate Attributes (as per NBA)

- Engineering Knowledge
- Problem Analysis
- Design / development of solutions (partly)

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 16 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Tai-Ran Hsu, "MEMES & MICROSYSTEMS- Design and Manufacturing", McGraw Hill, 2014. ISBN: 0072393912.

Reference Books:

1. Chang Liu, "Foundations of MEMS", Pearson.
2. G. K. Anthasuresh, K J Vinoy, S Gopalkrishnan, K N Bhat and V K Atre, "Microand Smart Systems," Wiley India.

LINEAR INTEGRATED CIRCUITS (LIC) LABORATORY

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Laboratory Code	14XXL47	IA Marks	20
Number of Lecture Hours/Week	01Hr Tutorial (Instructions) + 02 Hours Laboratory	Exam Marks	80
		Exam Hours	03

CREDITS – 02

Course objectives: This laboratory course enables students to:

- Demonstrate, Analyze and Design Op-AMP negative feedback amplifier, instrumentation amplifier, astable multivibrator and integrator circuit.
- Demonstrate, Analyze and Design basic analog circuits like comparator, filters, and oscillators.
- Demonstrate, Analyze and Design Op-AMP for specific analog circuits.

Laboratory Experiments:	**Revised Bloom's Taxonomy (RBT) Level**
1. Study the characteristics of negative feedback amplifier **Aim:** Design the following amplifiers: a) A unity gain amplifier b) A non-inverting amplifier with a gain of 'A' c) An inverting amplifier with a gain of 'A' Apply a square wave of fixed amplitude and study the effect of slew rate on the three types of amplifiers. **Applications:** • Amplifying bioelectric potentials (ECG, EEG, EMG, EOG) and piezoelectric with high output impedance. • Amplifying sensor output signals (temperature sensors, humidity sensors, pressure sensors etc.) **Sample questions** o Explain the need for unity gain amplifier. o Advantages of op-amp based amplifiers as compare to BJT amplifiers. o Mention the applications for inverting and non-inverting amplifiers. o Give your inference on the frequency response of the amplifier. o Give the significance of gain-bandwidth product.	**L2, L3, L6**
2. Design of an instrumentation amplifier **Aim:** Design an instrumentation amplifier of a differential mode gain of 'A' using three amplifiers. **Applications:** • Used in measuring instruments designed for achieving high accuracy and high stability. • Used for amplifying low voltage, low frequency and higher output	**L2, L3, L6**

impedance signals. **Sample questions** o Explain the need for two stages in any instrumentation amplifier. o Why CMRR is high for instrumentation amplifiers? o Give some examples for low voltage, low frequency and higher output impedance signals. o How do the tolerances of resistors affect the gain of the instrumentation amplifier?	
3. Study the characteristics of regenerative feedback system with extension to design an astable multivibrator **Aim:** Design and test an astable multivibrator for a given frequency. **Applications** • It can be used in signal generators and generation of timing signals. • It can be used in code generators and trigger circuits. **Sample questions** o Discuss the difference between astable and bi-stable multivibrator. o Discuss the frequency limitation of astablemultivibrator. o Discuss the various applications of bi-stable multivibrator.	**L2, L3, L6**
4. Study the characteristics of integrator circuit **Aim:** Design and test the integrator for a given time constant. **Applications** • Used in function generators, PI/PID controllers. • Used in analog computers, analog-to-digital converters and wave-shaping circuits. • Used as a charge amplifier. **Sample questions** o Compare the output with that of ideal integrator. o How will you design a differentiator and mention its drawback. o Discuss the limitation of the output voltage of the integrator. o How will you obtain drift compensation in an inverting integrator?	**L2, L3, L6**
5. Design of Analog filters – I **Aim:** Design a second order butterworth band-pass filter for the given higher and lower cut-off frequencies. **Applications:** • Used in signal conditioning circuits for processing audio signals. • Used in measuring instruments. • Used in radio receivers. **Sample questions** o Discuss the effect of order of the filter on frequency response. o How will you vary Q factor of the frequency response. o Discuss the need for going to Sallen Key circuit. o Compare the performance of Butterworth filter with that of Chebyshev filter.	
6. Design of Analog filters – II **Aim:** Design and test a notch filter to eliminate the 50Hz power line frequency.	**L2, L3, L5, L6**

Applications • Used for removing power supply interference. • Used for removing spur in RF signals. **Sample questions** o Explain the effect of supply frequency interference while amplifying sensor signals. o Suggest a method for adjusting the Q factor of the frequency response of notch filter. o What is the purpose of going for Twin T notch filter circuit?	
7. Design of a self-tuned Filter **Aim:** Design and test a high-Q Band pass self-tuned filter for a given center frequency. **Applications:** • Used in spectrum analyzers **Sample Question:** o Discuss the effect of the harmonics when a square wave is applied to the filter o Determine the lock range of the self-tuned filter	L5, L6
8. Design of a function generator **Aim:** Design and test a function generator that can generate square wave and triangular wave output for a given frequency. **Applications:** • Used in testing, measuring instruments and radio receivers. • Used for obtaining frequency response of devices and circuits. • Used for testing and servicing of Electronic equipments. • Used in Electronic musical instruments. • Used for obtaining audiograms (Threshold of audibility Vs frequency) **Sample questions** o Discuss typical specifications of a general purpose function generator. o How can you obtain reasonably accurate sine wave from triangular wave. o Discuss the reason for higher distortion in sine wave produced by function generators. o What do you mean by Duty cycle and how can you vary the same in a function generator?	**L2, L3, L5, L6**
9. Design of a Voltage Controlled Oscillator **Aim:** Design and test voltage controlled oscillator for a given specification (voltage range and frequency range). **Applications:** • Used in Phase Lock Loop (PLL) circuits. • Used in frequency modulation circuits.	**L2, L3, L5, L6**

• Used in Function generators • Used in frequency Synthesizers of Communication equipments. **Sample Questions** o Discuss the following characteristics of a voltage controlled Oscillator. o Tuning range o Tuning gain and o Phase noise o Compare the performances VCO based Harmonic Oscillators and Relaxation Oscillators o What are the various methods adopted in controlling the frequency of oscillation in VCOs o Discuss any one method of obtaining FM demodulation using a VCO.	
10. Design of a Phase Locked Loop(PLL) **Aim:** Design and test a PLL to get locked to a given frequency 'f'. Measure the locking range of the system and also measure the change in phase of the output signal as input frequency is varied within the lock range. **Applications:** • Used in tracking Band pass filter for Angle Modulated signals. • Used in frequency divider and frequency multiplier circuits. • Used as Amplifiers for Angle Modulated signals. • Used in AM and FM Demodulators • Used in Suppressed Carrier Recovery Circuits **Sample Questions:** o Draw the block diagram of a PLL based divider and multiplier and explain the functions performed by each block. o Distinguish between Lock range and Capture Range, Explain the method of estimating the same for a given PLL circuit. o Discuss the differences between Analog Phase Lock Loop and Digital Phase Lock Loop.	**L2, L3, L5, L6**
11. Automatic Gain Control (AGC) Automatic Volume Control (AVC) **Aim:** Design and test an AGC system for a given peak amplitude of sine-wave output. **Applications** • Used in AM Receivers • Used as Voice Operated Gain Adjusting Device (VOGAD) in Radio Transmitters • Used in Telephone speech Recorders • Used in Radar Systems **Sample Questions** o Explain clearly the need for AGC in AM Receivers. o Draw the block diagram of feedback and feed forward AGC systems	**L2, L3, L5, L6**

and explain the functions of each block. o Discuss any one gain control mechanism present in biological systems. How can you use AGC in a Received Signal Strength Indicator (RSSI).	
12. Design of a low drop-out regulator **Aim:** Design and test a Low Dropout regulator using op-amps for a given voltage regulation characteristic and compare the characteristics with TPS7250IC **Applications:** • Used in Power Supply of all Electronic Instruments and Equipment's • Used as Reference Power Supply in Comparators • Used in Emergency Power Supplies • Used in Current Sources **Sample Questions** o Distinguish between Load Regulation and Line Regulation. o Mention some of the other important parameters in selecting a LDO. o What is power supply rejection ratio (PSRR)?	**L2, L3, L5, L6**
13. DC-DC Converter. **Aim:** Design of a switched mode power supply that can provide a regulated output voltage for a given input range using the TPS40200 IC. **Applications:** • Used is DSL/Cable Modems • Used in Distributed Power Systems **Sample Questions** Discuss the effect of varying the input voltage for a fixed regulated output voltage over the duty cycle of PWM.	**L2, L3, L5, L6**

NOTE: The above experiments can be conducted using TL 082/ MPY634/ ASLK Pro Kit/LM741

References:

1. Data Sheet: http://www.ti.com/lit/ds/symlink/tl082.pdf
2. Application Note: http://www.ti.com/lit/an/sloa020a/sloa020a.pdf
3. MPY634 Data Sheet: http://www.ti.com/lit/ds/symlink/mpy634.pdf
4. Application Note: http://www.ti.com/lit/an/sbfa006/sbfa006.pdf

ASLK Pro Manual: ASLK Manual

Course outcomes: This laboratory course enables students to:

- Gain hands-on experience in building analog systems for a given specification using the basic building blocks.
- Develop a macromodel for an IC based on its terminal characteristics, I/O characteristics, DC-transfer characteristics, frequency response, stability characteristic and sensitivity characteristic.
- Make the right choice for an IC for a given application.
- Able to perform basic fault diagnosis of an electronic system.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.

2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks, and
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

MICROCONTROLLERS FOR EMBEDDED SYSTEMS LABORATORY

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Laboratory Code	14XXL48	IA Marks	20
Number of Lecture Hours/Week	01Hr Tutorial (Instructions) + 02 Hours Laboratory	Exam Marks	80
		Exam Hours	03

CREDITS – 02

Course objectives: This laboratory course enables students to:

- Use Embedded C language to Develop embedded applications.
- Apply, Construct and Demonstrate various in-build interfaces/modules of MSP430 for specific application.
- Apply Embedded C code for utilizing Low power modes of MSP430.

Laboratory Experiments:	**Revised Bloom's Taxonomy (RBT) Level**
1. Interfacing and programming GPIO ports in C using MSP430 (blinking LEDs , push buttons) The main objective of this experiment is to blink the on-board, red LED (connected to P1.0) using GPIO. This experiment will help you to learn and understand the procedure for programming the MSP-EXP430G2 LaunchPad digital I/O pins. **Exercises:** a) Modify the delay with which the LED blinks. b) Modify the code to make the green LED blink. c) Modify the code to make the green and red LEDs blink: i. Together ii. Alternately d) Alter the code to turn the LED ON when the button is pressed and OFF when it is released. e). Alter the code to make the green LED stay ON for around 1 second every time the button is pressed. f). Alter the code to turn the red LED ON when the button is pressed and the green LED ON when the button is released.	**L3, L4, L5**
2. Usage of Low Power Modes: Use MSPEXP430FR5969 as hardware platform and demonstrate the low power modes and measure the active mode and standby mode current. The main objective of this experiment is to configure the MSP-EXP430G2 LaunchPad for Low Power Mode (LPM3) and measure current consumption " both in active and low power modes. This experiment will help in learning the Various low power modes of the MSP430G2553. **Exercises:** a) How many Low power modes are supported by the MSP430G2553 platform? b) Measure the Active and Standby Current consumption in LPM3 mode	**L2, L3**

for the same application using MSP430F5529 LaunchPad	
3. Interrupt programming examples through GPIOs The main objective of this experiment is to configure GPIO and interrupts for the MSP430G2553. This experiment will help to learn and understand the GPIO and interrupt Peripherals and their operation. **Exercises:** a) Write the code to enable a Timer interrupt for the pin P1.1. b) Write the code to turn on interrupts globally.	**L3, L4, L5**
4. PWM generation using Timer on MSP430 GPIO The main objective of this experiment is to implement Pulse Width Modulation to control the brightness of the on-board, green LED. This experiment will help you to learn and understand the configuration of PWM and Timer peripherals of the MSP430G2553. **Exercises:** a) Observe the PWM waveform on a particular pin using CRO. b) What is the maximum resolution of PWM circuitry in MSP430G2 LaunchPad? c) Change the above code to create a PWM signal of 75% duty cycle on particular PWM pin.	**L3, L4, L5**
5. Interfacing potentiometer with MSP430 The main objective of this experiment is to control the on-board, red LED by the analog input from a potentiometer. This experiment will help you to learn and understand how to configure an ADC to interface with a potentiometer. **Exercises:**a) Alter the threshold to 75% of V_{cc} for the LED to turn on. b) Modify the code to change the Reference Voltage from V_{cc} to 2.5V.	
6. PWM based Speed Control of Motor controlled by potentiometer connected to MSP430 GPIO The main objective of this experiment is to control the speed of a DC Motor using the potentiometer. This experiment will help to learn and understand how to configure the PWM and ADC modules of the processor to control the DC motor using potentiometer input. **Exercises:** a) Interface a Stepper motor with MSP-EXP430G2 LaunchPad to run it in a predetermined uniform speed. b) Describe the applications of PWM in a digital power supply control. c) Create Switch case code from the example code to run the DC Motor in 3 set of speeds.	**L3, L4, L5**
7. Using ULP advisor in Code Composer Studio on MSP430 The main objective of this experiment is to optimize the power efficiency of an application on MSPEXP430G2 LaunchPad using ULP Advisor in CCS Studio. This experiment will help to learn and understand the ULP Advisor capabilities and usage of ULP Advisor to create optimized, power-efficient applications on the MSP-EXP430G2 LaunchPad.	**L3, L4, L5**

Exercises: a) How does the ULP Advisor software help in designing power optimized code? b) Which ULP rule violation helps us to detect a loop counting violation?	
8. Connect the MSP430 to terminal on PC and echo back the data The main objective of this experiment is to use UART of the MSP430G2553 to communicate with the computer. This experiment will help to learn and understand the configuration of Universal Serial Communication Interface (USCI) module of MSP430G2553 for UART based serial communication. **Exercise:** Modify the above code to transmit the set of strings to the serial terminal via UART as shown below: **char str1[]="MSP430G2 launchpad"** **char str2[]= "Ultra low power mixed signal processing applications"**	**L3, L4**
9. Master Slave Communication between 2 MSP430s using SPI The main objective of this experiment is to establish the SPI master-slave communication using 3-wire mode in MSP430F5529 Launchpad. This experiment will help understand the configuration of USCI_A0 SPI 3-Wire Master Incremented Data in MSP430F5529. **Exercises:** a) Which port pins of MSP430 can be configured for SPI communication? b) What is the data transfer rate supported by MSP430 for SPI communication?	**L3, L4**
10. A basic Wi-Fi application The main objective of this experiment is to configure CC3100 Booster Pack as a Wireless Local Area Network (WLAN) Station. This experiment will help you understand the WLAN concepts and communication between Station and Access Point. **Exercises:** a) In the terminal output window, we have received a debug message "Pinging...!". Search in the code and change the message to "Pinging the website". Repeat the experiment to observe this change in the Serial Window. b) In main. C replace www.ti.com with any non existing web address and repeat the Experiment and observe what happens. **#define** HOST_NAME www.ti.com c) In main. C replace again with www.ti.com and repeat the experiment.	**L3, L5**
11. Enable Energy Trace and Energy Trace ++ modes in CCS The main objective of this experiment is to enable Energy Trace and Energy Trace++ modes in MSP-EXP430G2 LaunchPad by using MSP430FR5969. This experiment will help you learn how to analyze the Energy and Power graphs by enabling the Energy Trace Technology of MSP430 in CCS studio.	**L3, L4**

Exercises: a) What is the difference between the Energy Trace and Energy Trace ++? b) What hardware options available that supports Energy Trace++?	
12. Compute Total Energy, and Estimated lifetime of an AA battery running MSP430 application The main objective of this experiment is to compute the total energy of MSP-EXP430G2 Launchpad running an application and to estimate the lifetime of a battery. **Exercises:** Compute the energy measurement and the estimated lifetime of a battery for Experiments 4 to 7.	**L3, L4, L5**

Books and other References:

MSP430 Microcontroller Basics by John H. Davis
http://processors.wiki.ti.com/index.php/MSP430_LaunchPad_Low_Power_Mode
http://processors.wiki.ti.com/index.php/MSP430_16-Bit_Ultra-Low_Power_MCU_Training

Note: The above experiments can be conducted using MSP 430 IC/ MSP 430 Launch pad.

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

- Get hands-on exposure in MSP430 platform and will gain confidence in building Embedded C based applications for MSP430 platform.
- Design Embedded C programs that are low power and optimized for a building specific applications.
- Apply various TI design tools, methodologies and use them for testing and designing embedded applications.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks, and
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.