**AC11.05.2017**
**Item No. 4.184**

# UNIVERSITY OF MUMBAI


## Bachelor of Electronics and Electrical Engineering

### Final Year (Semester VII and VIII), Revised course

### (Rev2012) From Academic Year 2017-18

(As per Credit Based Semester and Grading System with effect from the academic year 2012–2013)

**From Dean's Desk:**

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development. Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEO's) and give freedom to affiliated Institutes to add few (PEO's) and course objectives and course outcomes to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. It was also resolved that, maximum senior faculty from colleges and experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology, and developed curriculum accordingly. In addition to outcome based education, semester based credit and grading system is also introduced to ensure quality of engineering education.

Semester based Credit and Grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes and Faculty of Technology has devised a transparent credit assignment policy and adopted ten points scale to grade learner's performance. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 12-13 weeks and remaining 3-2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

Credit and grading based system was implemented for First Year of Engineering from the academic year 2012-2013. Subsequently this system will be carried forward for Second Year Engineering in the academic year 2013-2014, for Third Year and Final Year Engineering in the academic years 2014-2015 and 2015-2016 respectively.

**Dr. S. K. Ukarande**
**Dean,**
**Faculty of Technology,**
**Member -Management Council, Senate, Academic Council**
**University of Mumbai, Mumbai**

## B. E. Electronics and Electrical Engineering - (Semester VII)

| Sub Code | Subject Name | Teaching Scheme (Hrs) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELC701 | Drives & Control | 04 | -- | -- | 04 | -- | -- | 04 |
| ELC702 | Embedded System & Real Time Programming | 04 | -- | -- | 04 | -- | -- | 04 |
| ELC703 | Basics of VLSI Design | 04 | -- | -- | 04 | -- | -- | 04 |
| ELC704 | Power System Operation & Control | 04 | -- | -- | 04 | -- | -- | 04 |
| ELE70X | Elective-I | 04 | -- | -- | 04 | -- | -- | 04 |
| ELL701 | Drives & Control Laboratory | -- | 02 | -- | -- | 01 | -- | 01 |
| ELL702 | Embedded System & Real Time Programming Laboratory | -- | 02 | -- | -- | 01 | -- | 01 |
| ELL703 | Basics of VLSI Design Laboratory | -- | 02 | -- | -- | 01 | -- | 01 |
| ELL704 | Power System Operation & Control Laboratory | -- | 02 | -- | -- | 01 | -- | 01 |
| ELP701 | Project-I | -- | 06 | -- | -- | 03 | -- | 03 |
| **Total** | | **20** | **14** | **--** | **20** | **07** | **--** | **27** |

**University of Mumbai {B.E.(Electronics and Electrical Engineering R-2012)}**

| Subject Code | Subject Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term Work | Pract. /Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test1 | Test 2 | Avg. | | | | | |
| ELC701 | Drives & Control | 20 | 20 | 20 | 80 | 3 | | | 100 |
| ELC702 | Embedded System & Real Time Programming | 20 | 20 | 20 | 80 | 3 | | | 100 |
| ELC703 | Basics of VLSI Design | 20 | 20 | 20 | 80 | 3 | | | 100 |
| ELC704 | Power System Operation & Control | 20 | 20 | 20 | 80 | 3 | | | 100 |
| ELE70X | Elective-I | 20 | 20 | 20 | 80 | 3 | | | 100 |
| ELL701 | Drives & Control Laboratory | | | | | | 25 | 25 | 50 |
| ELL702 | Embedded System & Real Time Programming Laboratory | | | | | | 25 | 25 | 50 |
| ELL703 | Basics of VLSI Design Laboratory | | | | | | 25 | 25 | 50 |
| ELL704 | Power System Operation & Control Laboratory | | | | | | 25 | | 25 |
| ELP701 | Project-I | | | | | | 25 | 25 | 50 |
| **Total** | | 100 | 100 | **100** | **400** | | **125** | **100** | **725** |

## B. E. Electronics and Electrical Engineering - (Semester VIII)

| Sub Code | Subject Name | Teaching Scheme (Hrs) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELC801 | Digital Image Processing | 04 | -- | -- | 04 | -- | -- | 04 |
| ELC802 | Industrial Automation | 04 | -- | -- | 04 | -- | -- | 04 |
| ELC803 | High Voltage DC Transmission | 04 | -- | -- | 04 | -- | -- | 04 |
| ELE80X | Elective- II | 04 | -- | -- | 04 | -- | -- | 04 |
| ELL801 | Digital Image Processing Laboratory | -- | 02 | -- | -- | 01 | -- | 01 |
| ELL802 | Industrial Automation Laboratory | -- | 02 | -- | -- | 01 | -- | 01 |
| ELL803 | High Voltage DC Transmission Laboratory | -- | 02 | -- | -- | 01 | -- | 01 |
| ELL804 | Elective- II Laboratory | -- | 02 | -- | -- | 01 | -- | 01 |
| ELP801 | Project-II | -- | 12 | -- | -- | 06 | -- | 06 |
| **Total** | | **16** | **20** | -- | **16** | **10** | -- | **26** |

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| Subject Code | Subject Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term Work | Pract./ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test1 | Test 2 | Avg. | | | | | |
| ELC801 | Digital Image Processing | 20 | 20 | 20 | 80 | 3 | | | 100 |
| ELC802 | Industrial Automation | 20 | 20 | 20 | 80 | 3 | | | 100 |
| ELC803 | High Voltage DC Transmission | 20 | 20 | 20 | 80 | 3 | | | 100 |
| ELE80X | Elective- II | 20 | 20 | 20 | 80 | 3 | | | 100 |
| ELL801 | Digital Image Processing Laboratory | | | | | | 25 | 25 | 50 |
| ELL802 | Industrial Automation Laboratory | | | | | | 25 | 25 | 50 |
| ELL803 | High Voltage DC Transmission Laboratory | | | | | | 25 | 25 | 50 |
| ELL804 | Elective- II Laboratory | | | | | | 25 | 25 | 50 |
| ELP801 | Project-II | | | | | | 50 | 50 | 100 |
| **Total** | | | | **80** | **320** | | **150** | **150** | **700** |

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| **Subject Code** | **Elective - I** | **Subject Code** | **Elective – II** |
|---|---|---|---|
| ELE701 | Protection & Switch Gear Engineering | ELE801 | Advanced Control System |
| ELE702 | Renewable Energy & Energy Storage Systems | ELE802 | Power Quality |
| ELE703 | Artificial Neural Network | ELE803 | Analog & Mixed Signal VLSI |
| ELE704 | Optical Fibre Communication | ELE804 | Robotics |
| ELE 705 | Digital Signal Processing & Processors | | |

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELC701 | Drives and Control | 4 | - | - | 4 | - | - | 4 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELC701 | Drives and Control | 20 | 20 | 20 | 80 | 03 | - | - | 100 |

| Course Code | Course Name | Credits |
|---|---|---|
| ELC701 | Drives and Control | 4 |
| Course Objectives | 1. To expose the students to the Engineering fundamentals of various Drives and its control, Dynamic operation and their applications. | |
| Course Outcomes | 1.Gain an ability to design and conduct performance experiments, as well as to identify, formulate and solve drives related problems. | |

| Module | Contents | Hours |
|---|---|---|
| 1 | **Electrical Drives: Introduction & Dynamics**<br>Introduction, Advantages of Electrical Drives, Parts of Electrical Drives, Choice of Electrical Drives, Status of DC and AC Drives, Fundamental Torque equations, Speed Torque conventions and Multi-quadrant Operation, Equivalent values of Drive Parameter, Measurement of Moment of Inertia, Components of Load Torques, Nature and Classification of Load Torques, Calculation of Time and Energy-Loss in Transient Operations, Steady State Stability, Load Equalization | 10 |
| 2 | **Selection of Motor Power Rating:**<br>Thermal Model of Motor for Heating and Cooling, Classes of Motor Rating, Determination of Motor Rating. | 04 |
| 3 | **Control of Electrical Drives:**<br>Modes of Operation, Speed Control, Drive Classification, Closed loop Control of Drives | 04 |
| 4 | **DC Drives:**<br>Review of Speed Torque relations for Shunt, Series and Separately excited Motors, Review of Starting, Braking (Regenerative, Dynamic, Plugging), | |

| | | |
|---|---|---|
| | Review of Speed control, Controlled rectifier fed DC drives (separately excited only): Single phase fully-controlled Rectifier, Single phase Half controlled Rectifier, Three phase fully-controlled Rectifier, Three phase Half-controlled Rectifier, Dual Converter Control, Chopper Control – Motoring and Braking of separately excited and Series Motor.<br>(No numerical from this module) | 06 |
| 5 | **AC Drives:**<br>Induction Motor drives, Review of Speed-Torque relations, Review of Starting methods, Braking (Regenerative, Plugging and AC dynamic braking), Transient Analysis, Speed Control: Stator voltage control, Variable frequency control from voltage source, Static Rotor Resistance control, Slip Power Recovery - Static Scherbius Drive, Review of d-q model of Induction Motor, Principle of Vector Control, Block diagram of Direct Vector Control Scheme, Comparison of Scalar control and Vector control, Basic Principle of Direct Torque Control (block diagram) of induction motor. Introduction to Synchronous Motor Variable Speed drives. | 18 |
| 6 | **Special Motor Drives:**<br>Stepper Motor drives- Types, Torque vs. Stepping rate characteristics, Drive circuits, Introduction to Switched reluctance motor drives and Brushless DC motor drives. | 06 |

**Assessment:**
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

**End Semester Examination:**

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No.1 will be compulsory and based on entire syllabus.
4. Remaining question (Q.2 to Q.6) will be set from all the modules.

**Books Recommended:**

*Text Books***:**

1. Fundamentals of Electrical Drives by G.K.Dubey, Narosa Publication
2. A First Course on Electrical Drives by S.K.Pillai, New Age International.
3. Electrical Drives: Concepts and Applications by VedamSubramanyam, T.M.H
4. Modern Power Electronics and AC Drives by B.K.Bose, Prentice Hall PTR
5. Special Electrical Machines by E.G. Janardanan, PHI

*Reference Books:*

1. Electric Motor Drives: Modeling, Analysis and Control by Krishnan.R, PHI
2. Power Electronics by Joseph Vithayathil, Tata McGraw Hill
3. Power Semiconductor Controlled Drives by G. K. Dubey, Prentice Hall International.

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| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELC702 | Embedded System & Real Time Programming | 4 | - | - | 4 | - | - | 4 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELC702 | Embedded System & Real Time Programming | 20 | 20 | 20 | 80 | 03 | - | - | 100 |

| Course Code | Course Name | Credits |
|---|---|---|
| ELC702 | Embedded System & Real Time Programming | 4 |
| Course Objectives | 1. Understanding embedded system, processor & distributed embedded systems architecture.<br>2. Understanding Real Time system, Real time task scheduling & Real time operating system. | |
| Course Outcomes | 1. Students should be able to design distributed embedded system for specific example.<br>2. Students should be able to schedule real time tasks as per the specific requirement. | |

| Module | Contents | Hours |
|---|---|---|
| 1 | Introduction to Embedded systems, Design Metrics, Examples of embedded systems, hardware/software co- design, Embedded micro controller cores (ARM, RISC, CISC, and SOC), embedded memories, sensors and interfacing techniques, Architecture of Embedded Systems. | 4 |
| 2 | Introduction to MSP 430 RISC Controllers, parallel I/O, external interrupts. Introduction to ARM 7 instruction set, addressing modes, operating modes with ARM core, ARM7 TDMI modes, ADC, Timers, Interrupt structure. Byte ordering (LE, BE), Thumb mode normal mode instructions changes, Pipeline utilization with all register allocations, Floating to fixed point | 12 |

| | | |
|---|---|---|
| | conversion fundamentals.<br>System design with ARM as key processor.<br>DSP features of ARM Core<br>Digital Signal Controllers -DSC differences with conventional micro controllers | |
| 3 | Serial communications: SCI, SPI, Timing generation and measurements. Analog interfacing and data acquisition.<br>Hardware Interrupts:<br>- Various C ISR Declaration syntaxes<br>- Interrupt Vectors, Priorities and Nesting<br>- Tick Timer Interrupt as heart-beat of embedded system 7-Seg LED, Segment<br>- LCD, Alphanumeric LCD, Graphic LCD displays<br>Communications and Networks<br>- RS485 (2 and3 wire)and Modbus Protocol (Intro only)<br>- Ethernet and TCPIP Stack (Features and Usage only) - CAN features and protocol | 8 |
| 4 | Software Programming in Assembly Language (ALP) and in High Level Language 'C'<br>'C' Program Elements: Header and Source Files and Preprocessor Directives, Program Elements: Macros and Functions, Program Elements: Data Types, Data Structures, Modifiers, Statements, Loops and Pointers, Queues, Stacks, Lists and Ordered Lists<br>Embedded Programming in C++, 'C' Program Compiler and Cross-Compiler, Source Code Engineering Tools for Embedded C/C++, Optimization of Memory Needs. | 8 |
| 5 | Real-time concepts, real-time operating systems, Required RTOS services/capabilities (in contrast with traditional OS). Real-world issues: blocking, unpredictability, interrupts, caching, Benefits of using RTOS<br>- Concepts of Tasks/Threads/Process<br>- Multitasking - Task Scheduling<br>- Task management<br>- Inter-task communication and Synchronization:<br>- Device Drivers<br>- How to choose an RTOS | 10 |
| 6 | Fundamentals of Design and Development<br>Program Modeling tools Testing and Debugging methodologies Applications of Embedded Systems:<br>Case studies - Consumer and Home<br>- Industrial and Automation<br>- Medical<br>- Robotics<br>- Access Control Systems (Smart Cards, RFIDs, Finger Scan) | 6 |

**Assessment:**

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

**End Semester Examination:**

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No.1 will be compulsory and based on entire syllabus.
4. Remaining question (Q.2 to Q.6) will be set from all the modules.

**Books Recommended:**

*Text Books*

1. Rajkamal, Embedded Systems - Architecture, Programming and Design, Tata McGraw Hill, Second edition, 2009
2. Shibu K V, Introduction to Embedded Systems , Tata Mc Graw Hill, 2009
3. Sriram Iyer and Pankaj Gupta, Embedded Realtime Systems Programming, Tata McGraw Hill, first edition, 2003

*Reference Books*

1. Embedded Microcomputer Systems -Jonathan W. Valvano ñ Thomson
2. An Embedded Software Primer ñ David E. Simon ñ Pearson Education
3. Embedded real time system, Dr. K.V.K.Prasad, Dreamtech Press

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| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELC703 | Basics of VLSI Design | 4 | - | - | 4 | - | - | 4 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELC703 | Basics of VLSI Design | 20 | 20 | 20 | 80 | 03 | - | - | 100 |

| Course Code | Course Name | Credits |
|---|---|---|
| ELC703 | Basics of VLSI Design | 4 |
| Course Objectives | 1. To teach fundamental principles of VLSI circuit design and layout techniques<br>2. To highlight the circuit design issues in the context of VLSI technology | |
| Course Outcomes | After successful completion of the course student will be able to<br>1. demonstrate a clear understanding of choice of technology and technology scaling<br>2. design MOS based circuits and draw layout<br>3. realize logic circuits with different design styles<br>4. demonstrate a clear understanding of system level design issues such as protection, timing and power dissipation | |

| Module | Contents | Hours |
|---|---|---|
| 1 | **Technology Trend**<br>Technology Comparison: Comparison of BJT, NMOS and CMOS technology<br>MOSFET Scaling: Types of scaling, Level 1 and Level 2 MOSFET Models, MOSFET capacitances | 6 |
| 2 | **MOSFET Inverters**<br>Circuit Analysis: Static and dynamic analysis (Noise, propagation delay and power dissipation) of resistive load and CMOS inverter, comparison of all types of MOS inverters, design of CMOS inverters, CMOS Latch-up<br>Logic Circuit Design: Analysis and design of 2-I/P NAND and NOR using equivalent CMOS inverter | 10 |
| 3 | **MOS Circuit Design Styles**<br>Design Styles: Static CMOS, pass transistor logic, transmission gate, Pseudo NMOS, Domino, NORA, Zipper, C2MOS, sizing using logical effort<br>Circuit Realization: SR Latch, JK FF, D FF, 1 Bit Shift Register, MUX, decoder using above design styles | 10 |
| 4 | **Semiconductor Memories**<br>SRAM: ROM Array, SRAM (operation, design strategy, leakage currents, read/write circuits), DRAM (Operation 3T, 1T, operation modes, leakage currents, refresh operation, Input-Output circuits), Flash (mechanism, NOR flash, NAND flash)<br>Peripheral Circuits: Sense amplifier, decoder | 8 |
| 5 | **Data Path Design**<br>Adder: Bit adder circuits, ripple carry adder, CLA adder<br>Multipliers and shifter: Partial-product generation, partial-product accumulation, final addition, barrel shifter | 8 |
| 6 | **VLSI Clocking and System Design**<br>Clocking: CMOS clocking styles, Clock generation, stabilization and distribution<br>Low Power CMOS Circuits: Various components of power dissipation in CMOS, Limits on low power design, low power design through voltage scaling<br>IO pads and Power Distribution: ESD protection, input circuits, output circuits, simultaneous switching noise, power distribution scheme<br>Interconnect: Interconnect delay model, interconnect scaling and crosstalk | 10 |

**Assessment:**

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

**End Semester Examination:**

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No.1 will be compulsory and based on entire syllabus.
4. Remaining question (Q.2 to Q.6) will be set from all the modules.

**Recommended Books:**

1. Sung-Mo Kang and Yusuf Leblebici, "CMOS Digital Integrated Circuits Analysis and Design", Tata McGraw Hill, 3rd Edition.
2. Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic, "Digital Integrated Circuits:A Design Perspective", Pearson Education, 2nd Edition.
3. Etienne Sicard and Sonia Delmas Bendhia, "Basics of CMOS Cell Design", Tata McGraw Hill, First Edition.
4. Neil H. E. Weste, David Harris and Ayan Banerjee, "CMOS VLSI Design: A Circuits and Systems Perspective", Pearson Education, 3rd Edition.
5. Debaprasad Das, "VLSI Design", Oxford, 1st Edition.
6. Kaushik Roy and Sharat C. Prasad, "Low-Power CMOS VLSI Circuit Design", Wiley, Student Edition.

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| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELC704 | Power System Operation and Control | 4 | - | - | 4 | - | - | 4 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELC704 | Power System Operation and Control | 20 | 20 | 20 | 80 | 03 | - | - | 100 |

| Course Code | Course Name | Credits |
|---|---|---|
| ELC704 | Power System Operation and Control | 4 |
| Course Objectives | 1. To impart knowledge in power system operation and its control.<br>2. To study steady state and transient analysis in power system. | |
| Course Outcomes | 1. Student should be capable to analyze power system problem and find out its solution. | |

| Module | Contents | Hours |
|---|---|---|
| 1. | **Load Flow Studies:** Network model formulation, Y bus formation and singular matrix transformation. Load flow problem, Gauss Seidel (GS) methods. Newton Raphson methods (NR) (Polar, Rectangular form). Decoupled, Fast Decoupled load flow and comparison. Concept of DC loads flow. | 10 |
| 2. | **Economic System Operation:** Generator operating cost:- input-output, Heat rate and IFC curve, Constraints in operation, Coordinate equation, Exact coordinate equation, Bmn coefficients, transmission loss formula. Economic operation with limited fuel supply and shared generators, Economic exchange of power between the areas Optimal unit commitment and reliability considerations. | 08 |
| 3. | **Automatic Generation and control:** Load frequency control problem, Thermal Governing system and transfer function. Steam Turbine and Power system transfer function. Isolated power system:- static and dynamic response PI and control implementation Two area load frequency | 12 |

| | | |
|---|---|---|
| | control, static and dynamic response Frequency biased Tie line Bias control-implementation and effect Implementation of AGC, AGC in restructured power system, under frequency load shedding, GRC, Dead band and its effect. | |
| 4. | **Inter Change of Power and Energy:** Multiple utility interchange transaction, Other types of transactions, Power Pool. | 04 |
| 5. | **Power System Stability:** Types of Stability Study, Dynamics of synchronous machine, Power angle equation, Node elimination technique, Simple Systems, Steady state stability, Transient stability, Equal area criteria and its applications, Numerical solution of swing equation, Modified Euler‟s method. | 10 |
| 6. | **Voltage stability:** Introduction, reactive power transmission, short circuit capacity, Problems of reactive power transmission, rotor angle stability and voltage stability, surge impedance loading, P-V and V- Q curve, various methods of voltage control –shunt and series compensation. Voltage Control- Tap changing transformers, Booster transformers, Static voltage compensators, Thyristorised series voltage injection | 04 |

**Assessment:**
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

**End Semester Examination:**

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No.1 will be compulsory and based on entire syllabus.
4. Remaining question (Q.2 to Q.6) will be set from all the modules.

**Books Recommended:**
*Text Books***:**


1. Kothari. D. P, Nagrath. I. J., “Modern Power System Analysis‟, TMH Publication, Third Edition, 2008
2. Kothari. D. P, Nagrath. I. J., “Power System Engineering‟, TMH Publication, Second Edition, 2008
3. George Kausic. “Computer Aided Power System Analysis‟, Prentice Hall Publication.2008
4. Chakrabarti .A, Halder. S, “Power System Analysis- Operation and Control‟, PHI, Second Edition 2008.
5. Allen. J. Wood., Bruce. F. Wollenberg., “Power Generation operation and Control‟, Wiley India, Second Edition, 2007.
6. Prabha Kundur , “Power System Stability and Control‟ , TMH Publication, 2008.

*Reference Books:*


1. Soman. S. A, Kharphade. S. A, and Subha Pandit "Computer Methods for Large Power System Analysis, an Object Oriented Approach", Kluwer Academic Publisher New York 2001
2. Anderson P.M, Fouad A.A, „Power System Control and Stability", Wiley InterScience, 2008 Edition
3. Kimbark E W, "Power System Stability", Volume I, and III, Wiley Publication.
4. Jr W.D. Stevenson., G. J. Grainger. "Elements of Power System". Mc-GrawHill, Publication.
5. Hadi Saadat, Power System Analysis, TMH Publication, Second Edition, 2002
6. S.Sivanagaraju, G.Sreenivasan Power System Operation and Control, Pearson Publication, 2010.

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELE701 | Elective-I Protection & Switch Gear Engineering | 4 | - | - | 4 | - | - | 4 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELE701 | Elective-I Protection & Switch Gear Engineering | 20 | 20 | 20 | 80 | 03 | - | - | 100 |

| Course Code | Course Name | Credits |
|---|---|---|
| ELE701 | Elective-I Protection & Switch Gear Engineering | 4 |
| Course Objectives | • To impart the basic knowledge on power system protection concepts, substation equipment and protection schemes | |
| Course Outcomes | • This knowledge leads to the in depth understanding of how the power system and the major apparatus used in the system are being protected against faults and abnormal conditions | |

| Module | Contents | Hours |
|---|---|---|
| 1. | **Instrument Transformers:**<br>Current Transformers - Introduction, Terms and Definitions, Accuracy class, Burden on CT, Vector diagram of CT, Magnetization curve of CT, Open circuited CT secondary, Polarity of CT and connections, Selection of CT for protection ratings, Types & construction, Multi wound CTs, Intermediate CTs, Transient behavior, Application for various protections.<br>Voltage Transformers - Introduction, Theory of VT, Specifications for VT, Terms & definitions, Accuracy classes & uses, Burdens on VT, Connection of VTs, Residually connected VT, Electromagnetic VT, CVT & CVT as coupling capacitor, Transient behavior of CVT, Application of | 04 |

| | | |
|---|---|---|
| | CVT for protective relaying. | |
| 2. | **Substation Equipment:**<br>**Switching Devices**:- Isolator & Earthling Switch(Requirements & definitions, Types of construction, Pantograph isolators, Ratings), Contactors(Basic working principle, Terms & definitions, Contactors as starters for motors, Rated characteristics/utilization category of contactors), Circuit Breakers (working principle, Construction, operating mechanisms, Arc initiation, arc quenching principles, ratings & applications of MCB, MCCB, ELCB, air circuit breakers, oil circuit breakers, SF6 circuit breakers, vacuum circuit breakers, Mechanical life, electrical life and testing of circuit br3eakers), Switch Boards, Acquaintance with ISI Standards<br>**HRC Fuses & their applications**-Introduction, types of devices with fuse, definitions, construction, fuse link of HRC fuse, Action of HRC fuse, shape of fuse element, specification of a fuse link, characteristics of fuse, cut-off, classification & categories, selection of fuse links, fuse for protection of motor, discrimination, fuse for protection of radial lines/meshed feeders, equipment incorporating fuses, high voltage current limiting fuses, expulsion type high voltage fuses, drop out fuse. | 12 |
| 3. | **Introduction to Protective relaying:** About protective relaying, Shunt & Series Faults, causes and Effects of faults, Importance of protective relaying, Protective zones, primary & Back-up protection, Back-up protection by time grading principle, desirable qualities of protective relaying, some terms in protective relaying, Distinction between relay unit, protective scheme and Protective system, Actuating quantities, Thermal Relays Electromechanical relays and static relays, Power line carrier channel, programmable relays, system security, role of engineers.<br>**Electromagnetic relays** - Introduction, basic connections of relay, Auxiliary switch, sealing and auxiliary relays, measurement in relays, Pick up, drop off, Attracted armature & induction disc relays, Thermal, bimetal relays, Frequency relays, under/over voltage relays, DC relays, All or nothing relays.<br>**Different Principles of protection** - Over current& earth fault (non-directional & directional types) , differential protection, distance protection (Working Principle of Impedance relay, Causes and remedies of Over reach-under reach, Reactance and Mho relay, Power swing blocking relay). | 10 |
| 4. | **Protection schemes provided for major apparatus:**<br>**Generators** - Stator side(Differential , Restricted Earth fault, protection for 100% winding, Negative phase sequence, Reverse power, turn-turn fault), Rotor side (Field suppression, field failure, Earth fault, turn to turn fault) | 12 |

| | | |
|---|---|---|
| | **Transformers**-Differential protection for star delta Transformer, Harmonic restraint relay, REF protection, Protection provided for incipient faults (Gas actuated relay).<br>**Induction motors** - Protection of motor against over load, short circuit, earth fault, single phasing, unbalance, locked rotor, phase reversal, under voltage, winding temperature. | |
| 5. | **Protection of Transmission Lines:**<br>Feeder protection - Time grading, current grading , combined time & current grading protection provided for Radial, Ring Main, Parallel, T-Feeder.<br>Bus Zone Protection - Differential protection provided for different types of bus zones.<br>LV, MV, HV Transmission Lines - Protection provided by over current, earth fault, Differential and Stepped distance protection.<br>EHV & UHV Transmission lines - Need for auto reclosure schemes, Carrier aided distance protection (Directional comparison method), Power Line Carrier Current protection (Phase comparison method). | 06 |
| 6. | **Introduction to Static & Numerical Relays**<br>Advantages and Disadvantages, Revision and application of op-amps, logic gates, DSP, Signal sampling, Relays as comparators (Amplitude & phase), Distance relays as comparators. | 04 |

**Assessment:**

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

**End Semester Examination:**

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No.1 will be compulsory and based on entire syllabus.
4. Remaining question (Q.2 to Q.6) will be set from all the modules.

**Books Recommended:**

*Text Books***:**

1. Switchgear & Protection by Sunil.S.Rao, Khanna Publications
2. Power system Protection & Switchgear by Badriram Vishwakarma, TMH
3. Power System Protection And Switchgear by Bhuvanesh A O, Nirmal CN, Rashesh PM, Vijay HM, Mc Graw Hill

*Reference Books:*

1. Fundamentals of protection by Paithanker & Bhide.S.R, P.H.I
2. Static Relays by Madhava Rao, TMH
3. A text book on Power system Engineering by Soni, Gupta, Bhatnagar & Chakraborthi, Dhanpat Rai & Co
4. Protective Relaying by Lewis Blackburn, Thomas.J.Domin
5. Power System Protection by P.M.Anderson, Wiley Interscience

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| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELE702 | Elective-I Renewable Energy and Energy Storage Systems | 4 | - | - | 4 | - | - | 4 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELE702 | Elective-I Renewable Energy and Energy Storage Systems | 20 | 20 | 20 | 80 | 03 | - | - | 100 |

| Course Code | Course Name | Credits |
|---|---|---|
| ELE702 | Elective-I Renewable Energy and Energy Storage Systems | 4 |
| Course Objectives | 1. To introduce the new paradigm of power generation in the form of renewable energy and the various means used for power processing and optimization.<br>2. To relate and study the various energy storage technology and their significance in the context of renewable energy based applications. | |
| Course Outcomes | 1. Students will understand the basics of utilization of renewable energy sources, related power systems configurations and basis for futuristic power grid scenario. | |

| Module | Contents | Hours |
|---|---|---|
| 1. | **Introduction:**<br>Review of worlds production and reserves of commercial energy sources, India‟s Production and reserves, energy alternatives, Review of conventional and non conventional energy sources. Distributed generation, Future trends in power generation and distribution. | 04 |
| 2. | **Solar Energy:**<br>Review of solar thermal applications-solar thermal conversion devices and storage applications.<br>Review of solar photovoltaic (PV) cells, principle of power generation using solar PV; Solar PV cell model, emerging solar cell technologies; Solar PV modules from solar cells, Mismatch in module , hot spots in the module , Bypass diode, Design and structure of PV modules , PV module power output, I-V and power curve of module; BOS of PV system**,** battery charge controllers, MPPT, and different algorithms for MPPT, distributed MPPT, Types of PV systems; Design methodology of standalone PV system. Solar PV Micro-inverters. Power quality and protection issues, review of regulatory standards. | 14 |
| 3. | **Wind Energy:**<br>Review of wind energy system and its components, types of wind turbines, characteristics; Power generation and control in wind energy systems, performance calculations of wind energy systems. Topologies of WES, WES with rectifier / inverter system, Power Converters for Doubly Fed Induction Generators (DFIG) in Wind Turbines. | 08 |
| 4. | **Fuel Cell:**<br>Review of fuel cells and their principle of operation, Review of types of fuel cell and their performance comparison. Topologies of fuel cell power systems, applications. | 05 |
| 5. | **Other Sources:**<br>Review of other nonconventional sources, their features and applications; Biomass, Tidal, Ocean Thermal Electric Conversion, geothermal, and Micro-hydro. | 03 |
| 6. | **Energy Storage**<br>Forms of energy storage, importance of storage system in new power generation scenario; Types, characteristics and performance evaluation of: batteries, ultra-capacitors, flywheels, SME, pumped hydro storage system; Applications of Energy storage in distributed generation, smart grid systems, Electric and Hybrid electric vehicles. Hybrid power system based on renewable energy and energy storage. | 14 |

**Assessment:**

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

**End Semester Examination:**

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No.1 will be compulsory and based on entire syllabus.
4. Remaining question (Q.2 to Q.6) will be set from all the modules.

.

**Books Recommended:**

*Reference Books:*


1. Chetan Singh Solanki , Solar Photo Voltaics , PHI Learning Pvt Ltd., New Delhi,2009
2. Hashem Nehrir and Caisheng Wang, Modeling and control of fuel cells: Distributed Generation Applications, IEEE Press, 2009
3. J.F. Manwell and J.G. McGowan, Wind Energy Explained, theory design and applications, Wiley publication
4. D. D. Hall and R. P. Grover, Biomass Regenerable Energy, John Wiley, New York, 1987.
5. Felix A. Farret and M. Godoy Simoes, Integration of Alternative Sources of Energy, 2006, John Wiley and Sons.
6. M. Ehsani, Y. Gao, and Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, Second Edition, CRC Press.
7. S. Chakraborty, M. G. Simões and W. E. Kramer, Power Electronics for Renewable and Distributed Energy System, Springer 2013
8. Ahmed Faheem Zobaa, Energy storage – Technologies and Applications, InTech Publication 2013.
9. N. Femia G. Petrone, G. Spagnuolo and M. Vitelli, Power Electronics and Control Techniques for Maximum Energy Harvesting in Photovoltaic Systems, CRC Press, 2013

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELE703 | Elective-I Artificial Neural Network | 4 | - | - | 4 | - | - | 4 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELE703 | Elective-I Artificial Neural Network | 20 | 20 | 20 | 80 | 03 | - | - | 100 |

| Course Code | Course Name | Credits |
|---|---|---|
| ELE703 | Elective-I Artificial Neural Network | 4 |
| Course Objectives | • To understand the basics of ANN and comparison with Human brain<br>• To study about various methods of representing information in ANN<br>• To learn various architectures of building an ANN and its applications<br>• To understand the Pattern classification and Pattern Association techniques | |

| Module | Contents | Hours |
|---|---|---|
| 1. | **Artificial Neural Systems: Preliminaries**<br>Neural Computation: Some Examples and Applications<br>History of Artificial Neural Systems Development | 6 |
| 2. | **Fundamental Concepts and Models of Artificial Neural Systems**<br>Biological Neurons and Their Artificial Models | 08 |

| | | |
|---|---|---|
| | Models of Artificial Neural Networks<br>Neural Processing<br>Learning and Adaptation<br>Neural Network Learning Rules | |
| 3. | **Single-Layer Perceptron Classifiers**<br>Classification Model, Features, and Decision Regions<br>Discriminant Functions<br>Linear Machine and Minimum Distance Classification<br>Nonparametric Training Concept<br>Training and Classification Using the Discrete Perceptron<br>Single-Layer Continuous Perceptron Networks for Linearly Separable Classifications<br>Multicategory Single-Layer Perceptron Networks | 10 |
| 4. | **Multilayer Feedforward Networks**<br>Linearly Nonseparable Pattern Classification<br>Delta Learning Rule for Multiperceptron Layer<br>Generalized Delta Learning Rule<br>Feedforward Recall and Error Back-Propagation Training<br>Learning Factors<br>Classifying and Expert Layered Networks<br>Functional Link Networks | 10 |
| 5. | **Single-Layer Perceptron Classifier**<br>Classification Model, Features, and Decision Regions<br>Discriminant Functions<br>Linear Machine and Minimum Distance Classification<br>Nonparametric Training Concept<br>Training and Classification Using the Discrete Perceptron<br>Single-Layer Continuous Perceptron Networks for Linearly Separable Classifications<br>Multicategory Single-Layer Perceptron Networks | 10 |
| 6 | **Multilayer Feedforward Networks**<br>Linearly Nonseparable Pattern Classification<br>Delta Learning Rule for Multiperceptron Layer<br>Generalized Delta Learning Rule<br>Learning Factors<br>Classifying and Expert Layered Networks<br>Functional Link Networks | 10 |

**Assessment:**

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

**End Semester Examination:**

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No.1 will be compulsory and based on entire syllabus.
4. Remaining question (Q.2 to Q.6) will be set from all the modules.

**Books Recommended:**

*Text Books:*

1. LaureneV. Fausett, "Fundamentals of Neural Networks-Architectures, Algorithms and Applications", Pearson Education, 2011.
2. Jacek M. Zurada, "Introduction to artificial neural systems", West Publishing Company

*Reference Books:*

1. James. A. Freeman and David.M.Skapura, "Neural Networks Algorithms, Applications and Programming Techniques ",Pearson Education, Sixth Reprint, 2011.
2. Simon Haykin, "Neural Networks and Learning Methods", PHI Learning Pvt. Ltd., 2011.
3. James A. Anderson, "An Introduction to Neural Networks", PHI Learning Pvt. Ltd., 2011.
4. Martin T. Hagan, Howard B. Demuth, Mark Beale, "Neural Network Design", Cengage Learning, Fourth Indian Reprint, 2010.
5. Bart Kosko, "Neural Networks and Fuzzy Systems-A Dynamical Approach to Machine Intelligence", PHI Learning Pvt. Ltd., 2010.

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| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELE704 | Elective-I Optical Fibre Communication | 4 | - | - | 4 | - | - | 4 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELE704 | Elective-I Optical Fibre Communication | 20 | 20 | 20 | 80 | 03 | - | - | 100 |

| Course Code | Course Name | Credits |
|---|---|---|
| **ELE704** | **Elective-I Optical Fibre Communication** | **4** |
| **Course Objectives** | To teach students<br>• Optical fiber wave guide structures, fabrication and signal degradation in fiber<br>• The characteristics and working of various components used in optical link<br>• Design and management of optical networks | |
| **Course Outcomes** | After successful completion of the course student will be able to<br>• understand light wave propagation through fiber<br>• identify structures, materials, and components used in optical link<br>• analyze transmission characteristics of fiber<br>• design and management of optical fiber links | |

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| Module | Contents | Hours |
|---|---|---|
| 1. | **Overview of Optical Fiber Communication**<br>- The evolution of fiber optic systems, elements of an optical fiber transmission link, block diagram, advantages of optical fiber communication, applications<br>- Ray theory transmission, total internal reflection, acceptance angle, numerical aperture and skew rays<br>- Modes, electromagnetic mode theory and propagation, single mode and multimode fibers, linearly polarized modes<br>- Fiber material, fiber cables and fiber fabrication, fiber joints, fiber connectors, splicer | 10 |
| 2. | **Optical Sources and Detectors**<br>- Coherent and non-coherent sources, quantum efficiency, modulation capability of optical sources<br>- LEDs: Working principle and **c**haracteristics<br>- Laser diodes: Working principle and **c**haracteristics<br>- Working principle and characteristics of detectors: PIN and APD, noise analysis in detectors, coherent and non-coherent detection, receiver structure, bit error rate of optical receivers, and receiver performance | 10 |
| 3. | **Components of Optical Fiber Networks**<br>- Overview of fiber optic networks, trans-receiver, semiconductor optical amplifiers<br>- Couplers/splicer, wavelength division multiplexers and de-multiplexers<br>- Filters, isolators and optical switches | 08 |
| 4. | **Transmission Characteristic of Optical Fiber**<br>- Attenuation, absorption, linear and nonlinear scattering losses, bending losses, modal dispersion, waveguide dispersion and pulse broadening<br>- Dispersion shifted and dispersion flattened fibers, and non linear effects<br>- Measurement of optical parameters, attenuation and dispersion, OTDR | 08 |
| 5. | **Optical Networks**<br>- SONET and SDH standards, architecture of optical transport networks (OTNs), network topologies<br>- Operational principle of WDM, WDM network elements and Architectures, Introduction to DWDM, Solitons | 08 |
| 6. | **Network Design and Management**<br>- Point to point links system considerations, link power budget, and rise time budget<br>- Transmission system model, power penalty-transmitter, receiver optical amplifiers, crosstalk, dispersion, wavelength stabilization.<br>- Network management functions, configuration management, performance management, fault management, optical safety and service interface | 08 |

**Assessment:**

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

**End Semester Examination:**

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No.1 will be compulsory and based on entire syllabus.
4. Remaining question (Q.2 to Q.6) will be set from all the modules.

**Books Recommended:**

1. John M. Senior, "*Optical Fiber Communication*", Prentice Hall of India Publication, Chicago, 3rd Edition, 2013
2. Gred Keiser, "*Optical Fiber Communication*", Mc-Graw Hill Publication , Singapore, 4th Edition, 2012
3. G Agarwal, "*Fiber Optic Communication Systems*", John Wiley and Sons, 3rd Edition, New York 2014
4. S.C. Gupta, "*Optoelectronic Devices and Systems*", Prentice Hall of India Publication, Chicago, 2005.

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELE705 | Elective-I Digital Signal Processing & Processors | 4 | - | - | 4 | - | - | 4 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELE705 | Elective-I Digital Signal Processing & Processors | 20 | 20 | 20 | 80 | 03 | - | - | 100 |

| Course Code | Course Name | Credits |
|---|---|---|
| ELE705 | Elective-I Digital Signal Processing & Processors | 4 |
| Course Objectives | 1. To study DFT and its computation<br>2. To study the design techniques for digital filters<br>3. To study the finite word length effects in signal processing<br>4. To study the fundamentals of digital signal processors<br>5. To get acquainted with the DSP applications | |
| Course Outcomes | Students will be able to understand concept of digital filters<br>1. Students will be able to decide the selection and design of digital filters<br>2. Students will understand the effect of hardware limitation<br>3. Students will be understand need of DSP processors<br>4. Students will be able to understand the use and application of DSP processors | |

| Module | Unit No. | Contents | Hours |
|---|---|---|---|
| 1. | | **Discrete Fourier Transform and Fast Fourier Transform** | |
| | 1.1 | **Discrete Fourier Series**: Properties of discrete Fourier series, DFS representation of periodic sequences. | |

| | | | |
|---|---|---|---|
| | **1.2** | **Discrete Fourier transforms**: Properties of DFT, linear convolution of sequences using DFT, computation of DFT, relation between Z-transform and DFS | 10 |
| | **1.3** | **Fast Fourier Transforms**: Fast Fourier transforms (FFT), Radix-2 decimation in time and decimation in frequency FFT algorithms, inverse FFT, and composite FFT | |
| **2.** | | **IIR Digital Filters** | 10 |
| | **2.1** | Mapping of S-plane to Z-plane, impulse invariance method, bilinear Z transformation (BLT) method, frequency warping, pre-warping | |
| | **2.2** | **Analog filter approximations**: Butter worth and Chebyshev, design of IIR digital filters from analog filters, design examples | |
| | **2.3** | **Analog filter approximations**: Butter worth and Chebyshev, design of IIR digital filters from analog filters, design examples | |
| **3.** | | **FIR Digital Filters** | 10 |
| | **3.1** | Characteristics of FIR digital filters, frequency response, location of the zeros of linear phase FIR filters | |
| | **3.2** | Design of FIR digital filters using window techniques, Gibbs phenomenon, frequency sampling technique, comparison of IIR and FIR filters | |
| **4.** | | **Finite Word Length Effects in Digital Filters** | 08 |
| | **4.1** | Number representation, fixed point, sign magnitude, One's complement, two's complement forms, floating point numbers. | |
| | **4.2** | to truncation and rounding, Input quantization error, Product quantization error, co-efficient quantization error, zero-input limit cycle oscillations, overflow limit cycle oscillations, scaling | |
| | **4.3** | IIR digital filters, finite word length effects in FIR digital filters, quantization effects in the computation of the DFT- quantization errors in FFT algorithms | |
| **5.** | | **Introduction to DSP Processors** | 08 |
| | **5.1** | Introduction to fixed point and floating point DSP processor, multiplier and multiplier accumulator (MAC), modified bus structures and memory access schemes in DSPs, multiple access memory, multiport memory, VLIW architecture, pipelining, special addressing modes, on-chip peripherals | |
| | **5.2** | Features of TMS 320c67xx DSP processor, architecture of TMS 320c67xx DSP processor, architecture features: computational units, bus architecture memory, data addressing, address generation unit, program control, program sequencer, pipelining, interrupts, features of external interfacing, on-chip peripherals, hardware timers, host interface port, clock generators, SPORT | |
| **6.** | | **Application of DSP processors** | 06 |

| | | | |
|---|---|---|---|
| | **6.1** | Speech processing: speech analysis, speech coding, sub band coding, channel vocoder, homomorphic vocoder, digital processing of audio signals. | |
| | **6.2** | **Radar signal processing**: Radar principles, radar system and parameter considerations, signal design | |

**Assessment:**
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

**End Semester Examination:**

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No.1 will be compulsory and based on entire syllabus.
4. Remaining question (Q.2 to Q.6) will be set from all the modules.

**Books Recommended:**

*Text Books:*


1. Proakis J., Manolakis D., "Digital Signal Processing", 4th Edition, Pearson Education
2. Oppenheim A., Schafer R., Buck J., "Discrete Time Signal Processing", 2nd Edition, Pearson Education.
3. Babu R., "Digital Signal Processing", 4th Edition, Scitech Publications.
4. B. Venkata Ramani and M. Bhaskar, “Digital Signal Processors, Architecture, Programming and Applications”, Tata McGraw Hill, 2004.
5. L. R. Rabiner and B. Gold, “Theory and Applications of Digital Signal Processing”, Prentice-Hall of India, 2006.
6. B. Kumar, “Digital Signal Processing”, New Age International Publishers, 2014.


*Recommended Books:*


1. S. Salivahanan, A. Vallavaraj, , Tata McGraw-Hill Education, 2001
2. A. Nagoor Kani, “Digital Signal Processing”, Tata McGraw Hill Publishing Company in 2012

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| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELL701 | Drives and Control Laboratory | - | 2 | - | - | 1 | - | 1 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELL701 | Drives and Control Laboratory | - | - | - | - | - | 25 | 25 | 50 |

***Includes both Practical and Oral examination**

**Term Work**:
At least 8 experiments based on the entire syllabus of ELC701**(**Drives and Control Laboratory**)** should be set to have well predefined inference and conclusion. Computation/simulation based experiments are also encouraged. The experiments should be students' centric and attempt should be made to make experiments more meaningful, interesting and innovative.

Term work assessment must be based on the overall performance of the student with every experiment graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme.

**The distribution of marks for the term work shall be as follows:**

Laboratory work (experiments) : 10 marks
Assignments : 10 marks
Attendance : 05 marks

The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

**Practical and Oral examination**:

The distribution of marks shall be as follows:

Performance of Experiments : 15 marks
Oral examination : 10 marks

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELL702 | Embedded System & Real Time Programming Laboratory | - | 2 | - | - | 1 | - | 1 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELL702 | Embedded System & Real Time Programming Laboratory | - | - | - | - | - | 25 | 25 | 50 |

***Includes Oral examination**

**Suggested Laboratory Experiments**

Minimum Six experiments covering topics in the syllabus

- Interfacing keyboard, LED, LCD Displays
- Programming should be using Suitable IDE and Embedded C
- Serial Communication

**Term work:**

At least 10 experiments based on the entire syllabus of ELC702 **(**Embedded System & Real Time Programming Laboratory**)** should be set to have well predefined inference and conclusion. Computation/simulation based experiments are also encouraged. The experiments should be students' centric and attempt should be made to make experiments more meaningful, interesting and innovative.

Term work assessment must be based on the overall performance of the student with every experiment graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme.

**The distribution of marks for the term work shall be as follows:**

Laboratory work (experiments) :10 marks

Assignments : 10 marks

Attendance : 05 marks

The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

**Oral Examination:**

Oral will be based on any experiment performed from the list of experiment given in the syllabus and the entire syllabus.

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| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELL703 | Basics of VLSI Design Laboratory | - | 2 | - | - | 1 | - | 1 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELL703 | Basics of VLSI Design Laboratory | - | - | - | - | - | 25 | 25 | 50 |

***Includes Oral examination**

**Term Work:**

At least 10 experiments based on the entire syllabus of Subject ELC703 (Basics of VLSI Design) should be set to have well predefined inference and conclusion. Computation/simulation based experiments are encouraged.

The experiments should be students" centric and attempt should be made to make experiments more meaningful, interesting and innovative. Term work assessment must be based on the overall performance of the student with every experiment graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme.

The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

**The distribution of marks for the term work shall be as follows:**

Laboratory work (experiments) : 10 marks

Assignments : 10 marks

Attendance : 05 marks

The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

**Oral Examination:** Oral will be based on any experiment performed from the list of experiment given in the syllabus and the entire syllabus.

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELL704 | Power System Operation and Control Laboratory | - | 2 | - | - | 1 | - | 1 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELL704 | Power System Operation and Control Laboratory | - | - | - | - | - | 25 | 25 | 50 |

**Term Work:**

At least 10 experiments based on the entire syllabus of Subject ELC704 (Power System Operation and Control) should be set to have well predefined inference and conclusion. Computation/simulation based experiments are encouraged.

The experiments should be students" centric and attempt should be made to make experiments more meaningful, interesting and innovative. Term work assessment must be based on the overall performance of the student with every experiment graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme.

The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

**The distribution of marks for the term work shall be as follows:**

Laboratory work (experiments) : 10 marks

Assignments : 10 marks

Attendance : 05 marks

The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELP701 | Project-I | - | 6 | - | - | 3 | - | 3 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELP701 | Project-I | - | - | - | - | - | 25 | 25 | 50 |

In final year group of maximum **four** students will be completing a comprehensive project work based on the courses studied. The project work may be internally assigned or may be externally assigned by the research institutes, industry etc. Each group will be assigned one faculty as a supervisor. This project work in final year may be extension of the Mini Project work done in pre-final year.

The main intention of Project work is to enable students to apply the knowledge and skills learned out of courses studied to solve/implement predefined practical problem. The Project work may be beyond the scope of curriculum of courses taken or may be based on the courses but thrust should be

- Learning additional skills
- Development of ability to define, design, analysis and implementation of the problem and lead to its accomplishment with proper planning
- Learn the behavioral science by working in a group
- The project area may be selected in which the student intend to do further education and/or may be either intend to have employment or self employment
- The topic of project should be different and / or may be advancement in the same topic of Mini Project
- The students may use this opportunity to learn different computational techniques as well as some model development. This they can achieve by making proper selection of Project work.

The college should keep proper assessment record of the progress of project and at the end of the semester it should be assessed for awarding TW marks. The TW should be examined by approved internal faculty appointed by the head of the institute on the basis of following:

- Scope and objective of the project work.
- Extensive Literature survey.
- Progress of the work (Continuous assessment)
- Report in prescribed University format.

An approved external examiner and internal examiner appointed by the head of the institute together will assess during oral examination. The oral examination is a presentation by the group members on the project along with demonstration of the work done. In the examination each individual student should be assessed for his/her contribution, understanding and knowledge gained.

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELC801 | Digital Image Processing | 4 | - | - | 4 | - | - | 4 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELC801 | Digital Image Processing | 20 | 20 | 20 | 80 | 03 | - | - | 100 |

| Course Code | Course Name | Credits |
|---|---|---|
| ELC801 | Digital Image Processing | 4 |
| Course Objectives | • To develop an overview of the field of image processing<br>• To learn the fundamental concepts of Digital Image Processing<br>• To understand basic image enhancement and segmentation techniques.<br>• To illustrate Image Transform calculations mathematically and develop fast transform algorithm<br>• To learn Image Compression and Decompression Techniques | |
| Course Outcomes | • Understand the concept of Digital Image processing.<br>• Explain image enhancement and Segmentation technique.<br>• Understand Digital Image compression and decompression technique<br>• Perform Binary Image Processing Operations | |

| Module No. | Topics | Hrs. |
|---|---|---|
| 1. | **Digital Image Processing Fundamentals**<br>**Introduction:** Background, Digital Image Representation, Fundamental Steps in Image Processing, Elements of a Digital | 06 |

| | | |
|---|---|---|
| | Image Processing System<br>**Digital Image Fundamentals:** Elements of Visual Perception, A Simple Image Model, Sampling and Quantization, Some Basic Relationships between Pixels, Imagining Geometry. Image File Formats: BMP, TIFF and JPEG. Colour Models (RGB, HSI, YUV) | |
| **2.** | **Image Enhancement**<br>Spatial Domain Methods, Frequency Domain Methods, Some Simple Intensity Transformations, Histogram Processing, Image Subtraction, Image Averaging, Background<br>Smoothing Filters, Sharpening Filters, Lowpass Filtering, Highpass Filtering, Generation of Spatial Masks from Frequency Domain Specifications. Homomorphic Filtering. | 08 |
| **3.** | **Image Segmentation and Representation**<br>Detection of Discontinuities, Edge Linking using Hough Transform, Thresholding, Region based Segmentation, Split and Merge Technique.<br>Image Representation and Description, Chain Code, Polygonal, Representation, Shape Number, Moments. | 08 |
| **4.** | **Binary Image Processing**<br>Binary Morphological Operators, Hit-or-Miss Transformation, Boundary Extraction, Region Filling, Thinning and Thickening, Connected Component Labeling, Iterative Algorithm and Classical Algorithm | 06 |
| **5.** | **Image Transform**<br>Introduction to the Fourier Transform, The Discrete Fourier Transform, Some Properties of the Two-Dimensional Fourier Transform Fast Fourier Transform(FFT)<br>Discrete Hadamard Transform(DHT), Fast Hadamard Transform(FHT), Discrete Cosine Transform(DCT), Discrete Wavelet Transform(DWT) | 12 |
| **6.** | **Image Compression:**<br>Fundamentals – Coding Redundancy, Interpixel Redundancy, Psychovisual Redundancy, Fidelity Criteria.<br>Image Compression Models – The Source Encoder and Decoder, Lossless Compression Techniques : Run Length Coding, Arithmetic Coding, Huffman Coding, Differential PCM<br>Lossy Compression Techniques: Improved Gray Scale Quantization, Vector Quantization, JPEG, MPEG-1 | 12 |

**Assessment:**

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

**End Semester Examination:**

Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.

**Recommended Books**:

1. Rafel C. Gonzalez and Richard E. Woods, 'Digital Image Processing', Pearson Education Asia, Third Edition, 2009,

2. S. Jayaraman, E.Esakkirajan and T.Veerkumar, "Digital Image Processing" TataMcGraw Hill Education Private Ltd, 2009,

3. Anil K. Jain, "Fundamentals and Digital Image Processing", Prentice Hall of India Private Ltd, Third Edition

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELC802 | Industrial Automation | 4 | - | - | 4 | - | - | 4 |

| Course Code | Course Name | Examination Scheme | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam | Exam. Duration (in Hrs) | | | |
| | | Test | Test | Avg | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | | | | | | |
| ELC802 | Industrial Automation | 20 | 20 | 20 | 80 | 03 | - | - | 100 |

| **Course Code** | **Course Name** | **Credits** |
|---|---|---|
| **ELC802** | **Industrial Automation** | **4** |
| **Course Objectives** | • Involves the integration of information systems with material and energy flows.<br>• A synthesis of automatic control, real time systems and instrumentation engineering.<br>• Automation concentrates on the structural problems in manufacturing systems, processing industries or power industries.<br>• The subject's focus is on the coordination of and interaction between many different components such as machines or processes, rather than control of individual components. | |
| **Course Outcomes** | • Provides the student with basic knowledge of the industrial automation systems design, installation, modification, maintenance, and repair | |

| **Module No.** | **Topics** | **Hrs.** |
|---|---|---|
| **1.** | **Introduction to Industrial Automation, Plant wide control systems and Automation Strategy.**<br>Introduction to Industrial Automation, Role of automation in industries, Introduction to the types of manufacturing industries, Introduction to type of automation system, Benefits of automation. Introduction to Automation pyramid, Introduction to automation tools like PAC, PLC, SCADA, DCS, Hybrid DCS with reference to automation pyramid, Comparison of PLC, PAC, and SCADA on the basis of Performance criteria Control system audit, Performance criteria, Development of User Requirement Specifications (URS) for automation. Functional Design Specifications (FDS) for automation tools. | 06 |
| **2**. | **Instrumentation Standard Protocols**<br>Definition of protocol, Introduction to Open System Interconnection (OSI) model, Communication standard (RS232, RS485), Modbus (ASCII/RTU), Introduction to third party interface, concept of OPC (Object linking and embedding for Process Control), HART Protocol: Introduction, frame structure, programming, implementation examples, benefits, advantages and | 08 |

| | | |
|---|---|---|
| | limitation. Foundation Fieldbus H1: Introduction, frame structure, programming, implementation examples, benefits, advantages and limitation. Comparison of HART, Foundation Fieldbus, Devicenet, Profibus, Controlnet, Industrial Ethernet. | |
| **3.** | **PLC Configuration, Applications and Machine automation** PLC programming methods as per IEC 61131, Developing programs using Sequential Function Chart, Functional Block Diagram, Analog control using PLC ( PID controller configuration), Interfacing PLC to SCADA/DCS using communication link (RS232, RS485) , Protocols (Modbus ASCII/RTU) and OPC, Development stages involved for PLC based automation systems. Introduction Computer Numerically Controlled (CNC) Machines, Basic CNC Principle, servo control, types of servo control for motion axes, Control system of CNC, Introduction to G-code. | 08 |
| **4.** | **Distributed Control System Basics** DCS introduction, Various function Blocks, DCS components/block diagram, DCS Architecture of different makes, comparison of these architectures with automation pyramid, DCS specification, latest trend and developments, DCS support to Enterprise Resources Planning (ERP), performance criteria for DCS and other automation tools. | 06 |
| **5.** | **Distributed Control Systems Engineering and Design** DCS detail Engineering, configuration and programming, functions including database management, reporting, alarm management, diagnosis, Historical database management, security and user access management, communication, third party interfaces ,control, display etc. Enhanced functions like Advance process control, fuzzy logic, ANN | 12 |
| **6.** | **Process safety and Safety Management Systems** Introduction to process safety, risk, risk terminologies, consequence and risk, risk measurement, Process Hazard Analysis (PHA), Hazard and operability study ( HaZOp), Safety Integrity Level (SIL), Introduction to IEC61511 standard for Functional safety , protection layers, Safety Instrumented System: function, architecture, safety life cycle, Application of safety system | 12 |

**Assessment:**

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

**End Semester Examination:**

Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.

**Recommended Books**:


1. "The management of control system: Justification and Technical Auditing", N.E. Bhttiha, ISA
2. "Computer aided process control", S.K.Singh, PHI.
3. "Understanding Distributed Process Systems For Control", Samuel Herb, ISA.
4. "Programmable Logic Controllers: Principles and Applications", Webb &Reis, PHI.
5. "Introduction to Programmable Logic Controllers", Garry Dunning, Thomson Learning.
6. "Distributed computer control for industrial automation", Ppovik Bhatkar, Dekkar Pub.
7. "Computer Based Process control", Krishna Kant, PHI
8. "Mechatronics", HMT, TMH publication.

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| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELC 803 | High Voltage DC Transmission | 4 | - | - | 4 | - | - | 4 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELC 803 | High Voltage DC Transmission | 20 | 20 | 20 | 80 | 03 | - | - | 100 |

| Course Code | Course Name | Credits |
|---|---|---|
| ELL 803 | High Voltage DC Transmission | 4 |
| Course Objectives | • To give the students in depth knowledge of the configuration and working of HVDC system | |
| Course Outcomes | • Student should able to analyze HVDC system and its impact on existing power system. | |

| Module | Contents | Hours |
|---|---|---|
| 1. | **Introduction to HVDC transmission**: Early discoveries and applications, , Limitation and advantages of AC and DC transmission, Economic factors, Classification of HVDC links, Components HVDC Transmission system, Application of DC transmission , Ground Return Advantages and Problems | 4 |
| 2. | **Analysis of the Bridge rectifier:** Analysis of six pulse converter with grid control but no overlap, Current and phase relations, Analysis of six pulse converter with grid control and overlap less than 600, Relation between AC and DC quantities, Analysis with overlap greater than 600, Rectifier operation and inverter operation, Equivalent circuit of rectifier and inverter, Multi bridge converter, Numerical from converter circuits and multiple bridge converter. | 10 |

| | | |
|---|---|---|
| **3.** | **Control:** Basic means of control, Limitation of manual control, Constant current verses constant voltage control, Desired features of control, Actual control characteristics, Significance of current margin, Power reversal, Alternative, Inverter Control Mode. | 6 |
| **4.** | **Converter Firing Control:** Control Implementation, Converter Firing Control Schemes. | 4 |
| **5.** | **Faults and protection:** Malfunction of mercury arc valves, By pass valves:- transfer of current from main valves to bypass valves and back to main valves (both rectifier and inverter), Commutation failure: causes and analysis, double commutation failure, Protection against over current, over voltage, Surge arrester. | 8 |
| **6.** | **Harmonics & Filters:** Characteristics Harmonics and Un-Characteristics Harmonics, Causes, Consequences, Trouble Caused by Harmonics, Means of Reducing Harmonics, Filters, AC & DC Filters. | 4 |

**Assessment:**
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

**End Semester Examination:**
Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.

**Books Recommended:**
*Text Books:*
1. Edward Wilson Kimbark "Direct Current Transmission" Wiley publication Inter science

2. K R Padiyar "HVDC power transmission systems" second edition, New Age International (p)Ltd

3. S. Kamkshaiah and V Kamraju "HVDC transmission" Tata McGraw Hill Education Pvt. Ltd, New Delhi

*Reference Books:*
1. S. Rao "EHVAC and HVDC Transmission Engineering and Practice" –Khanna publication, 1990

2. J. Arrillaga "HVDC Transmission" – Wiley publication Inter science

3. C.L. Wadhwa "Electrical Power System (2nd Edition)"

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| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELE 801 | Advanced control system | 4 | - | - | 4 | - | - | 4 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELE 801 | Advanced control system | 20 | 20 | 20 | 80 | 03 | - | - | 100 |

| Course Code | Course Name | Credits |
|---|---|---|
| ELE 801 | Advanced control system | 4 |
| Course Objective | • To understand the basics of mathematical modeling<br>• To study the stability analysis of linear and non linear systems | |
| Course outcomes | • At the end of the course students will be able apply the modeling concepts<br>• Students will be equipped with stability analysis of linear and non linear systems | |

| Module | Contents | Hours |
|---|---|---|
| 1. | **NON-LINEAR SYSTEMS**<br>Types of non-linearity, typical examples, singular points, Phase plane analysis, Limit cycles, linearization, Describing functions. Need for model reduction, Dominant pole concept. Model reduction via partial realization. Time moment matching and pade approximation, Hankel norm model reduction. | 10 |
| 2. | **STABILITY**<br>Stability concepts - Equilibrium points - BIBO and asymptotic stability, Lyapunov Theory, Definitions (Stability and Functions). Direct method of Lyapunov, Application to non-linear problems. Stability analysis by describing function method –jump resonance. Frequency domain stability criteria, Popov's method and is extensions. | 10 |
| 3. | **MODEL REFERENCE ADAPTIVE CONTROL** | 8 |

| | | |
|---|---|---|
| | Different configurations and classifications of MRAC - Mathematical description - Direct and indirect model reference adaptive control - MIT rule for continues time MRAC systems -Lypunov approach and hyper stability approach for continuous time and discrete time MRAC systems - Multivariable systems - Stability and convergence studies. | |
| **4.** | **SELF TUNING REGULATORS**<br>Different approaches to self-tuning - Recursive parameter estimation Implicit and explicit STR -LQG self-tuning - Convergence analysis Minimum variance and pole assignment approaches to multivariable selftuning regulators. | 8 |
| **5.** | **RECENT TRENDS AND APPLICATIONS OF ADAPTIVE CONTROL**<br>Recent trends in self-tuning Robustness studies multivariable system. Model updating. General-purpose adaptive regulator. Application to Process control components and systems. Industrial Applications. | 8 |
| **6.** | **OPTIMAL CONTROL**<br>Problem formulation, necessary conditions of optimality, state regulator problem. Matrix Riccati equation, infinite time regulator problem, output regulator and tracking problems. Pontryagin's minimum principles, time, and optimal control problem. Dynamic programming. Linear Quadratic Regulator, model matching based on Linear Quadratic optimal regulator. Observer design, Linear optimal filter. | 8 |

**Assessment:**
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

**End Semester Examination:**
Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.

**Books Recommended:**
*Reference Books:*
1. Chalam, V.V., "Adaptive Control Systems", Techniques & Applications, Marcel Dekker, Inc. NY and Basel. 1987.
2. Eveleigh, V.W., "Adaptive Control and Optimisation Techniques". McGraw-Hill, 1967.
3. Narendra and Annasamy, "Stable Adaptive Control Systems", Prentice Hall, 1989.
4. Astry, S. and Bodson, M., "Adaptive Control", Prentice Hall,1989.
5. M. Vidyasagar, "Nonlinear Systems Analysis", 2nd Ed., Prentice Hall, 1993.
6. Hassan K. Khalil, "Nonlinear Systems", Third Edition, Prentice Hall, 2002.
7. William S. Levine (Editor), "The Control Handbook(Electrical Engineering Handbook Series)", CRC Press, March 1996.
8. Nagrath I.J., and Gopal, M., "Control system Engineering" Wiley Eastern Reprint 1995.
9. Kirk D.E., "Optimal control theory-an introduction", Prentice Hall, N.J. 1970.
10. Gopal. M., "Modern control system Theory", Wiley Eastern Ltd., 2nd Edition Reprint 1995.
11. Graham C., Goodwill, S. F. Graebe and M. E. Salgado,"Control
12. System Design" Prentice Hall India, New Delhi, 2000

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| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELE 802 | Power Quality | 4 | - | - | 4 | - | - | 4 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELE 802 | Power Quality | 20 | 20 | 20 | 80 | 03 | - | - | 100 |

| Course Code | Course Name | Credits |
|---|---|---|
| ELE 802 | Power Quality | 4 |
| Course Objectives | • To get awareness about non-linear loads in power system<br>• To understand how non-linear loads affects power quality<br>• To study the solution to improve power quality | |
| Course Outcomes | • Students should be able to analyze the problems due to non-linear load and suggest solution for the same | |

| Module | Contents | Hours |
|---|---|---|
| 1. | **Introduction:**<br>Disturbances, Unbalance, Distortion, Voltage Fluctuations, Flicker, Quality Assessment | 06 |
| 2. | **Harmonics:**<br>Definition of harmonics, odd and even harmonics, Harmonic phase rotation and phase angle relationship, Causes of voltage and current harmonics, non-sinusoidal voltage and current waveform equations(numerical included), individual and total harmonic distortion with problems, Power assessment under waveform | 10 |

| | | |
|---|---|---|
| | distortion with numerical | |
| **3.** | **Power Quality monitoring & standards:**<br>Introduction, transducers current transformers, voltage transformers, Power quality instrumentation, Harmonic monitoring, Power quality standards IEEE 519 | 06 |
| **4.** | **Effects of harmonics:**<br>Rotating Machines – Transformers – Cables – Capacitors – Harmonic resonance – Voltage Notching – EMI (Electromagnetic Interference)<br>Overloading of Neutral conductor– Protective relays and Meters | 06 |
| **5.** | **Power factor and its improvement under sinusoidal and non-sinusoidal conditions:**<br>Power factor when both voltage and current sinusoidal, Power factor compensation using capacitor (vector diagram and numerical included), power factor when voltage is sinusoidal and current is non-sinusoidal (numerical included), Effect of capacitor compensation in power factor improvement under non-sinusoidal condition. | 12 |
| **6.** | **Harmonic mitigation and power factor improvement**<br>Mitigation of harmonics- Passive filters- Advantages and disadvantages of passive filters- Active filters-shunt connection, series connection and hybrid connection( Detailed diagram with inverters and its working), Power factor improvement using shunt active filter(both reactive power and harmonic power compensation), Generating reference currents for shunt active filter using Instantaneous PQ Theory | 08 |

**Assessment:**
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

**End Semester Examination:**
Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.

**Books Recommended:**
*Text Books:*
1. "Power System Quality Assessment", J. Arrillaga, N.R.Watson, S.Chen
2. "Power Quality" , C. Shankaran, CRC press
3. "Reactive power control in electric systems" by Timothy J. E. Miller
4. "Power Quality Enhancement Using Custom Devices" Arindam Ghosh, Gerard Ledwich
5. "Power Electronics" Ned Mohan, Undeland, Robbins, John Wiley Publication
6. "Power System Analysis- Short Circuit Load Flow and Harmonics" J.C.Das.

7. "Understanding Power Quality Problems,Voltage Sag and Interruptions " Math H.J.Bollen

*Reference Book:*

1. "Power System Harmonics" Jos Arrillaga, Neville R Watson
2. "Electric Power Quality", G.T.Heydt
3. "Electric Power Systems and Quality", Roger C. Dugan,Mark F. McGranaghan, H.Wayne Beaty
4. "IEEE-519 Standard"

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| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELL803 | Elective-II Analog & Mixed Signal VLSI | 4 | - | - | 4 | - | - | 4 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELE803 | Elective-II Analog & Mixed Signal VLSI | 20 | 20 | 20 | 80 | 03 | - | - | 100 |

| Course Code | Course Name | Credits |
|---|---|---|
| **ELE803** | **Elective-II Analog & Mixed Signal VLSI** | **4** |
| **Course Objectives** | • To study the concepts of MOS large signal model and small signal model<br>• To understand the concepts of D/A conversion methods and their architectures.<br>• To design filters for ADC.<br>• To study about the switched capacitor circuits. | |

| Module | Contents | Hours |
|---|---|---|
| **1.** | **Introduction and basic MOS devices**<br>Challenges in analog design-Mixed signal layout issues- MOS FET structures and characteristics large signal model – small signal model- single stage Amplifier-Source follower- Common gate stage – Cascaded Stage | 10 |
| **2.** | **Submicron circuit design**<br>Submicron CMOS process flow, Capacitors and resistors, Current mirrors, Digital Circuit Design, Delay Elements – Adders- OP | 10 |

| | | |
|---|---|---|
| | Amp parameters and Design | |
| **3.** | **Data converters**<br>Characteristics of Sample and Hold- Digital to Analog Converters- architecture-Differential Non linearity-Integral Non linearity-Voltage Scaling-Cyclic DAC-Pipeline DAC-Analog to Digital Converters- architecture – Flash ADC-Pipeline ADC-Differential Non linearity-Integral Non linearity | 10 |
| **4.** | **SNR in data converters**<br>Overview of SNR of Data Converters- Clock Jitters- Improving Using Averaging – Decimating Filters for ADC- Band pass and High Pass Sinc Filters- Interpolating Filters for DAC | 10 |
| **5.** | **Switched capacitor circuits:**<br>Resistors, First order low pass Circuit, Switched capacitor Amplifier, Switched Capacitor Integrator | 12 |

**Assessment:**
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

**End Semester Examination:**
Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.

**Books Recommended:**

1. Vineetha P.Gejji, "Analog and Mixed Mode Design" - Prentice Hall, 1st Edition , 2011
2. JeyaGowri, "Analog and Mixed Mode Design" - Sapna publishing House 2011.

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| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELL 804 | Robotics | 4 | - | - | 4 | - | - | 4 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELE 804 | Robotics | 20 | 20 | 20 | 80 | 03 | - | - | 100 |

| Course Code | Course Name | Credits |
|---|---|---|
| ELE 804 | Robotics | 4 |
| Course Objectives | • To prepare students with basics of robotics<br>• To familiarize students with kinematics & dynamics of robots<br>• To familiarize students with path & Trajectory planning of robots<br>• To familiarize students with robot vision | |
| Course Outcomes | Upon completion of the course, students will be able to understand:<br>• Describe kinematics and dynamics of stationary and mobile robots<br>• Describe trajectory planning for robots<br>• Implement trajectory generation and path planning various algorithms<br>• Work in interdisciplinary projects | |

| Module | Contents | Hours |
|---|---|---|
| 1. | **Fundamentals of Robotics.**<br>Robot classification, robot components, Degrees of freedom, Joints, co-ordinates, coordinate frames, workspace, applications. | 03 |
| 2. | **Forward & Inverse Kinematics of Robots.**<br>Homogeneous transformation matrices, Inverse transformation | 09 |

| | | |
|---|---|---|
| | matrices, Forward and inverse kinematic equations – position and orientation<br>Homogeneous transformation matrices, Inverse transformation matrices, Forward and inverse kinematic equations – position and orientation | |
| **3.** | **Velocity Kinematics and Dynamics**<br>Differential motions and velocities: Differential relationship, Jacobian, Differential motion of a frame and robot, Inverse Jacobian, Singularities.<br>Dynamic Analysis of Forces : Lagrangian mechanics, Newton Euler formulation, Dynamic equations of robots, Transformation of forces and moment between coordinate frames | 14 |
| **4.** | **Robot Motion Planning**<br>Concept of motion planning, Bug algorithms-Bug1, Bug2, Tangent Bug. | 04 |
| **5.** | **Potential Functions and Visibility Graphs**<br>Attractive/Repulsive potential, Gradient descent, wave-front planner, navigation potential functions, Visibility map, Generalized Voronoi diagrams and graphs, Silhouette methods. | 08 |
| **6.** | **Trajectory planning**<br>Trajectory planning, Joint-space trajectory planning, Cartesian | 08 |
| **7.** | **Robot Vision**<br>Image representation, template matching, Polyhedral objects, Shape analysis, segmentation, Iterative processing, perspective transform. | 06 |

**Assessment:**
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

**End Semester Examination:**
Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.

**Recommended Books:**

1. Robert Shilling, Fundamentals of Robotics - Analysis and control, Prentice Hall of India
2. Saeed Benjamin Niku, "Introduction to Robotics – Analysis, Control, Applications", Wiley India Pvt. Ltd., Second Edition, 2011
3. Howie Choset, Kevin M. Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia E. Kavraki and Sebastian Thrun, "Principles of Robot Motion – Theory, Algorithms and Implementations", Prentice-Hall of India, 2005.
4. Mark W. Spong , Seth Hutchinson, M. Vidyasagar, "Robot Modeling & Control ", Wiley India Pvt. Ltd., 2006

5. John J. Craig, "Introduction to Robotics – Mechanics & Control", Third Edition, Pearson Education, India, 2009
6. Aaron Martinez & Enrique Fernandez, "Learning ROS for Robotics Programming", Shroff Publishers, First Edition, 2013.
7. Mikell P. Groover et.al, "Industrial Robots-Technology, Programming & applications" ,McGraw Hill , New York, 2008

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELL801 | Digital Image Processing Laboratory | - | 2 | - | - | 1 | - | 1 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELL801 | Digital Image Processing Laboratory | - | - | - | - | - | 25 | 25 | 50 |

At least 10 experiments based on the entire syllabus of Subject **ELC801** should be set to have well predefined inference and conclusion. Computation/simulation based experiments are encouraged. The attempt should be made to make experiments more meaningful, interesting and innovative.

**Term work:**

Term work shall consist of minimum six experiments, assignments and attendance.

**The distribution of marks for the term work shall be as follows:**

Laboratory work (experiments) : 10 marks

Assignments : 10 marks

Attendance : 05 marks

The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

**Oral Examination:**

Oral will be based on any experiment performed from the list of experiment given in the syllabus and the entire syllabus.

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELL802 | Industrial Automation Laboratory | - | 2 | - | - | 1 | - | 1 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELL802 | Industrial Automation Laboratory | - | - | - | - | - | 25 | 25 | 50 |

**Suggested Laboratory Experiments**

1. Preparing URS and FDS for any small automation project.
2. Prepare cause and effect document for any small process and also develop logic diagram for the same.
3. Develop and implement any PLC and/or DCS program using FBD and SFC programming language.
4. Interfacing of PLC to any SCADA through Modbus protocol and/or OPC.
5. Interfacing of PLC to a DCS system through Modbus and/or OPC.
6. Developing and implementing any control loop using PLC system.
7. Developing and implementing any control loop using DCS system
8. Developing and configuring Graphic User Interface for any control loop.
9. Configuration of any HART device to PLC and/or DCS system.
10. Configuration of any Foundation Fieldbus device to PLC and /or DCS system.
11. Configure and implement different alarms in PLC and/or DCS system.
12. Configuring and implementing any Advance process control function like MPC/or Fuzzy/or ANN in a DCS system
13. Preparing a HaZOp document for any small process
14. Develop a G-code for any machining process.

**Term work:**

Term work shall consist of minimum six experiments, assignments and attendance. The distribution of marks for the term work shall be as follows:

Laboratory work (experiments) :10 marks

Assignments : 10 marks

Attendance : 05 marks

The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

**Oral Examination:**

Oral will be based on any experiment performed from the list of experiment given in the syllabus and the entire syllabus.

**University of Mumbai {B.E.(Electronics and Electrical Engineering R-2012)}**

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELL803 | High Voltage DC Transmission Laboratory | - | 2 | - | - | 1 | - | 1 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELL803 | High Voltage DC Transmission Laboratory | - | - | - | - | - | 25 | 25 | 50 |

**Term work:** Term Work shall consist of minimum two programs or two simulations based on above syllabus and six tutorials covering the entire syllabus

**The distribution of marks for the term work shall be as follows:**

Simulation/programs and tutorial: 10 marks
Assignments: 10 marks
Attendance: 05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of practical work and minimum passing in the term-work.

**University of Mumbai {B.E.(Electronics and Electrical Engineering R-2012)}**

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELL801 | Advanced Control System Laboratory | - | 2 | - | - | 1 | - | 1 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELE801 | Advanced Control System Laboratory | - | - | - | - | - | 25 | 25 | 50 |

**LIST OF EXPERIMENTS**

1. Analysis of first order/second order non-linear system.
2. Effect of Dominant pole and Critical pole on system performance.
3. Stability analysis of first order/ second order system by describing function method.
4. Obtain the stability of a system by Frequency domain criteria.
5. Study of Direct/indirect model reference adaptive control system. 6 Study of multivariable self-tuning regulators.
6. Analysis of Multivariable systems using step input
7. Any one Industrial Application of model reference control-a Survey.
8. Design of state observer
9. Design of linear filter.

**Term work:**

Term work shall consist of minimum six experiments, assignments and attendance.

**The distribution of marks for the term work shall be as follows:**

Laboratory work (experiments) :10 marks

Assignments : 10 marks

Attendance : 05 marks

The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

**Oral Examination:**

Oral will be based on any experiment performed from the list of experiment given in the syllabus and the entire syllabus

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELL802 | Power Quality Laboratory | - | 2 | - | - | 1 | - | 1 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELE802 | Power Quality Laboratory | - | - | - | - | - | 25 | 25 | 50 |

**Term work**: shall consist of minimum **Six** tutorials/experiments and **Two** simulations,

**The distribution of marks for the term work shall be as follows:**

Laboratory work (experiments) :10 marks

Assignments : 10 marks

Attendance : 05 marks

The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

**Oral Examination:**

Oral will be based on any experiment performed from the list of experiment given in the syllabus and the entire syllabus.

**University of Mumbai {B.E.(Electronics and Electrical Engineering R-2012)}**

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELL803 | Analog & Mixed Signal VLSI Laboratory | - | 2 | - | - | 1 | - | 1 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELL803 | Analog & Mixed Signal VLSI Laboratory | - | - | - | - | - | 25 | 25 | 50 |

At least 10 experiments based on entire syllabus of **ELE803 (Analog & Mixed Signal VLSI)** should be set to have well predefined inference and conclusion. Computation/simulation based experiments are also encouraged. The experiments should be students' centric and attempt should be made to make experiments more meaningful, interesting and innovative. Term work assessment must be based on the **overall performance** of the student with **every experiment graded from time to time.** The grades should be converted into marks as per the **Credit and Grading System** manual and should be **added and averaged**. The grading and term work assessment should be done based on this scheme.

The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Oral exam will be based on the entire syllabus.

**University of Mumbai {B.E.(Electronics and Electrical Engineering R-2012)}**

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELL804 | Robotics Laboratory | - | 2 | - | - | 1 | - | 1 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELL804 | Robotics Laboratory | - | - | - | - | - | 25 | 25 | 50 |

**List of Experiments**

These experiments can be performed using

1. Use of Control-X simulation Control of X-Y Position Table manually and thru Programming.
2. Use of Control-X simulation Control of Conveyor manually and thru Programming. Programming using sensors and conveyor. BE, VII-VIII , Electronics , wef 2010-11 32
3. Use of Control-X simulation Program for bottling plant experiment using Conveyer and Pneumatics
4. Use of PLC simulation builds a basic circuit using a NORMALLY OPEN INPUT and a NORMAL OUTPUT.
5. Use of P-Simulator design a pneumatic circuit using a double acting cylinder and 5/2 Air Spring Valve to open the main gate of a factory which can be controlled by a security personnel from the security room.
6. Use of H-Simulator designs a Hydraulic circuit by using a single acting cylinder to open or close the flush guard door of CNC lathe. The operator can open or close the door at the time of loading or unloading the component.
7.

**Term work:**

Term work shall consist of minimum six experiments, assignments and attendance.

**The distribution of marks for the term work shall be as follows:**

Laboratory work (experiments) :10 marks

Assignments : 10 marks

Attendance : 05 marks

The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

**Oral Examination:**

Oral will be based on any experiment performed from the list of experiment given in the syllabus and the entire syllabus.

**University of Mumbai {B.E.(Electronics and Electrical Engineering R-2012)}**

| Course Code | Course Name | Teaching Scheme | | | Credits assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
| ELP801 | Project-II | - | 12 | - | - | 6 | - | 6 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| ELP801 | Project-II | - | - | - | - | - | 50 | 50 | 100 |

The final year students have already under gone project assignment in their seventh semester and in this semester the students are expected to continue the project work of stage I.

The college should keep proper assessment record of the progress of project and at the end of the semester it should be assessed for awarding TW marks. The TW should be examined by approved internal faculty appointed by the head of the institute on the basis of following:

- Scope and objective of the project work.
- Extensive Literature survey.
- Progress of the work (Continuous assessment)
- Design, implementation, and analysis of the project work.
- Results, conclusions and future scope.
- Report in prescribed University format.

An approved external examiner and internal examiner appointed by the head of the institute together will assess during oral examination. The oral examination is a presentation by the group members on the project along with demonstration of the work done. In the examination each individual student should be assessed for his/her contribution, understanding and knowledge gained.