**Total Credits = 21**

| Semester 6TH | | Contact Hours | | | Max Marks | | Total Marks | Credits |
|---|---|---|---|---|---|---|---|---|
| **Subject Code** | **Subject Name** | **L** | **T** | **P** | **Int.** | **Ext.** | | |
| BELES1-601 | Power Systems – II (Protection) | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| BELES1-602 | Electrical Measurements & Instrumentation | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| BELES1-603 | Power Systems - II Laboratory | 0 | 0 | 2 | 60 | 40 | 100 | 1 |
| BELES1-604 | Electrical Measurements & Instrumentation Lab | 0 | 0 | 2 | 60 | 40 | 100 | 1 |
| BELES1-605 | Electrical Design & Estimation Lab | 0 | 0 | 2 | 60 | 40 | 100 | 1 |
| **Departmental Electives – II** | **(Select any one from the following list)** | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| BELED1-611 | Industrial Electrical Systems | | | | | | | |
| BELED1-612 | Non-Linear &Digital Control Systems | | | | | | | |
| BELED1-613 | Computer Architecture | | | | | | | |
| BELED1-614 | Computational Electromagnetics | | | | | | | |
| **Departmental Electives – III** | **(Select any one from the following list)** | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| BELED1-621 | Wind & Solar Energy Systems | | | | | | | |
| BELED1-622 | HVDC Transmission Systems | | | | | | | |
| BELED1-623 | EHVAC Transmission Systems | | | | | | | |
| BELED1-624 | FACTS Devices in Transmission & Distribution Networks | | | | | | | |
| XXXXX | **Open-Elective*** | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| BELES1-606 | Introduction to Industrial Management | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| Total | | **-** | **-** | **-** | **420** | **480** | **900** | **21** |

*Open Electives (OE) can also be taken from existing lists of Open Elective-I, Open Elective-II and Open Elective-III subject lists.

| POWER SYSTEMS – II (Protection) | | | | | |
|---|---|---|---|---|---|
| **Subject Code:** | **L** | **T** | **P** | **C** | **Duration: 45(Hrs.)** |
| **BELES1-601** | **3** | **0** | **0** | **3** | |

**Course Objectives:**

1. To provide knowledgeaboutprinciple andcomponents of protective system.
2. To impart knowledge about basics of Substation, Isolator and Fuses.
3. To provide knowledge about operating principle, types of relays and circuit breakers.
4. To provide knowledge about protection of Feeder, Bus bar, Generator and Transformer

**Course Outcomes:**

Students will be able to:

1. Explain causes and effects of faults,components usedfor power system protection such as;isolators and fuses, relays, circuit breakers etc.
2. Classify types of relays and circuit breakers and explain their working principles and operation.
3. Protecttransmission lines, feeders, bus bars, generator and transformer.
4. Develop concepts about the basic principlesof static anddigitalprotection.

**UNIT-I (11 Hours)**

**Introduction to Components of Protection System:**

Need for Protective System, Nature and causes of faults, Types and effects of faults, Zones of protection, Primary and backup protection, Essential qualities of protection, Basic principle of protectionsystem, Components and classification of protective system.

**Substation:**

Types, Classification, Main Equipment, Layout, Bus-bar Arrangement of Substation, Functions, Operation, Types and rating of Isolators, Characteristics, Types and rating of fuses.

**UNIT-II (12 Hours)**

**Circuit Breakers:**

Need for Circuit Breakers, Circuit Breaker Ratings, Arc Initiation and their Interruption Methods,Arc Quenching Theories, Re-striking voltage, Recovery Voltage, RRRV, Oil Circuit Breaker, Minimum Oil Circuit Breaker, Air Circuit Breaker, Air Blast Circuit Breaker, Vacuum Circuit breaker and $SF_6$ circuit breaker.

**Protective Relays:**Introduction, Classification, Constructional features, and Characteristics of Electromagnetic, Induction, Over-current relays, Directional over current relay, Distance relays; Impedance relay, Reactance relay and Mho relay, Differential Relays.

Under voltage relay, Over voltage relay, Trans-lay, Under-frequency relay, Over-frequency relay, Rate of change of frequency (df/dt) relays,Reverse-power relay, Negative sequence relay.

**UNIT-III (11 Hours)**

**Transmission Line, Feeder and Bus Bar Protection**:
Over current protection by time graded system, Current graded and Time- current graded system, Protection of parallel feeder, Protection of ring mains feeder, Over current earth fault protection.

**Distance Protection** of transmission lines, Comparison amongdistance relays, Differential and percentage differential protection, Pilot relaying protection of feeder, Differential protection of bus bars.

**Overvoltages** on transmission lines such as switching overvoltages and lightning overvoltages, Protection of transmission lines against lighting, Protection of power system apparatus against surges.

**UNIT-IV (11 Hours)**

**Transformer Protection:**
Over current protection, Percentage differential protection, Incipient faults in transformers, Inter-turn fault, Protection against over fluxing.

**Generator Protection:**
Various faults and abnormal operating conditions, Protection against unbalanced loading, Over-speeding, Loss of excitation, Loss of prime mover.

**Introduction to Advance Protection Systems:**
Carrier aided protection of transmission lines, Static comparators as relays, Structure and Operation of Digital protection system, Advantages of digital techniques in power system protection.

**Recommended Text Books / Reference Books:**

1. B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, "Electric Power Systems", Wiley, 2012.
2. Burke James, J. "Power Distribution Engineering; Fundamentals and Applications" Marcel Dekk., 1996.
3. C.L. Wadhwa, A Course in Electrical Power, New Age international Pvt. Ltd
4. Badri Ram and D.N. Vishwakarma, Power system Protection and Switchgear, Tata McGraw Hill, 2001
5. M.V. Deshpande, Switchgears and Protection, Tata McGraw Hill
6. Ashfaq Hussain, Electrical Power system, 3rd edition, CBS Publishers & Distributors Pvt. Ltd. New Delhi, 2007.
7. S. S. Rao, Switchgear Protection and Power System, Khanna Publishers, Delhi,10th Edition,1992
8. Dahiya and Attri, Substation Engineering, Khanna Publishers

## ELECTRICAL MEASUREMENTS & INSTRUMENTATION

| Subject Code: | L | T | P | C | Duration: 45 (Hrs.) |
|---|---|---|---|---|---|
| BELES1-602 | 3 | 0 | 0 | 3 | |

**Course Objectives:**

1. To make the students aware about the basics of measurements and instrumentation systems.
2. To impart knowledge about different instruments for electrical measurements.
3. To introduce to basic concepts of different types of sensors and transducers.

**Course Outcomes:**

Students will be able:

1. To explain the constructional features, characteristics and operation of various measurement devices and transducers.
2. To measure R, L and C using DC and AC bridges.
3. To use CRO and instrument transformers for measurement and instrumentation purposes.
4. To select transducers for different applications.

### UNIT-I (12 Hours)

**Measurment Systems:**

Introduction, Necessity of measurements, Block diagram of measurement system, Instrument characteristics such as True value, Accuracy, Precision, Resolution, Drift, Hysteresis, Dead-band, Repeatability and sensitivity, Different types of errors in measurement.

**Measuring Instruments:**

Principle of operation and constructional features of D'Arsonval galvanometer, Permanent magnet moving coil (PMMC), Moving Iron instruments (Repulsion and Attraction type), Electrodynamic type instruments, Measurement of current, voltage, power and power factor by using these instruments, Use of Shunts, Multipliers and Potential dividers, Energy meter, Digital Multi-meter, Clamp-on meters.

### UNIT-II (11 Hours)

**Measurement of Resistance:** Low, Medium and High resistance measurement using Kelvin Double Bridge, Ammeter-Voltmeter method, Wheat Stone Bridge, Megohm bridge, Megger.

**Measurement of Inductance and Capacitance:**Maxwell Inductance, Hay's, Anderson and Schering Bridges, Measurement of frequency by Wein bridge method.

**UNIT-III (11 Hours)**

**Oscilloscope:**

Basic principle and construction of Analog CRO, Sweep modes, Applications in measurement of voltage, frequency (Lissajous pattern), Introduction to Dual Trace Oscilloscope, Digital Storage Oscilloscope, Sampling oscilloscope, Comparison between analog and digital oscilloscope.

**Instrument Transformers:**

Theory and construction of current and potential transformers, Ratio and phase angle errors and their minimization, Characteristics of current transformers(CT) and potential transformers(PT) and their Testing.

**UNIT-IV (11 Hours)**

**Transducers:**

Transducer, Difference between sensor and transducer, Transducer characteristics, Classifications and Types, Basic requirements of Transducer/Sensors, Displacement Transducers: LVDT, RVDT and Piezoelectric, Resistance Thermometer, Thermistors, Thermocouples, Strain Gauge, Applications of Transducers.

**Recommended Text Books / Reference Books:**

1. Helfrick A.D. and Cooper W.D., "Modern *Electronic Instrumentation and MeasurementTechniques"*, PHI, 1990.
2. A.K. Sawhney, Puneet Sawhney, "A course in Electrical and Electronic Measurements and Instrumentation", Dhanpat Rai & Sons, 2011.
3. Jones and Chin, 'Electronic Instruments and Measurement', 2010.
4. J. Toppin, 'Theory of Errors', Wessely Publishing, 2000.
5. Bell David A., *Electronics Instrumentation and Measurements,* Prentice Hall,India
6. Golding Edward William and Widdis Frederick Charles, *Electrical Measurements andMeasuring instruments,* WheelersIndia
7. Murthy D. V. S., Transducers and Instrumentation, Prentice-Hall,India

## POWER SYSTEMS – II LABORATORY

| Subject Code: | L | T | P | C |
|---|---|---|---|---|
| BELES1-603 | 0 | 0 | 2 | 1 |

**Course Objectives:**

1. Understand operation of relays and circuit breakers.
2. To demonstrate the characteristics of different types of relays.

**Course Outcomes:**

Students will be able:

1. To demonstrate operation of relays and circuit breakers.
2. To analyze various protection schemes in power system.
3. To plot characteristics of various types of relays, circuit breakers and fuses.

### LIST OF EXPERIMENTS

1. To study the characteristics of over current protection.
2. To study the characteristics of earth fault protection.
3. To draw the operating characteristics of fuse (HRC or open type) and bimetal mini circuit breakers.
4. To study air circuit breakers, oil circuit breakers, vacuum circuit breakers and $SF_6$ circuit breakers and demonstrate at least two of them.
5. To study over current static relay.
6. To study the performance of under voltage relay and over voltage relay.
7. To study the characteristics of Distance (Impedance, Reactance and Mho) Relay.
8. To demonstrate the operation of Buchholz's relay.
9. To find the breakdown strength of transformer oil.
10. To study the different types of faults on transmission line demonstrationpanel/model.
11. Short circuit analysis and calculations of circuit breaker ratings for a power system network.

    OR

    Design of protection system for a substation.
12. To obtain relay co-ordination on a power system.
13. Visit to a power generation station/substation.

Note: At least ten experiments should be performed in a semester.

## ELECTRICAL MEASUREMENTS & INSTRUMENTATION LAB

| Subject Code: | L | T | P | C |
|---|---|---|---|---|
| BELES1-604 | 0 | 0 | 2 | 1 |

**Course Objectives:**

1. To demonstrate the constructional features of measuring instruments.
2. To demonstrate the applications of measuring instruments.
3. To draw the characteristics and use of various types of transducers.

**Course Outcomes:**

Students will be able:

1. To apply the basic measurement techniques and use measuring instruments.
2. To measure various electrical quantities using various types of meters.
3. To practically use current and potential transformers, CRO and DSO.

**List of Experiments**

1. To demonstrate the constructional features of various types of indicating measuring instruments, such as PMMC type, Moving iron type, Electrodynamo type etc.
2. Current Measurement using Clamp-on meter and Hall Sensor.
3. To measure high value of DC current and voltage using shunt and Multiplier.
4. To measure the active power in 3-phase balanced and unbalanced load by two wattmeter method and observe the effect of power factor variation on wattmeter reading.
5. To study and calibrate Energy Meter.
6. To measurement of low resistance using Wheat stone bridge and Kelvin's double bridge.
7. Measurement of High resistance and Insulation resistance using Megger.
8. Measurement of self-inductance by using any bridge technique such as Anderson's bridge as well as LCR meter.
9. Measurement of capacitance by using any bridge technique such as Schering bridge as well as LCR meter.
10. Measurement of frequency using Wein's Bridge.

    OR

    Determination of frequency and phase angle using CRO.
11. Use a DSO to capture transients like a step change in R-L-C circuit.

    OR

    Download one-cycle data of a periodic waveform from a DSO anduse values to compute the RMS value.
12. To study the connections and use of a potential transformer (PT) and to find out ratio error.
13. To study the connections and use of a current transformer (CT) and to find out ratio error.
14. Measurement of displacement usingLVDT and RVDT.
15. Study the characteristics of (i) Resistance TemperatureDetector(RTD) and (ii) Thermistor and measurement of temperature using them.
16. Study the characteristics of a strain gauge sensor and its application in a measuring unit.

Note: At least 12 experiments must be performed in a semester.

## ELECTRICAL DESIGN & ESTIMATION LAB

| Subject Code: | L | T | P | C |
|---|---|---|---|---|
| BELES1-605 | 0 | 0 | 2 | 1 |

**Course Objectives:**

1. To know about the layout of wiring circuits of electrical installations of a residential building or/and an educational institute or/and anindustry.
2. To enable the students to prepare the schedule of materials with specifications and estimates for different types of electrical installations.
3. To know about wiring arrangements of motor control circuits and to do an energy audit of a smallutility.

**Course Outcomes:**

Students will be able:

1. To estimate the cost of various types of electrical installations.
2. To identify design goals and analyze possible approaches to meet given specifications with realistic engineering constraints.
3. To use modern engineering software tools.
4. To work amicably as a member of an engineering design team.

**List of Experiments**

1. To study the Indian Electricity Act.
2. To estimate the cost of overhead serviceconnection and an underground serviceconnection.
3. To estimate (i) the load and cost of any five electricalappliances and (ii)their cost of repair and maintenance.
4. To carry out the schematic wiring diagram of a residential building/educationalinstitute/industry.
5. To study design parameters of electrical panelboards.
6. To draw wiring diagrams of motor control circuits for the starting of induction and synchronousmotors.
7. To study and design the earthing requirements for different types of installations and also to estimate the cost of earthing.
8. To carry out an electrical energy audit of a laboratory/office/workshop**.**
9. Protection of buildings and allied structures against lightning.
10. To design and estimate the cost of illumination of a Residential building/laboratory/drawing hall.
11. Lighting design: Different entities of illuminating systems; Exterior lighting- flood, street,

aviation and transport lighting.

**OR**

Lighting design for displays and signaling- neon signs, LED-LCD displays beacons and lighting for surveillance.

12. Introduction to and hands on working experience on any available programming and/or simulation platform(s), such as:
    (i) C/C++, FORTRAN, MATLAB, SIMULINK etc.
    (ii) ETAP (analytical engineering software)
    (iii) Different types of Electrical design softwares (CAD) for drawing of Electrical diagrams, schematics, control circuit diagrams etc.

Note: At least ten experiments should be performed in the semester.

**Recommended Text Books / Reference Books:**

1. Raina K.B. and Bhattacharya S.K., "Electrical Design, Estimating and Costing", Tata McGraw Hill, NewDelhi.
2. Gupta J.B., "A course in Electrical Installation, Estimating and Costing", SK Kataria and Sons, N.Delhi
3. Sharma B.R. and Rai H.M., "Electrical Estimating and Costing".
4. Uppal S.L., "Electrical Wiring, Estimating and Costing".
5. Singh Surjeet, "Estimating and Costing",DhanpatRai and Co., New Delhi

| INDUSTRIAL ELECTRICAL SYSTEMS | | | | | |
|---|---|---|---|---|---|
| **Subject Code:** | **L** | **T** | **P** | **C** | **Duration: 45 (Hrs.)** |
| **BELED1-611** | **3** | **0** | **0** | **3** | |

**Course Objectives:**

To make the students:

1. Familiar withthe electrical wiring systems for residential, commercial and industrial consumers.
2. To learn about various components of industrial electricalsystems.
3. To introduce to industrial automation.

**Course Outcomes:**

Students will be able:

1. To represent the electrical wiring systems for residential, commercial and industrial consumers with standard symbols and drawings,SLD.
2. To explain various components of industrial electricalsystems.
3. To analyze and select the proper size of various electrical systemcomponents.

**UNIT-I (11 Hours)**

**Electrical System Components:** LT system wiring components, Selection of cables, wires, switches, distribution box, metering system, Tariff structure, protection components; Fuse, MCB, MCCB, ELCB, Inverse current characteristics, Symbols, Single line diagram (SLD) of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and electrical safety practices.

**UNIT-II (12 Hours)**

**Residential and Commercial Electrical Systems:** Types of residential and commercial wiring systems, General rules and guidelines for installation, Load calculation and sizing of wire, Rating of main switch, distribution board and protection devices, Earthing system calculations, Requirements of commercial installation, Deciding lighting scheme and number of lamps, Earthing of commercial installation, Selection and sizing of components.

**Illumination Systems:** Understanding various terms regarding Light, Lumen, Intensity, Candle power, Lamp efficiency, Specific consumption, Glare, Space to height ratio, Waste light factor, Depreciation factor, various Illumination schemes, Incandescent lamps and modern luminaries like CFL, LED and their operation, Energy saving in illumination systems, Design of a lighting scheme for a residential and commercial premises, Flood lighting.

**UNIT-III (11 Hours)**

**Industrial Electrical Systems – I:** HT connection, Industrial substation, Transformer selection, Industrial loads, Motors, Starting of motors, SLD, Cable and Switchgear selection, Lightning protection, Earthing design, Power factor correction;kVAR calculations, type of Compensation, Introduction to PCC, MCC panels, Specifications of LT Breakers, MCB and other LT panel components.

**UNIT-IV (11 Hours)**

**Industrial Electrical Systems – II:** DG systems, UPS system, Electrical systems for the elevators, Battery banks, Sizing the DG, UPS and battery banks, Selection of UPS and batterybanks.

**Industrial Electrical System Automation:** Study of basic PLC, Role in automation, Advantages of process automation, PLC based control system design, Panel metering and introduction to SCADA system for distribution automation.

**Recommended Text Books / Reference Books:**

1. S. L. Uppal and G. C. Garg, " Electrical Wiring, Estimating &Costing", Khanna publishers,2008.
2. K. B. Raina, "Electrical Design, Estimating & Costing", New age International, 2007.
3. S. Singh and R. D. Singh, "Electrical estimating and costing", Dhanpat Rai and Co., 1997.
4. Web site for ISStandards.
5. H. Joshi, " Residential Commercial and Industrial Systems", McGraw Hill Education, 2008.

## NON-LINEAR & DIGITAL CONTROL SYSTEMS

| Subject Code: | L | T | P | C | Duration: 45 (Hrs.) |
|---|---|---|---|---|---|
| BELED1-612 | 3 | 0 | 0 | 3 | |

**Course Objectives:**

1. To introduce to discrete system analysis.
2. To introduce to stability aspects of discrete time systems.
3. To introduce to design of digital control and discrete output feedback control.

**Course Outcomes:**

Students can:

1. Represent discreteLTIsystems.
2. Analyse stability of open loop and closed loop discrete-timesystems.
3. Design and analyse digitalcontrollers.
4. Design state feedback and output feedback controllers.

**UNIT-I (10 Hours)**

**Discrete Representation of Continuous Systems:**

Basics of digital control systems, Discrete representation of continuous systems, Sample and hold circuit, Mathematical Modeling of sample and hold circuit, Sampling and Quantization, Choice of sampling frequency, ZOHequivalent.

**UNIT-II (12 Hours)**

**Discrete System Analysis:**

Z-Transform and Inverse Z Transform for analyzing discrete time systems, Pulse Transfer function, Pulse transfer function of closed loop systems, Mapping from S-plane to Z plane,

Solution of Discrete time systems, Time response of discrete time system.

**Stability of Discrete Time System:**
Stability analysis by Jury test. Stability analysis using bilinear transformation. Design of digital control system with dead beat response. Practical issues with dead-beat response design.

**UNIT-III (12 Hours)**

**State Space Approach for Discrete Time Systems:**

State space models of discrete systems, State space analysis, Lyapunov Stability, Controllability, Reach-ability, Reconstructibility and observability analysis, Effect of pole zero cancellation on the controllability &observability.

**Design of Digital Control System:**

Design of Discrete PID Controller, Design of discrete state feedback controller, Design of set point tracker, Design of discrete observer for LTI System, Design of discrete compensator.

**UNIT-IV (11 Hours)**

**Discrete Output Feedback Control:**

Design of discrete output feedback control, Fast output sampling (FOS) and periodic output feedback controller design for discrete time systems.

**Introduction to Optimal Control and Non-linear Control:**

Performance indices, Regulator problem, Tracking problem, Nonlinear system, Basic concepts and analysis.

**Recommended Text Books / Reference Books:**

1. K.Ogata,"DigitalControlEngineering",PrenticeHall,EnglewoodCliffs,1995.
2. K.Ogata,"ModernControlEngineering",PrenticeHall,1991.
3. M.Gopal,"DigitalControlEngineering", WileyEastern,1988.
4. B.C.Kuo,"DigitalControlSystem",Holt,RinehartandWinston,1980.
5. B. C. Kuo, " Automatic Control System",Prentice Hall, 1995.
6. I. J. Nagrath and M. Gopal, " Control Systems Engineering", New Age International, 2009
7. G. F. Franklin, J. D. Powell and M. L. Workman, " Digital Control of Dynamic Systems", Addison-Wesley,1998.

## COMPUTER ARCHITECTURE

| Subject Code: | L | T | P | C | Duration: 45 (Hrs.) |
|---|---|---|---|---|---|
| BELED1-613 | 3 | 0 | 0 | 3 | |

**Course Objectives:**

1. To develop the concept of computer architecture and its operation.
2. To understand the concepts of microprocessors, their principles andpractices.
3. To know about memory organisation.

**Course Outcomes:**

1. Organize a modern computer system and be able to relate it to realexamples.
2. Write efficient programs in assembly language of the 8086 family ofmicroprocessors.
3. Develop the programs in assembly language for 80286, 80386 and MIPS processors in real and protectedmodes.

### UNIT-I (11 Hours)

**Introduction to Computer Organization:**

Architecture and function of general computer system, CISC Vs RISC, Data types, Integer Arithmetic, Multiplication, Division, Fixed and Floating point representation and arithmetic, Control unit operation, Hardware implementation of CPU with Micro instruction, microprogramming, System buses, Multi-bus organization.

### UNIT-II (12 Hours)

**Memory Organization:** System memory, Cache memory, Types and organization, Virtual memory and its implementation, Memory management unit, Magnetic hard disks, Optical disks.

**Input – output Organization:** Accessing I/O devices, Direct memory access (DMA) and its controller, Interrupts and interrupt controllers, Arbitration, Multilevel bus architecture, Interface circuits, Parallel and serial port, Features of PCI and PCI express bus.

### UNIT-III (11 Hours)

**16 and 32 Microprocessors:** 80x86 Architecture, IA – 32 and IA – 64, Programming model, Concurrent operation of EU and BIU, Real mode addressing, Segmentation, Addressing modes of 80x86, Instruction set of 80x86, I/O addressing in80x86

### UNIT-IV (11 Hours)

**Pipelining:**Introduction to pipelining, Instruction level pipelining (ILP), Compiler techniques for ILP, Data hazards, Dynamic scheduling, Dependability, Branch cost, Branch prediction, Influence on instruction set.

**Different Architectures:**

VLIW Architecture, DSP Architecture, SoC architecture, MIPS Processor andprogramming.

**Recommended Text Books / Reference Books:**

1. V. Carl, G. Zvonko and S. G. Zaky, **"**Computer organization**"**, McGraw Hill,1978.

2. B. Brey and C. R. Sarma, "The Intel microprocessors", Pearson Education,2000.
3. J. L. Hennessy and D. A. Patterson, "Computer Architecture A Quantitative Approach", Morgan Kauffman,2011.
4. W. Stallings, "Computer organization", PHI,1987.
5. N. Mathivanan, "Microprocessors, PC Hardware and Interfacing", Prentice Hall,2004.
6. Y. C. Lieu and G. A. Gibson, "Microcomputer Systems: The 8086/8088 Family", Prentice Hall India,1986.
7. J. Uffenbeck, "The 8086/8088 Design, Programming, Interfacing", Prentice Hall,1987.
8. B. Govindarajalu, "IBM PC and Clones", Tata McGraw Hill,1991.
9. P. Able, "8086 Assembly Language Programming", Prentice HallIndia.

## COMPUTATIONAL ELECTROMAGNETICS

| Subject Code: | L | T | P | C | Duration: 45 (Hrs.) |
|---|---|---|---|---|---|
| BELED1-614 | 3 | 0 | 0 | 3 | |

**Course Objectives:**

1. To introduce to the basic concepts ofelectromagnetics and analytical methods.
2. To understand computational techniques for computingfields.

**Course Outcomes:**

1. Explain the basic concepts ofelectromagnetics.
2. Use computational techniques for electromagneticfields.
3. Apply the techniques to simple real-lifeproblems.

### UNIT-I (15 Hours)

**Introduction:**

Conventional design methodology, Computer aided design aspects, Advantages, Review of basic fundamentals of Electrostatics and Electromagnetics, Development of Helmhotz equation, Energy transformer vectors, Poynting and Slepian, Magnetic diffusion-transients and time-harmonics.

**Analytical Methods:**

Analytical methods of solving field equations, method of separation of variables, Roth's method, Integral methods, Green's function, Method of images.

### UNIT-II (15 Hours)

**Finite Difference Method (FDM):**

Finite difference schemes, Treatment of irregular boundaries, Accuracy and stability of FD solutions, Finite-difference time-domain (FDTD) method, Uniqueness and convergence.

**Finite Element Method (FEM):**

Overview of FEM, Variational and Galerkin Methods, shape functions, lower and higher order elements, vector elements, 2D and 3D finite elements, efficient finite element computations.

### UNIT-III (15 Hours)

**Special Topics:**

Background of experimental methods, Electrolytic tank, R-C network solution, Field plotting (graphical method), Hybrid methods, Coupled circuit, Field computations, Electromagnetic - thermal and electromagnetic - structural coupled computations, Solution of equations, Method of moments, Poisson's fields.

**Applications:**

Low frequency electrical devices, Static/ time-harmonic / transient problems in transformers, Rotating machines, Actuators, CAD packages.

**Text/Reference Books**

1. P. P. Silvester and R. L. Ferrari " Finite Element for Electrical Engineers" , Cambridge University press, 1996.
2. M. N. O. Sadiku, " Numerical Techniques in Electromagnetics", CRC press,2001.

| WIND & SOLAR ENERGY SYSTEMS | | | | | |
|---|---|---|---|---|---|
| **Subject Code:** | **L** | **T** | **P** | **C** | **Duration: 45 (Hrs.)** |
| **BELED1-621** | **3** | **0** | **0** | **3** | |

**Course Objectives:**

1. To understand the energy scenario and the consequent growth of the power generation from renewable energysources.
2. To develop the understanding about the issues related to the grid-integration of solar and wind energysystems.

**Course Outcomes:**

Students will be enabled:

1. To explain the basics of wind power powergeneration.
2. To elaborate the basics of solar power powergeneration.
3. To intrepret the network integration issuesand the power electronic interfaces for wind and solargeneration.

**UNIT-I (15 Hours)**

**Physics of Wind Power:**History of wind power, Indian and Global statistics, Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Wind speed statistics-probability distributions, Wind speed and power-cumulative distributionfunctions.

**Wind Generator Topologies:** Review of modern wind turbine technologies, Fixed and variable speed wind turbines, Induction generators, Doubly-Fed induction generators and their characteristics, Permanent- magnet synchronous generators, Power electronics converters, Generator-converter configurations, Converter control.

**UNIT-II (15 Hours)**

**The Solar Resource:**Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.

**Solar Photovoltaic:**
Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar Systems, Maximum Power Point Tracking (MPPT) algorithms, Converter Control.

**UNIT-III (15 Hours)**

**Network Integration Issues:**

Overview of grid code technical requirements, Fault ride-through for wind farms, Real and reactive power regulation, Voltage and frequency operating limits, Solar PV and wind farm behavior during grid disturbances, Power quality issues, Power system interconnection experiences in the world, Hybrid and isolated operations of solar PV and wind systems.

**Solar Thermal Power Generation:**

Technologies, Parabolic trough, Central receivers, Parabolic dish, Fresnel, Solar pond, Elementary analysis.

**Text / References:**

1. T.Ackermann,"WindPowerinPowerSystems",JohnWileyand SonsLtd.,2005.
2. G. M. Masters, "Renewable and Efficient Electric Power Systems**",** John Wiley and Sons,2004.
3. S.P.Sukhatme,"SolarEnergy:Principlesof ThermalCollectionandStorage",McGrawHill,1984.
4. H. Siegfried and R. Waddington, " Grid integration of wind energy conversion systems" John Wiley and Sons Ltd.,2006.
5. G.N.TiwariandM.K.Ghosal,"RenewableEnergyApplications",Narosa Publications,2004.
6. J. A. Duffie and W. A. Beckman, " Solar Engineering of Thermal Processes", John Wiley & Sons, 1991.

| HVDC TRANSMISSION SYSTEMS | | | | | |
|---|---|---|---|---|---|
| **Subject Code:** | **L** | **T** | **P** | **C** | **Duration: 45 (Hrs.)** |
| **BELED1-622** | **3** | **0** | **0** | **3** | |

**Course Objectives:**

1. To know about the components and typesof HVDC systems.
2. To know the role of power electronic converters in HVDC transmission.
3. To know about the use of HVDC transmission systems for power system stability.

**Course Outcomes:**

Students will be able:

1. To knowthe advantages of DC transmission over ACtransmission.
2. To explain the operation of Line Commutated Converters and Voltage Source converters.
3. To apply control strategies used forHVDC transmissionsystem.
4. Toimprovepower system stability usingHVDCsystem.

**UNIT-I (12 Hours)**

**DC Transmission Technology:**Comparison of AC and DC transmission;Economics, Technical performance and Reliability, Application of DC transmission, Types of HVDC systems, Components of a HVDC system, Line commutated converter, Voltage source converter basedsystems.

**Analysis of Line Commutated Converters:**Line commutated converters (LCCs), Six pulse converter, Analysis neglecting commutation overlap, Harmonics, Twelve pulse converters, Inverter operation, Effect of commutation overlap, Expressions for average DC voltage, AC current and reactive power absorbed by the converters, Effect of commutation failure, Misfire and current extinction in LCClinks.

**UNIT-II (12 Hours)**

**Voltage Source Converters (VSCs);**

Two and Three-level VSCs, PWM schemes; Selective harmonic elimination, Sinusoidal pulse width modulation, Analysis of six pulse converter, Equations in the rotating frame, Real and reactive power control using a VSC.

**Control of HVDC Converters:**

Principles of Link Control in a LCC HVDC system, Control hierarchy, Firing Angle Controls, Phase-Locked Loop, Current and extinction angle control, Starting and stopping of a link, Higher level controllers; Power control, Frequency control, Stability controllers, Reactive power control, Principles of link control in a VSC HVDC system, Power flow and DC voltage control, Reactive power control/AC voltageregulation.

**UNIT-III (10 Hours)**

**Components of HVDC Systems:**Smoothing reactors, Reactive power sources and Filters in LCC HVDC systems DC line: Corona Effects, Insulators, Transient over-voltages, DC line faults in LCC systems, DC line faults in VSC systems, DC breakers, Mono-polar operation, Ground electrodes.

**UNIT-IV (11 Hours)**

**Stability Enhancement using HVDC Control:** Basic Concepts: Power system angular, voltage and frequency stability, Power modulation, basic principles, Synchronous and asynchronous links, Voltage stability problem in AC/DCsystems.

**MTDC Links:** Multi-Terminal and Multi-Infeed systems, Series and parallel MTDC systems using LCCs, MTDC systems using VSCs, Modern trends in HVDC technology, Introduction to modular multi-level converters.

**Recommended Text Books / Reference Books:**

1. K. R. Padiyar, " HVDC Power Transmission Systems", New Age International Publishers,2011.
2. J. Arrillaga, "High Voltage Direct Current Transmission", Peter Peregrinus Ltd., 1983.
3. E. W. Kimbark, " Direct Current Transmission", Vol.1, Wiley-Interscience,1971.

## EHVAC TRANSMISSION SYSTEMS

| Subject Code: | L | T | P | C | Duration: 45 (Hrs.) |
|---|---|---|---|---|---|
| BELED1-623 | 3 | 0 | 0 | 3 | |

**Course Objectives:**

1. To familiarize the students with the need and advantages associated with EHVAC Transmission.
2. To acquaint the students with the reactive parameters of lines and methods of voltage control.
3. To make them aware about voltage gradients of conductors and effects ofcorona.

**Course Outcomes:**

Students will be enabled:

1. To explain the advantages of EHVAC Transmission and problems associated withit.
2. To examinethe reactive parameters of lines and use methods of voltagecontrol.
3. To compute the voltage gradients of conductors and explain the associated bad effects of corona.

**UNIT-I (11 Hours)**

**Preliminaries:**

Necessity of extra high voltage (EHVAC)transmission, Advantages and Problems, Power handling capacity and Line losses, Mechanical considerations, Resistance of conductors, Properties of bundled conductors, Bundle spacing and bundle radius, Examples.

**Line and Ground Reactive Parameters:**

Line inductance and capacitance, Sequence inductances and capacitances, Modes of propagation, Ground return, Examples.

**UNIT-II (12 Hours)**

**Travelling Wave Theory:**

Traveling wave expression and solution, Source of excitation, Terminal conditions, Open circuited and Short-circuited end reflection and refraction coefficients, Lumped parameters of distributed lines, Generalized constants, No load voltage conditions and Charging current.

**Voltage Control:**

Power circle diagram and its use, Voltage control using synchronous condensers, Cascade connection of shunt and series compensation, Sub synchronous resonance in series capacitor, Compensated lines, Static VAR compensating system.

**UNIT – III (11 Hours)**

**Voltage Gradients of Conductors:**

Electrostatics, field of sphere gap, field of line charges and properties, Charge, Potential relations for multi-conductors, Surface voltage gradient on conductors, Distribution of voltage gradient on sub conductors of bundle, Electrostatic field, Calculation of electrostatic field of EHV/AC lines, Effect on humans, animals and plants, Electrostatic induction in un-energized circuit of double-circuit line, Electromagnetic interference, No load voltage conditions and chargingcurrent.

**UNIT-IV (11 Hours)**

**Corona Effects:**

Power loss and audible noise (AN), Corona loss formulae, Charge voltage diagram, Generation, Characteristics, Limits and Measurements of AN, Relation between 1- phase and 3-phase AN levels, Radio interference (RI), Corona pulses: generation, properties, limits, frequency spectrum, Modes of propagation, Excitation function, measurement of RI, RIV and Excitation functions.

**Recommended Text Books / Reference Books:**

1.R.D. Begamudre, 'EHVAC Transmission Engineering', New Academic Science, 4th Edn.,**2011**.

2.S. Rao, 'EHVAC and HVDC Transmission and Distribution Engineering', 3rd Edn., Khanna Publishers,**2008**.

| FACTS DEVICES IN TRANSMISSION & DISTRIBUTION NETWORKS | | | | | |
|---|---|---|---|---|---|
| **Subject Code:** | **L** | **T** | **P** | **C** | **Duration: 45 (Hrs.)** |
| **BELED1-624** | **3** | **0** | **0** | **3** | |

**Course Objectives:**

1. To know about the need of shunt and series reactive power compensation.
2. To become familiar with the working principles of FACTS devices, theiroperating characteristics, and applications.
3. To understand the basic concepts of powerquality.

**Course Outcomes:**

1. To analyze the characteristics of AC transmission.
2. To explain the effect of shunt and series reactive power compensation.
3. To apply FACTS devices to control power flow and toimprove power quality.

**UNIT-I (11 Hours)**

**Transmission Lines and Series/Shunt Reactive Power Compensation:**

Basics of AC transmission, Analysis of uncompensated AC transmission lines, Passive reactive power compensation, Shunt and series compensation at the mid-point of an AC line, Comparison of series and shuntcompensation.

**Thyristor-based Flexible AC Transmission Controllers (FACTS):**

Description and characteristics of Thyristor-based FACTS devices, Static VAR compensator (SVC), Thyristor controlled series capacitor (TCSC), Thyristor controlled braking resistor and Single pole single throw (SPST) switch, Configurations/Modes of operation, Harmonics and control of SVC and TCSC, Fault current limiter.

**UNIT-II (11 Hours)**

**Voltage Source Converter based (FACTS) Controllers:**

Voltage source converters (VSC), Six pulse VSC, Multi-pulse and Multi-level converters, Pulse-width modulation for VSCs, Selective harmonic elimination, Sinusoidal PWM and Space vector modulation, STATCOM: Principle of operation, Reactive power control: Type I and Type II controllers, Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC): Principle of Operation and Control, Working principle of Interphase power flow controller. Other Devices: GTO controlled series compensator, Fault currentlimiter.

**UNIT-III (12 Hours)**

**Application of FACTS:** Application of FACTS devices for power-flow control and stability improvement, Simulation example of power swing damping in a single-machine infinite bus system using a TCSC, Simulation example of voltage regulation of transmission mid-point voltage using a STATCOM.

**Power Quality Problems in Distribution Systems:**

Power Quality problems in distribution systems: Transient and Steady state variations in voltage and frequency. Unbalance, Sags, Swells, Interruptions, Wave-form Distortions: harmonics, noise, notching, dc-offsets, fluctuations, Flicker and its measurement, Tolerance of Equipment, CBEMAcurve.

**UNIT-IV (11 Hours)**

**DSTATCOM (Distribution Static Compensator):**

Reactive Power Compensation, Mitigation of harmonics and unbalance in distribution systems using DSTATCOM and shunt active filters, Synchronous reference frame, Extraction of reference currents, Current control techniques for DSTATCOM.

**Dynamic Voltage Restorer and Unified Power Quality Conditioner:**

Voltage sag and swell mitigation: Dynamic Voltage Restorer; Working principle and control strategies, Series active filtering, Unified power quality conditioner (UPQC): Working principle, capabilities and control strategies.

**Recommended Text Books / Reference Books:**

1. N. G. Hingorani and L. Gyugyi, " Understanding FACTS: Concepts and Technology of FACTS Systems", Wiley-IEEE Press,1999.
2. K. R. Padiyar, " FACTS Controllers in Power Transmission and Distribution", New Age International (P) Ltd. 2007.
3. T. J. E. Miller, "Reactive Power Control in Electric Systems", John Wiley and Sons, New York,1983.
4. R.C.Dugan,"ElectricalPowerSystemsQuality",McGrawHillEducation,2012.
5. G. T. Heydt, "Electric Power Quality" , Stars in a Circle Publications,1991

## INTRODUCTION TO INDUSTRIAL MANAGEMENT

**Subject Code: BELES1-606** **L T P C** **Duration: 45 Hrs**
**3 0 0 3**

**Course Objectives**

**The aim of this course is:**

1. To introduce the concepts of Industrial Management
2. To provide knowledge about various Costs and Inventory Management
3. To highlight the latest trend in Industrial Management

**Course Outcome**

**After completing this course, the students will be able to:**

1. Understand the theories and principles of modern management
2. Apply the concepts to the management of organizations in private and public sector
3. Plot and analyze inventory control models and techniques.
4. Understand JIT, MRP and Six Sigma

**UNIT-I (10 Hrs.)**

**Concepts of Industrial Management:** Introduction: Concept and scope of Industrial Management. Productivity: Definition, measurement, productivity index, types of production system, Industrial Ownership. Functions of Management, Evolution of Management Thought : Taylor's Scientific Management, Fayol's,Principles of Management, Douglas Mc-Gregor's Theory X and Theory Y, Mayo's Hawthorne, Experiments, Hertzberg's Two Factor Theory of Motivation, Maslow's Hierarchy of Human Needs

**Introduction to Human resources management**: Nature of HRM, functions and importance of HRM.

**UNIT-II (10 Hrs.)**

**Designing Organizational Structures:** Concept, Importance and characteristics of organization, Types of organization - Project, matrix and informal organization. Span of control, Delegation of authority.

**Work Study:** Introduction, Definition, Objectives, Steps in Work Study, Method Study: Definition, Objectives, Steps of Method Study,

**Work Measurement:**Purpose, Types of study:Stop Watch Methods-Steps, allowances, Standard Time Calculations, Work Sampling, Production Planning and Control

**UNIT-III (11 Hrs.)**

**Cost Analysis:** Cost classification: Prime cost, Overhead cost, Selling and Distribution Cost, Fixed cost, Variable cost, Implicit cost, Explicit cost, Replacement cost, Opportunity cost, Marginal cost

**Inventory Control**: Inventory, Cost, Models of inventory control: EOQ, ABC, VED

**UNIT-IV (14 Hrs.)**

**Quality Control:**Statistical Quality Control, Control charts for variables and attributes, Acceptance Sampling- Single sampling- Double sampling plans,

**Recent Trends in Industrial Management**–Material Requirement Planning (MRP), Enterprise Resource Planning (ERP), Just in Time (JIT), Six Sigma-Concept and benefits.

**Recommended Books**

1. O.P Khanna, Industrial Engineering.
2. M.S. Saiyada, 'Minappa and Personnel Managements'.Tata Mc Graw Hill
3. C.B. Mamoria, 'Personnel Management', Himalaya Publications
4. Ravi Shankar, 'Industrial Engineering', Galgotia