



**RAMAIAH**  
Institute of Technology

# **CURRICULUM**

**Academic year 2022 – 2023**

## **ELECTRICAL AND ELECTRONICS ENGINEERING**

**V & VI SEMESTER B.E.**

**RAMAIAH INSTITUTE OF TECHNOLOGY**  
(Autonomous Institute, Affiliated to VTU)  
Bangalore – 560054.

## **About the Institute:**

Dr. M. S. Ramaiah a philanthropist, founded 'Gokula Education Foundation' in 1962 with an objective of serving the society. M S Ramaiah Institute of Technology (MSRIT) was established under the aegis of this foundation in the same year, creating a landmark in technical education in India. MSRIT offers 17 UG programs and 15 PG programs. All these programs are approved by AICTE. All eligible UG and PG programs are accredited by National Board of Accreditation (NBA). The institute is accredited with 'A+' **grade by NAAC in March 2021** for 5 years. University Grants Commission (UGC) & Visvesvaraya Technological University (VTU) have conferred Autonomous Status to MSRIT for both UG and PG Programs since 2007. The institute is also been conferred autonomous status for Ph.D program since 2021. The institute is a participant to the Technical Education Quality Improvement Program (TEQIP), an initiative of the Government of India. The institute has 380 competent faculty out of which 65% are doctorates. Some of the distinguished features of MSRIT are: State of the art laboratories, individual computing facility for all faculty members, all research departments active with sponsored funded projects and more than 300 scholars pursuing Ph.D. To promote research culture, the institute has established Centre of Excellence for Imaging Technologies, Centre for Advanced Materials Technology, Centre for Antennas and Radio Frequency systems (CARFS), Center for Cyber Physical Systems, Schneider Centre of Excellence & Centre for Bio and Energy Materials Innovation. **M S Ramaiah Institute of Technology has obtained "Scimago Institutions Rankings" All India Rank 107 & world ranking 600 for the year 2022.**

The Entrepreneurship Development Cell (EDC) and Section 8 company "Ramaiah Evolute" have been set up on campus to incubate startups. **M S Ramaiah Institute of Technology is recognized by Atal Ranking of Institutions on Innovation Achievements (ARIIA), MoE, Govt. of India.** MSRIT has a strong Placement and Training department with a committed team, a good Mentoring/Proctorial system, a fully equipped Sports department, large air-conditioned library with good collection of book volumes and subscription to International and National Journals. The Digital Library subscribes to online e-journals from Elsevier Science Direct, IEEE, Taylor & Francis, Springer Link, etc. MSRIT is a member of DELNET, CMTI and VTU E-Library Consortium. MSRIT has a modern auditorium and several hi-tech conference halls with video conferencing facilities. The institute has excellent hostel facilities for boys and girls. MSRIT Alumni have distinguished themselves by occupying high positions in India and abroad and are in touch with the institute through an active Alumni Association.

**As per the National Institutional Ranking Framework (NIRF), MoE, Government of India, M S Ramaiah Institute of Technology has achieved 67<sup>th</sup> rank among 1249 top Engineering Institutions & 17<sup>th</sup> Rank for School of Architecture in India for the year 2022 and is 1<sup>st</sup> amongst the Engineering Colleges affiliated to VTU, Karnataka.**

### **About the Department:**

The department was started in the year 1962 along with the establishment of the Institute. In 2003, the Department has been recognized as a Research Centre by Visvesvaraya Technological University, Belagavi and offers Ph.D and MS(by Research) programs. PG program in Computer Applications in Industrial Drives has been started in the year 2004. UG programme has been accredited by NBA since 2001. The department has 18 well-qualified faculty members. The entire faculty holds postgraduate degree specialized in diversified areas of Electrical Engineering like Power Systems, Power Electronics, Control Systems, Electrical Machines, etc. 13 of the faculty members are doctorates from various esteemed institutions like University of Ontario Institute of Technology (UOIT), Ontario, Canada, IISc, Bangalore, IIT-Dhanbad, NITK, Surathkal, Vellore Institute of Technology, Vellore, Visvesvaraya Technological University, Belagavi, Pondicherry University, Pondicherry and Jain University, Bengaluru. In addition, the department is actively involved in research, testing and consultancy in the area of high voltage applications under the able guidance of Dr. G. R. Nagabhushana, Formerly Chairman, Dept. of High Voltage Engineering, Indian Institute of Science, Bangalore, and is presently with the department as Professor Emeritus. Also, Sri. K V Jayaram, Retired JM-DGM, Bokaro Steel Plant /SAIL is with the department for all the activities related to Home and Building Automation lab. The main focus of the department is to impart quality technical education to students in UG, PG and Ph.D levels based on OBE. Many technical activities are in place to enhance both technical and communication skills for students and staff.

## **VISION OF THE INSTITUTE**

To be an Institution of International Eminence, renowned for imparting quality technical education, cutting edge research and innovation to meet global socio-economic needs.

## **MISSION OF THE INSTITUTE**

MSRIT shall meet the global socio-economic needs through

- Imparting quality technical education by nurturing a conducive learning environment through continuous improvement and customization.
- Establishing research clusters in emerging areas in collaboration with globally reputed organizations.
- Establishing innovative skills development, techno-entrepreneurial activities and consultancy for socio-economic needs.

## **QUALITY POLICY**

We at MS Ramaiah Institute of Technology strive to deliver comprehensive, continually enhanced, global quality technical and management education through an established Quality Management System complemented by the synergistic interaction of the stake holders concerned

## **VISION OF THE DEPARTMENT**

To excel in engineering education and research, inculcating professional ethics in students and emerge as leaders globally in the field of electrical & electronics engineering.

## **MISSION OF THE DEPARTMENT**

The mission of the department is to produce graduates who will

1. Be able to apply their knowledge to identify and solve problems arising in any industry.
2. Be able to contribute to research and developmental activities in frontier areas.
3. Master innovative skills to be entrepreneurs and/or consultants.

## **PROGRAM EDUCATIONAL OBJECTIVES (PEOs):**

**PEO 1:** Produce graduates who will have the ability to apply the knowledge of basic Sciences engineering sciences and electrical engineering to excel in professional career.

**PEO 2:** Produce graduates who will continue to enhance their knowledge.

**PEO 3:** Produce graduates who are confident to take up diverse career paths.

**PEO 4:** Produce graduates who will provide leadership and demonstrate the importance of professional integrity.

## **PROGRAM OUTCOMES (POs):**

**PO1: Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

**PO2: Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

**PO3: Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

**PO4: Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

**PO5: Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

**PO6: The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

**PO7: Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

**PO8: Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

**PO9: Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

**PO10: Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

**PO11: Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

**PO12: Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

## **PROGRAM SPECIFIC OUTCOMES (PSOs):**

- PSO1:** Identify, formulate, analyze, design and implement—electrical and electronics circuits, control systems, drives, power systems and power electronic systems.
- PSO2:** Use modern tools to solve problems in diverse and multidisciplinary environment.
- PSO3:** Understand the impact of engineering solutions in societal and environmental context, commit to professional ethics, lifelong learning and communicate effectively.
- PSO4:** Apply project management techniques to electrical/electronic(s) systems, exhibiting team work.

## Semester wise Credit Breakdown for B.E Degree Curriculum

**Batch 2020-24**

Semester Course Category	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Total Credits
<b>Basic Sciences (BSC)</b>	9	8	4	4					<b>25</b>
<b>Engineering Sciences (ESC)</b>	11	10							<b>21</b>
<b>Humanities, Social Sciences and Management (HSMC)</b>		2			3		3		<b>8</b>
<b>Professional Courses – Core (PCC)</b>			21	21	15	11	10		<b>78</b>
<b>Professional Courses– Elective (PEC)</b>					3	6	6	3	<b>18</b>
<b>Other Open Elective Courses (OEC)</b>					3	3			<b>6</b>
<b>Project Work (PROJ), Internship (IN)</b>						4	1	14	<b>19</b>
<b>Total Credits</b>	<b>20</b>	<b>20</b>	<b>25</b>	<b>25</b>	<b>24</b>	<b>24</b>	<b>20</b>	<b>17</b>	<b>175</b>



**SCHEME OF TEACHING**  
**V SEMESTER**

Sl. No.	Course Code	Course Name	Category	Credits				Contact Hours
				L	T	P	Total	
1	EE51	Signals and Systems	PCC	3	1	0	4	5
2	EE52	Control Systems	PCC	3	1	0	4	5
3	EE53	Power System Engineering- I	PCC	4	0	0	4	4
4	EE54	Intellectual Property Rights	HSMC	3	0	0	3	3
5	EEExxx	Department Elective – 1	Elective	3	0	0	3	3
6	xxOExx	Open Elective-1	Elective	3	0	0	3	3
7	EEL56	Electrical Machines – II Lab	Lab	0	0	1	1	2
8	EEL57	Power Electronics Lab	Lab	0	0	1	1	2
9	EEL58	Electronic Devices & Circuits Lab	Lab	0	0	1	1	2
<b>Total</b>				<b>19</b>	<b>2</b>	<b>3</b>	<b>24</b>	<b>29</b>

Elective Code	Department Elective-1
EEE551	Introduction to Deep Learning
EEE552	Solar and Wind Energy Systems
EEE553	Advanced Industrial Automation
EEE554	Digital System Design using Verilog HDL

## SCHEME OF TEACHING

### VI SEMESTER

Sl. No.	Course Code	Course Name	Category	Credits				Contact Hours
				L	T	P	Total	
1	EE61	Digital Signal Processing	PCC	3	1	0	4	5
2	EE62	Power System Engineering- II	PCC	3	1	0	4	5
3	EEExxx	Department Elective – 2	Elective	3	0	0	3	3
4	EEExxx	Department Elective – 3	Elective	3	0	0	3	3
5	xxOEExx	Open Elective-2	Elective	3	0	0	3	3
6	EE65	Mini project/ NPTEL / Department Elective	Lab	0	0	4	4	4
7	EEL66	Digital Signal Processing Lab	Lab	0	0	1	1	2
8	EEL67	Building Automation Lab	Lab	0	0	1	1	2
9	EEL68	Control Systems Lab	Lab	0	0	1	1	2
<b>Total</b>				<b>15</b>	<b>2</b>	<b>7</b>	<b>24</b>	<b>29</b>

Elective Code	Elective Title	Elective Code	Elective Title
EEE631	Modern Control Theory	EEE641	Nanofabrication and Characteristics
EEE632	Energy Audit	EEE642	Machine Learning
EEE633	Electric Vehicle Technology	EEE643	Virtual Instrumentation

## V SEMESTER

### SIGNALS AND SYSTEMS

**Subject code:** EE51

**Credits:** 3:1:0

**Prerequisites:** Nil

**Contact Hours:** 70

**Course Coordinator/s:** Dr. R Subha/Sri. Victor George

#### Course content

##### Unit I

**Introduction:** Definitions of signals and a system, Classification of signals, Basic operations on signals, Elementary signals viewed as interconnections of operations. Relation between the elementary signals, specific systems, Properties of systems

##### Unit II

**Time – domain representations for LTI systems:** Convolution Integral and Convolution sum, Impulse response representation, Properties of impulse response representation, step response.

##### Unit III

Block diagram representation, direct form I and direct form II. Differential and difference equation representation, Solution of differential and difference equation. Sampling theorem, quantization.

##### Unit IV

Concept of Fourier Series and Fourier transform. Fourier representation of discrete-time periodic signals, Properties of discrete time Fourier series (DTFS)

**The Discrete-Time Fourier Transform:** Representations of non-periodic signals: The discrete-time Fourier transform (DTFT), Properties of DTFT.

##### Unit V

**Z- Transforms:** Introduction, Z-transform, Properties of ROC, Properties of Z transforms, inversion of Z-transforms, Transforms analysis of LTI systems, Transfer function, Stability and causality, Unilateral Z-transform and its application to solve difference equations.

## **Text Books**

1. Simon Haykin, Barry Van Veen, *Signals and Systems*, John Wiley & Sons, 2001. Reprint 2002.
2. Alan V Oppenheim, Alan S. Willsky, S. Hamid Nawab, *Signals and Systems*, Pearson Education Asia, 2nd edition, 1997.

## **Reference Books**

1. Michel J Roberts, *Signals and Systems Analysis of signals through linear systems*, Tata McGraw Hill, 2003.

## **Course Outcomes (COs)**

At the end of the course the student will be able to

1. Perform various operations on elementary signals used in systems and identify its properties. (PO-1) (PSO-1)
2. Represent Linear Time Invariant (LTI) system through different techniques. (PO-1) (PSO-1)
3. Analyze the relation between the input and output of an LTI system through its impulse response. (PO-1) (PSO-1)
4. Determine the various responses of an LTI system using different techniques. (PO-1) (PSO-1)
5. Apply various properties of transform techniques in the analysis of signals and systems. (PO-1) (PSO-1)

# CONTROL SYSTEMS

Subject code: EE52

Credits: 3:1:0

Prerequisites: Nil

Contact Hours: 70

Course Coordinator/s: Dr. B V Sumangala/Dr. S. Dawnee

## Course content

### Unit I

**Modelling of Systems:** The control system, mathematical models of physical systems- introduction, differential equations of physical systems, Mechanical systems, Friction, Translational systems, Rotational systems, Electrical systems, Analogous systems.

**(Numerical only on finding transfer function, No numerical on analogous systems)**

**Block diagram and signal flow graph:** To find overall transfer function. **(No numerical)**

### Unit II

**Time response analysis: Standard** test signal, unit step response of first and second order system, time response specifications, time response specifications of second order systems, steady state errors and error constants.

**Stability Analysis:** Concepts of stability, necessary conditions for stability, Routh-Hurwitz criterion, relative stability. **(Numerical only with max. 2-Poles, 2-Zeros)**

### Unit III

**Root Locus Technique:** Introduction, Root locus concepts, construction of root loci. **(Numerical only with max. 2-Poles, 2-Zeros)**

**Frequency Domain Analysis:** Frequency Domain Specifications, Correlation between time and frequency responses, Polar plot.

### Unit IV

**Stability in Frequency Domain:** Nyquist stability criterion. **(Numerical only with max. 2-Poles, 2-Zeros)**, Bode plot **(Numerical only with max. 2-Poles, 2-Zeros)**, Determination of transfer function from Bode plot, Compensators- RC lag, RC lead, RC lag-lead networks.

### Unit V

**Controllers:** Introduction to Controllers, Necessity of Controllers, Block diagram representation of of feedforward and feedback controller, Effects of Addition of Poles and zeros in plant transfer function **(With respect to stability)**, Introduction to PID

Control: Effect of Proportional, Integral, and Differential controller on time domain behavior of the system, Introduction to Zeigler-Nichols Method for designing PID controller (No Numerical).

### **Text Books**

1. J. Nagrath and M. Gopal, '*Control Systems Engineering*', New Age International (P) Ltd, 4<sup>th</sup> Edition.

### **Reference Books**

1. K. Ogata, '*Modern Control Engineering*', Pearson Education Asia / PHI, 4<sup>th</sup> Edition.
2. Benjamin Kuo, '*Automatic Control Systems*', PHI, 7<sup>th</sup> Edition.
3. MATLAB Documentation on SIMIAM Package.

### **Course Outcomes (COs):**

At the end of the course the student will be able to:

1. Derive the transfer function and mathematical model of variety of mechanical, electromechanical systems. (PO- 1, 2)(PSO-1)
2. Find the time domain specifications and time response of the system for various inputs. (PO- 1, 2)(PSO-1, 2)
3. Analyze the stability of the system using graphical and algebraic techniques. (PO- 1, 2)(PSO-1)
4. Find the frequency domain specifications and identify the need of compensation. (PO- 1, 2)(PSO-1)
5. Understand the need of PID control in mobile robotics. (PO- 1, 4)(PSO-1, 2)

# POWER SYSTEM ENGINEERING - I

**Subject Code:** EE53

**Credits:** 4:0:0

**Prerequisites:** Nil

**Contact Hours:** 56

**Course Coordinator/s:** Dr. Neelamsetti Kiran Kumar / Sri. Victor George

## Course content

### Unit I

**Introduction to Electrical Power Transmission and Distribution:** Standard Voltages for transmission, a typical transmission and distribution system, feeders, distributors, and service mains, classification of power transmission systems, advantages of high voltages for transmission, classification of distribution systems, connection schemes - radial, ring main, requirements and design considerations for distribution system.

**AC Distribution:** AC distribution calculations -concentrated loads with power factor referred to receiving end voltage and power factor referred to respective load voltages, numerical problems.

**Sag Calculations:** Main components of overhead lines, Sag and tension for overhead lines with equal and unequal supports, **(no derivations, only concepts and problems).**

### Unit II

**Transmission Line Parameters:** Transmission line constants, resistance of transmission line and skin effect. Inductance of transmission line, magnetic field intensity inside and outside the conductor, inductance of single phase two wire line, inductance of three phase lines with equilateral and unsymmetrical spacing and transposition, Capacitance of transmission lines, electric field of a long straight conductor, capacitance of single phase system, capacitance of three phase symmetrically spaced and un-symmetrically spaced conductors, effect of earth on the capacitance of transmission lines. **(No derivation, concepts and problems only)**

**Insulators:** Properties of materials used for insulators, types of insulators, voltage distribution over a string of insulators, calculation of string efficiency, methods of improving string efficiency - expression for line to pin capacitor with static shielding, numerical problems. Introduction to composite insulators.

### Unit III

**Performance of power transmission lines:** Classification of Transmission Lines, ABCD constants for short, medium and long transmission lines, Ferranti effect.

**Underground cables:** Advantages of underground cables over overhead lines, cable

construction, Insulation resistance of single core sheathed cable, capacitance of single core cable, dielectric stress in single core cable, most economical size of a cable, grading of cables - capacitance grading and inter sheath grading, capacitance of 3 core cable, numerical problems (**only concepts and problems, no derivation**).

**Representation of Power System Components:** Introduction, circuit models of power system components, one - line diagram, Impedance and reactance diagrams, per-unit system, change in base quantities, per-unit impedance and reactance diagrams.

#### Unit IV

**Symmetrical Components:** Resolution of unbalanced phasors, the ‘a’ operator, expression for phase voltage in terms of symmetrical components, expression for symmetrical components in terms of phase voltages relation between sequence components of phase and line voltages in star of equivalent star connected systems, relation between sequence components of phase and line currents in delta connected systems, symmetrical components in star-delta, transformer banks.

**Sequence Impedances and Sequence Networks:** Introduction, sequence impedances of a symmetrical circuit, sequence networks of power systems elements, sequences impedances and network of three-phase transformers, sequence impedance and networks of transmission lines, construction of sequence networks of a power system.

#### Unit V

**Symmetrical and Unsymmetrical Faults:** Introduction, analysis of three -phase symmetrical faults, fault calculations of a synchronous generator, single line-to-ground fault on an unloaded generator, line-to-line fault on an unloaded generator, double line-to-ground fault on an unloaded generator. Unsymmetrical Faults on Power System, single line-to-ground fault, line-to line fault, double line-to-ground fault, single line-to-ground fault on an unloaded generator through a fault impedance, series types of faults

#### Text Books

1. J.B Gupta, ‘*Transmission and Distribution of Electrical Power*’, Katson Books, 10<sup>th</sup> Edition.
2. W.D.Stevenson Jr., ‘*Elements of Power System Analysis*’, McGraw Hill, 4<sup>th</sup> Edition.
3. C.L.Wadhwa, ‘*Electrical Power Systems*’, Wiley Eastern Ltd., 3<sup>rd</sup> Edition.



## Reference Books

1. Soni, Gupta & Bhatnagar, '*A course in Electrical Power*', Dhanapat and Sons, 2001.
2. S.M.Singh, '*Electric Power Generation, Transmission and Distribution*', Prentice Hall of India Private Ltd., 2003.

## Course Outcomes (COs):

At the end of the course, the student will be able to:

1. Identify different components of transmission and distribution systems and calculate sag in over-head transmission lines. (PO-1) (PSO-1)
2. Compute the parameters of the transmission line and evaluate performance of the line. (PO-1) (PSO-1)
3. Determine voltage drop in AC distributors. (PO-1) (PSO-1)
4. Select the configurations of line insulators / underground cables and evaluate their performance. (PO-1) (PSO-1)
5. Analyze symmetrical faults by representing components of power system on per unit basis. (PO-1) (PSO-1)
6. Construct sequence networks to determine short-circuit currents and phase voltages for unbalanced faults. (PO-1) (PSO-1)

# INTELLECTUAL PROPERTY RIGHTS

**Subject Code: EE54**

**Credits: 3:0:0**

**Prerequisites: Nil**

**Contact Hours: 42**

**Course Coordinator/s: Sri. Vinayak V Rao**

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## Course content

### Unit I

Basic concepts of Intellectual property [IP] law, Introduction, concept of property, need for a holistic approach, constitutional aspects of IP, evolution of the patent system in UK, US and India, basis for protection, invention, criteria for patentability, Nature of IP, Commercial exploitation of IP, Enforcement of rights and remedies against infringement, Intellectual property and economic development, International character of IP, New acts affecting IP, Importance and need of world intellectual property organizations [WIPO], Trade related intellectual property rights [TRIPS].

### Unit II

Patent: Principles underlying patent law in India, object of patent law, value of patent system, advantages of patent to inventor, Patentable inventions, non-patentable inventions.

Procedure for obtaining the patent, Specification, Provisional and complete specification, construction and amendment of specification, Opposition proceedings to grant patents, register of patents and patent office.

Rights and obligations of a patentee, transfer of patent rights, government use of inventions, revocation and surrender of patents, infringements of patents, action for infringement, drafting of patent, Case studies.

Trade secrets: Introduction, Factors, Trade secrets v/s Patents

### Unit III

Copyrights: Nature, characteristics, subject matter of copyright, term, author, ownership, rights conferred by copyright, registration, regulatory authorities, assignment/licensees, infringement, remedies, International copyright, Case studies.

### Unit IV

Trademarks: Meaning, function, essentials of trademarks, Principles of registration, rights conferred by registration, Infringement and action against infringement, Case studies.

Industrial design: registration, procedure, piracy and remedies of industrial designs, Case studies.

Geographical indicators: Meaning, registration, rights, infringements, remedies, Case studies. Discussion on defence and obscure publication about IPR.

### Unit V

**Cyber Law:** Need and role of law in the cyber world, concept of property in cyberspace, protection, infringement and remedies for the copyrights in cyberspace, Implications on intellectual property rights, relevance of domain names in intellectual property rights, software copyrights, Information technology act 2000-significance, objectives and offenses, case studies

#### Text Books

1. P.Narayanan, “*Intellectual Property Law*”, Eastern Law house, 3<sup>rd</sup> edition, 2018.
2. Dr.B.L.Wadehra, “*Intellectual Property Law Handbook*”, Universal Law Publishing Co. Ltd., 5<sup>th</sup> edition , 2012.
3. Pawan Duggal “*Textbook on Cyber Law*”, Universal law publishing house, 2<sup>nd</sup> edition.
4. Harish Chander, “*Cyber Laws and IT Protection*”, PHI publication, 4<sup>th</sup> edition, 2012.

#### Reference Books

1. Dr. T Ramakrishna, “*Ownership and Enforcement of Intellectual Property Rights*”, CIPRA, NSLIU -2005.
2. “*Intellectual Property Law (Bare Act with short comments)*”, Universal Law Publishing Co. Ltd.. 2007.
3. “*The Trade marks Act 1999 (Bare Act with short comments)*”, Universal Law Publishing Co. Ltd., 2005.
4. “*The Patents Act, 1970 (Bare Act with short comments), as amended by Patents (Amendment) Rules 2006 w.e.f. 5-5-2006*”. Commercial law publishers (India) Pvt. Ltd., 2006.
5. Thomas T Gordon and Arthur S Cookfair, “*Patent Fundamentals for Scientist and Engineers*”, CRC Press 1995.
6. Prabuddha Ganguli, “*Intellectual Property Rights*”, TMH Publishing Co. Ltd, 2001

### **Course Outcomes (COs):**

At the end of the course the student will be able to:

1. Access the need, criteria and legal aspects of IPR. (PO-1, 6, 8)(PSO-3)
2. Understand registration, opposition and amendments procedures in the IPR domain. (PO-1, 6, 8)(PSO-3)
3. Apply the drafting concepts for any product of electrical domain. (PO-1, 6, 8)(PSO-3)
4. Gain awareness on different infringements scenarios, remedial action and latest case studies in the IPR domain. (PO-1, 6, 8, 10)(PSO-3)
5. Familiarize with cyber law in IPR domain (PO-1, 6, 8)(PSO-3)

## ELECTRICAL MACHINES – II LAB

**Subject Code: EEL56**

**Credit: 0: 0: 1**

**Prerequisites: Nil**

**Contact Hours: 28**

**Course Coordinator/s: Dr. Chandrashekhara Badachi/ Dr. Nagaraj. C**

### List of Experiments:

1. Open circuit and short circuit tests on a single phase transformer.
2. Load test on single phase transformer direct loading
3. Scott connection of two single phase transformers.
4. Load characteristics of a single phase induction motor.
5. Sumpner's test or back to back test on a pair of single phase transformers.
6. Equivalent circuit & Circle diagram of three phase induction motor.
7. Parallel operation and load sharing of single phase transformers.
8. Load test on three phase induction motor.
9. Separation of iron losses of 1 phase transformer
10. Speed control of induction motor
11. Experiment on induction generator.
12. Three phase transformer connections

### Text Books

1. A Langsdorf, '*Theory of alternating current machines*', TMH, 2<sup>nd</sup> Edition.
2. M. G. Say, '*performance and design of AC machines*', CBS Publications, 2005.

### Reference Books

1. J. Nagarath and Kothari, '*Electrical Machines*', TMH, 2<sup>nd</sup> Edition.
2. Ashafaq Hussaim, '*Electric Machines*', Dhanpat Rai & Co., 1999.

### Course Outcomes (COs)

At the end of the course the students will be able to:

1. Predetermine the % efficiency, regulation of single phase transformer. (PO1, 4) (PSO-1)
2. Determine the performance of single phase and three phase induction motor. (PO1,4) (PSO-1)
3. Determine the performance of three phase induction machine (PO1,4) (PSO-1)

## POWER ELECTRONICS LAB

**Subject code: EEL57**

**Credits: 0:0:1**

**Prerequisites: Nil**

**Contact Hours: 28**

**Course Coordinator/s: Smt. Mamatha G M**

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### List of experiments:

1. Static characteristics of Power MOSFET
2. Static characteristics of IGBT
3. Static characteristics of SCR
4. Static characteristics of TRIAC
5. RC half-wave and full-wave triggering circuit for a thyristor
6. Single phase fully controlled rectifier (R, RL Load, RL Load with FWD)
7. AC voltage controller using Triac-Diac combination
8. SCR firing circuit using synchronized UJT relaxation circuit
9. Commutation circuits for thyristor-LC circuit and Impulse commutation circuit
10. Digital firing circuit for thyristor, TRIAC
11. Voltage impulse commutated chopper
12. Study of the working of series inverter

### Text Books

1. M. H. Rashid, "*Power Electronics: Circuits, Devices and Applications*", Third Edition, PHI, 2005.
2. Vedam Subrahmanyam, "*Power Electronics*", Revised Second Edition, New Age International Publishers, 2006.

### Reference Books

1. G. K. Dubey, S. R. Doradla, A. Joshi and R. M. K. Sinha, "*Thyristorised Power Controller*", New Age International Publishers.
2. M. D. Singh and Khanchandhani K.B, "*Power Electronics*", TMH, 2001.

### Course Outcomes (COs):

At the end of the course the student will be able to:

1. Gain knowledge about the working of power electronic switches like MOSFET, IGBT, SCR and Triac. (PO 4, 5) (PSO 1, 2)
2. Design, build and test firing circuits for thyristors. (PO 3, 4) (PSO 1, 2)
3. Design, build and test commutation circuits for thyristors. (PO 3, 4) (PSO 1, 2)
4. Design, build and test power electronic circuits. (PO 4, 5) (PSO 1, 2)

## **ELECTRONIC DEVICES AND CIRCUITS LAB**

**Subject Code: EEL58**

**Credits: 0:0:1**

**Prerequisites: Nil**

**Contact Hours: 28**

**Course Coordinator/s: Sri. Ramakrishna Murthy K / Sri. Victor George**

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### **List of Experiments:**

1. Design and implementation of Clippers and clampers using i) Diodes ii) Op-Amp
2. Design and implementation of full wave rectifier using i) Diodes ii) Op-Amp and also to demonstrate the concept of regulated output using voltage regulator
3. Design and implementation of RC phase shift oscillator using i) FET/BJT ii) Op-amp
4. Design of BJT emitter follower, Darlington emitter follower (with & without bootstrap) and determination of the gain, input & output impedance. Implementation of Voltage follower and its comparison with emitter follower
5. Design, build and test RC coupled single stage FET/BJT amplifier and determination of the frequency response, input & output impedances
6. Design and implementation of inverting amplifier, non - inverting amplifier and inverting summing amplifier using Op-amp
7. Design and implementation of the following Active filters
  - i. First order low pass filter
  - ii. Second order low pass filter
8. Design and implementation of the following Active filters
  - i. First order high pass filter
  - ii. Second order high pass filter
9. Design and implementation of zero crossing detector, inverting and non-inverting voltage level detector using Op-Amp
10. Design and implementation of
  - i. Differentiator and Integrator using op-Amp
  - ii. Monostable and Astable Multivibrator using 555 timer
11. Design and simulation of Amplifier circuits and clippers.
12. Design and simulation of clampers and oscillators

## Text Books

1. Robert L Boylestad & Louis Nashelsky, “*Electronic Devices & Circuit Theory*”, 6th Edition, PHI, 2002.
2. David A Bell, “*Operational amplifiers and Linear IC’s*”, Prentice Hall, 2<sup>nd</sup> Edition.
3. Ramakant A Gayakwad, “*Op-Amps and Linear Integrated Circuits*”, Prentice Hall, 4<sup>th</sup> Edition.
4. Robert F Coughlin, Frederick F Driscoll, “*Operational Amplifiers and Linear Integrated Circuits*”, Prentice Hall, 6<sup>th</sup> Edition.

## Reference Books

1. Jacob Millman & Christos C Halkias, “*Integrated Electronics*”, Tata McGraw-Hill, 1991.
2. Albert Malvino & David J Bates, “*Electronic Principles*”, 7th Edition, TMH, 2007.
3. Sergio Franco, “*Design with Operational Amplifiers and Analog Integrated Circuits*”, TMC, 2008.
4. Roy Choudhary, “*Linear Integrated Circuits*”, New Age International, 2003.
5. J. Nagarath, “*Electronic Devices & Circuits*”, PHI, 2007.
6. Sudhaker Samuel, “*Electronic Circuits*”, 2nd Edition, Tata McGraw Hill, 2010.

## Course Outcomes (COs):

At the end of the course the student will be able to:

1. Design the biasing circuits for establishing the Q point of a transistor amplifier. (PO-1, 4) (PSO-1)
2. Design, Simulate (using PSpice), build and test clipper, clamper, rectifiers, voltage regulator, oscillators and RC coupled amplifier. (PO-1, 4) (PSO-1)
3. Design and analyze the performance of various linear circuits and non-linear circuits using Op-Amp. (PO-1, 4) (PSO-1)
4. Evaluate the performance of different active filters using Op-Amps. (PO-1, 4) (PSO-1)
5. Design and analyze the performance different multivibrators using 555 timer. (PO-1, 4) (PSO-1)



# DIGITAL SIGNAL PROCESSING

**Subject code:** EE61

**Credits:** 3:1:0

**Prerequisites:** Nil

**Contact Hours:** 70

**Course Coordinator/s:** Sri. Victor George/Smt. Kusumika Krori Dutta

## Course content

### Unit I

Basic elements of digital signal processing, Advantages of digital signal processing over analog signal processing.

**Discrete Fourier Transform:** Frequency domain sampling, DFT as a linear transformation, circular convolution, Use of DFT in linear filtering.

### Unit II

**Filtering of Long Data Sequence:** Overlap-save method, Overlap-add method.

**Fast Fourier Transform Algorithms:** Radix-2 FFT Algorithm, Decimation in time, Decimation in frequency algorithms.

### Unit III

**Structure for FIR systems:** Direct form, Linear phase and cascade form structure.

**Structure of IIR systems:** Direct form I, Direct form II, Cascade and parallel structure.

### Unit IV

**Design of FIR Filters:** Introduction to filters, Design of linear phase FIR Filters using rectangular, hamming and hanning windows, FIR filter design by frequency sampling method.

### Unit V

**Design of IIR Filters from Analog Filters:** IIR Filter design by impulse invariance, Bilinear transformation. Characteristics of analog filters -Butterworth and Chebyshev, frequency transformation in analog domain. Introduction to the TMS320LF2407 digital signal controller, C2xx DSP CPU architecture (block diagram level explanation).

## **Text Books**

1. John G Prokis & Dimitris G Manolakis, '*Digital Signal Processing*', PHI, 3<sup>rd</sup> Ed.,
2. Hamid Toliyat and Steven Campbell, '*DSP- Based Electro Mechanical Motion Control*', CRC Press, 2011.

## **Course Outcomes (COs)**

At the end of the course the student will be able to:

1. Identify different engineering problems where digital signal processing is involved (PO-1)(PSO-1)
2. Analyze the various techniques to obtain the transformation of discrete signals (PO-1)(PSO-1)
3. Apply various transform techniques in linear filtering (PO-1)(PSO-1)
4. Apply fundamental principles, methodologies and techniques of the digital signal processing to design various filter circuits (PO-1)(PSO-1)
5. Understand the basic functional blocks available in a digital signal processor (PO-1)(PSO-1)

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## POWER SYSTEM ENGINEERING- II

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**Subject code:** EE62

**Credits:** 3:1:0

**Prerequisites:** Nil

**Contact Hours:** 70

**Course Coordinator/s:** Dr. Sridhar. S/ Dr. Neelamsetti Kiran Kumar

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### Course content

#### Unit I

Modeling of transmission lines, off nominal transformer, loads and generator. Formation of  $Y_{BUS}$  by method of inspection. Basic definitions of Elementary graph theory. Formation of Incidence Matrices. Primitive network- Impedance form and admittance form. Formation of  $Y_{BUS}$  by method of singular transformation.  $Z_{BUS}$  formation by inverting  $Y_{BUS}$  and  $Z_{BUS}$  building Algorithm (Without mutual coupling). Computation of 3phase fault current using  $Z_{BUS}$  (derivation excluded).

#### Unit II

**Load Flow Studies:** Introduction, review of numerical solutions of algebraic equations by iterative methods, power flow equations, and classification of buses, operating constraints and data for load flow study. Load flow solution using Gauss–Seidal method, (numerical problem for not more than 2 iteration), acceleration of convergence. Load flow solution using Newton–Raphson method in polar co-ordinates (numerical problem for 1 iteration only). Fast Decoupled load flow method.

#### Unit III

**Economic Operation of Power System:** Introduction, economic generation scheduling neglecting losses and, iterative techniques. Derivation of transmission loss formula. Economic dispatch including transmission losses. Approximate penalty factor. Iterative technique for solution of economic dispatch with losses. Introduction to unit commitment (problem formulation).

#### Unit IV

**Stability Studies:** Introduction, steady state stability, power angle equation of synchronous machines, methods of improving SSSL, dynamics of a synchronous machine, Swing equations, Swing curve, Equal Area Criterion(EAC), applications of Equal Area Criterion, critical clearing angle. Transient stability, Numerical solution of swing equation by Point-by-Point method and Runge–Kutta method.

## Unit V

**Load Frequency Control:** Schematic diagram of automatic load frequency control and automatic voltage control. Generator model, turbine model and governor model. Block diagram representation of single area ALFC.

**Compensation in Power Systems:** Introduction, load compensation, line compensation, series compensation and shunt compensators. Principle and operation of converters. Introduction to FACTS Controllers.

**Power System Security:** Introduction, Factors affecting power system security, Contingency Analysis, Contingency Selection and Ranking.

### Text books

1. Nagrath, I. J., and Kothari, D. P., '*Modern Power System Analysis*', TMH, 2003.
2. K.Uma Rao, '*Computer Techniques and Models in Power Systems*', I.K. International, 2007.

### Reference books

1. Allen J Wood et al, '*Power Generation, Operation and Control*', Wiley, 2003.
2. Stag G. W., and El Abiad, A. H. '*Computer Methods in Power System Analysis*', McGraw Hill International Student Edition, 1968.
3. Pai, M.A, '*Computer Techniques in Power System Analysis*', TMH, 2<sup>nd</sup> Edition.
4. John Grainger, Jr., William Stevenson, '*Power System Analysis*', McGraw Hill, 1994.
5. Singh L. P., '*Advanced Power System Analysis and Dynamics*', New Age International (P) Ltd, New Delhi, 2001.
6. Haadi Sadat, '*Power System Analysis*', TMH, 2<sup>nd</sup> Edition, 12<sup>th</sup> Reprint.

### Course Outcomes (COs):

At the end of the course the student will be able to:

1. Formulate the  $Y_{BUS}$  and  $Z_{BUS}$ . (PO-1) (PSO-1)
2. Obtain load flow solution by Gauss Siedel method, Newton Raphson Method and FDLF Method. (PO-1) (PSO-1)
3. Obtain economic load dispatch of a thermal power plant. (PO-1) (PSO-1)
4. Analyze the stability aspects of power system. (PO-1) (PSO-1)
5. Develop the block diagram of ALFC, evaluate load sharing. (PO-1) (PSO-1)

## MINI PROJECT

**Subject Code: EE65**

**Credits: 0:0:4**

**Prerequisites: Nil**

**Contact Hours: 84**

**Course Coordinator/s: Dr. Hemachandra Gudimindla**

### Course content

This course will provide an introduction to mini-project. Students will work in a group of 3/4 to solve a problem of current concern requiring an engineering solution. They are required to follow a systematic approach towards developing the solution by considering technical and non-technical factors. The working model of the solution along with the design documentation will be considered for final evaluation.

### Course Outcomes (COs):

At the end of the course Students will be able to:

1. Perform sufficient literature survey on existing methods in the area of selected topic. (POs – 1, 2, 3, 4, PSO– 1)
2. Describe the proposed design method in terms of technical block diagram or flowchart. (POs – 2, 3, 10, PSO– 2, 3)
3. Implement the proposed design method using appropriate software or/and hardware tools (POs – 2, 3, 4, 5, PSO– 2, 3).
4. Analyze the complexity at various stages of building project involving multiple hardware or/and software technologies. (POs – 2, 3, 4, 5, PSO– 2, 3)
5. Present and prepare technical details of the project at regular intervals using oral, written and visual aids for effective communication. (POs – 9, 10, PSO– 2, 3)

## DIGITAL SIGNAL PROCESSING LAB

**Subject Code: EEL66**

**Credit: 0: 0: 1**

**Prerequisites: Nil**

**Contact Hours: 28**

**Course Coordinator/s: Sri. Victor George/Smt. Kusumika Krori Dutta**

### LIST OF EXPERIMENTS

1. Verification of sampling theorem.
2. Frequency domain analysis using FFT.
3. Convolution of given sequence.
4. Analysis of an audio file.
5. Pulse Width Modulation.
6. Noise reduction of signals.
7. DTMF generation and filtering.
8. Design of LP & HP FIR filter to meet given specifications.
9. Design of BP & BS FIR filter to meet given specifications.
10. Hardware implementation of FIR filter to meet given specifications.
11. Design of IIR filter to meet given specifications.
12. Hardware implementation of IIR filter to meet given specifications.

### Text Books

1. J. G. Proakis, Ingle, “*Digital Signal Processing using MATLAB*”, MGH, 2000.
2. B. Venkataramani and Bhaskar, “*Digital Signal Processors*”, TMH, 2002.

### Reference Books

1. Sanjit K Mitra, “*Digital Signal Processing using MATLAB*”, TMH, 2001.

### Course Outcomes (COs):

At the end of this course students will be able to

1. Understand the basic operations in digital signal processing. (PO – 1, 2, 6) (PSO-1, 2)
2. Understand the use of the FFT algorithm in signal analysis. (PO – 2, 6) (PSO-1, 2)
3. Design FIR/IIR filters for practical applications. (PO – 2, 3, 4, 6) (PSO-1, 2)
4. Understand the handling of digital signals using a simulation package. (PO – 1, 2, 6) (PSO-1, 2)
5. Understand the handling of digital signals using hardware circuits. (PO – 2, 6) (PSO-1, 2)

## BUILDING AUTOMATION LAB

**Subject code: EEL67**

**Credits: 0:0:1**

**Prerequisites: Nil**

**Contact Hours: 28**

**Course Coordinator/s: Smt. Mamatha G M/ Dr. Hemachandra Gudimindla**

### List of experiments:

1. Installing and Testing KNX Bus Line, Create a project and add devices to the project.
2. Develop an application to program a switch and a switch actuator.
3. Develop an application to program a switch, a dimming control and a blind actuator.
4. Develop an application to configure touch Pro to control blind actuator, switch actuator, and dimming
5. Develop an application for Lighting control using the occupancy sensor  
Using 4 gang, create the following
  - a. Rocker – 1: operate dimming at 0% - 50% - 100%
  - b. Rocker – 2 : operate "All On" and "All Off"
6. Develop a mobile wiser application to control the given installation.
7. To operate and control HVAC using PID controller and BMS controller
8. To configure the field instruments in the BMS-“Ecostuxure Building Expert”
9. Configuration of DI and DO modules
  - a. Switching on Heating, when humidity is high
  - b. Open Damper when CO<sub>2</sub> level is high
  - c. Switch off AHU, when fire is activated
10. Configuration of AI and AO modules
  - a. Configure a pressure sensor & pressure transmitter
  - b. Configure a temperature sensor & temperature transmitter
11. Creating Graphics of the given HVAC system and Binding of variables to Graphical representation
12. Create logic for the AHU operation
  - a. Using Humidity inputs
  - b. Using CO<sub>2</sub> level
  - c. Input from Fire alarm System
  - d. Using flow switch

### Course Outcomes (COs):

At the end of the course the student will be able to:

1. Develop a program to control loads of a smart home. (PO1,3)(PSO2,3)
2. Develop a program to control HVAC system. (PO1,3)(PSO2,3)

## **CONTROL SYSTEMS LAB**

**Subject Code: EEL68**

**Credits: 0:0:1**

**Prerequisites: Nil**

**Contact Hours: 28**

**Course Coordinator/s: Dr. S. Dawnee**

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### **List of Experiment**

1. Obtain Time response of second order system (RLC circuit) and find time domain specifications of the same. And simulate the same using MATLAB.
2. Obtain frequency response of second order system (RLC circuit) and find time domain specifications of the same. And simulate the same using MATLAB.
3. Design and implementation of RC lead compensator. And verify the results using MATLAB.
4. Design and implementation of RC lag compensator. And verify the results using MATLAB.
5. Implementation of RC Lag-Lead compensator.
6. Experiment to draw speed torque characteristics of a AC servo motor.
7. Experiment to draw speed torque characteristics of a DC servo motor.
8. Simulate DC position control System for PI, PD and PID Controller.
9. To draw root loci for different transfer functions using MATLAB and verification by theoretical method, Obtain phase margin, gain margin for different transfer function by drawing Bode plot using MATLAB and verification by theoretical method
10. Introduction to SISO toolbox and analyzing of step, frequency responses for different pole, zero locations.
11. Introduction to SIMIAM package for Mobile robotics.
  - i) Implementation of PID Control for GoToGoal application.
  - ii) Implementation of PID Control for obstacle avoidance application.

### **Text Books**

1. J. Nagrath and M. Gopal, 'Control Systems Engineering', 4<sup>th</sup> edition

### **Reference Books**

1. K. Ogata, 'Modern Control engineering', 4<sup>th</sup> edition.
2. Benjamin Kuo, 'Automatic Control Systems', PHI, 7<sup>th</sup> Edition.



### **Course Outcomes (COs):**

At the end of the course Students are able to:

1. Analyze time domain response for different damping ratio. (PO-1,2,5)  
(PSO-1,2,4)
2. Analyze the stability of the system by various methods. (PO-1,2,5)(PSO-1,2,4)
3. Analyze the behavior of mobile robots for different PID co-efficients.  
(PO-1,2,5)(PSO-1,2,4)
4. Distinguish the performance of Servo motors. (PO-1,2)(PSO-1)
5. Design the appropriate compensator. (PO-1,3,5)(PSO-1,2,4)

## Department Elective- 1

### **INTRODUCTION TO DEEP LEARNING**

**Subject Code: EEE551**

**Credits: 2:1:0**

**Prerequisites: Nil**

**Contact Hours: 56**

**Course Coordinator/s: Smt. Kusumika Krori Dutta**

#### **Course content**

##### **Unit I**

Introduction: Human brain, neuron models, neural nets as directed graphs, feedback, neural architectures, knowledge representation, connection to artificial intelligence.

##### **Unit II**

Learning Process: Error-correction learning, memory based learning, Hebbian learning, competitive learning, Boltzmann learning, credit assignment, learning with and without a teacher, learning tasks, memory, statistical learning theory.

##### **Unit III**

Modern practical deep neural networks: Deep feed forward networks, regularization for deep learning, optimization for training deep models, convolutional Networks.

##### **Unit IV**

Sequence Modelling: Recurrent and recursive nets, practical Methodology, applications.

##### **Unit V**

Deep Learning Research: Linear factor models, auto encoders, variation auto encoders, restricted Boltzmann machine, generative adversarial networks.

#### **Text Books**

1. Simon Haykin, '*Neural networks: A comprehensive foundation*', Second Edition, Prentice Hall, New Delhi, 1999, ISBN-81-203-2373-4.
2. Ian Goodfellow, Yoshua Bengio and Aaron Courville, '*Deep Learning*', MIT Press, 2016.

### **Course Outcomes (COs):**

At the end of the course, the student will be able to:

1. Understand the concepts of neural networks and deep learning. (PO1,2) (PSO-1)
2. Analyze various types of learning and their usage. (PO-1,2) (PSO-1)
3. Apply deep feedforward networks and convolutional to solve practical problems. (PO-2,5)(PSO-2)
4. Demonstrate recurrent and recursive nets function and implementation in practical problems solving. (PO-2,5)(PSO-2)
5. Design end-to-end deep learning architectures for practical applications. (PO-2,3,5) (PSO-1, 2)

# SOLAR AND WIND ENERGY SYSTEMS

**Subject code: EEE552**

**Credits: 3:0:0**

**Prerequisites: Nil**

**Contact Hours: 42**

**Course Coordinator: Dr. Sridhar. S/ Dr. Hemachandra Gudimindla**

## Course content

### Unit I

**Fundamentals of Energy Science and Technology:** Introduction, Energy, Economy and Social Development, Classification of Energy Sources, Importance of Non - conventional Energy Sources, Salient features of Non-conventional Energy Sources, World Energy Status, Energy Status in India.

**Energy Conservation and Efficiency:** Introduction, Important Terms and Definitions, Important Aspects of Energy Conservation, Global Efforts, Achievements and Future Planning, Energy Conservation/Efficiency Scenario in India, Energy Audit, Energy Conservation Opportunities.

**Energy Storage:** Introduction, Necessity of Energy Storage, Specifications of Energy Storage Devices.

**Solar Energy-Basic Concepts:** Introduction, The Sun as Source of Energy, The Earth, Sun, Earth Radiation Spectrum, Extraterrestrial and Terrestrial Radiations, Spectral Power Distribution of Solar Radiation, Depletion of Solar Radiation.

### Unit II

**Solar Energy-Basic Concepts (continued):** Measurement of Solar Radiation, Solar Radiation Data, Solar Time, Solar Radiation Geometry, Solar Day Length, Extraterrestrial Radiation on Horizontal Surface, Empirical Equations for Estimating Terrestrial Solar Radiation on Horizontal Surface, Solar Radiation on Inclined Plane Surface.

**Solar Thermal Systems:** Introduction, Solar Collectors, Solar Water Heater, Solar Passive Space Heating and Cooling Systems, Solar Industrial Heating Systems, Solar Refrigeration and Air Conditioning Systems, Solar Cookers

### Unit III

**Solar Photovoltaic Systems:** Introduction, Solar Cell Fundamentals, Solar Cell Characteristics, Solar Cell Classification, Solar Cell Technologies, Solar Cell, Module, and Array Construction, Maximizing the Solar PV Output and Load Matching, Maximum Power Point Tracker. Balance of System Components, Solar PV Systems, Solar PV Applications

## Unit IV

**Wind Energy:** Introduction, Basic Principles of Wind Energy Conversion, History of Wind Energy, Wind Energy Scenario – World and India. The Nature of the Wind, the Power in the Wind, Forces on the Blades, Wind Energy Conversion, Wind Data and Energy Estimation, Site Selection Considerations

**Wind energy systems:** Environment and Economics Environmental benefits and problems of wind energy, Economics of wind energy, Factors influence the cost of energy generation, machine parameters, Life cycle cost analysis

## Unit V

**Basic Components of a Wind Energy Conversion (WEC) System:** Classification of WEC systems, Advantages and Disadvantages of WECS, Types of Wind Machines (Wind Energy Collectors), Analysis of Aerodynamic Forces Acting on the Blade, Performance of Wind- machines, Generating Systems, Energy Storage, Applications of Wind Energy, Environmental Aspects.

### Text Books

1. G.D. Rai, '*Non-conventional Sources of Energy*', Khanna Publishers, 4<sup>th</sup> Edition
2. B.H. Khan, '*Non-conventional energy sources*', TMH, 2<sup>nd</sup> Edition

### Reference Books:

1. Shobh Nath Singh, '*Non-Conventional Energy Resources*', Pearson, 2015.
2. S.P. Sukhatme J.K. Nayak, '*Solar Energy – Principles of Thermal Collections and Storage*', McGraw Hill, 2008.
3. Ahmad Hemami, '*Wind Turbine Technology*', Cengage, 2012.

### Course Outcomes (COs):

At the end of the course the student will be able to:

1. Discuss the importance of the role of renewable energy, the concept of energy storage and the principles of energy storage devices.(PO-1)(PSO-1)
2. Discuss the concept of solar radiation data and solar PV system fabrication, operation of solar cell, sizing and design of PV system. (PO-1)(PSO-1)
3. Describe the process of harnessing solar energy and its applications in heating and cooling. (PO-1)(PSO-1)
4. Explain basic Principles of Wind Energy Conversion, collection of wind data, energy estimation and site selection. (PO-1)(PSO-1)
5. Discuss the performance of Wind-machines, energy storage, applications of Wind Energy and environmental aspects. (PO-1)(PSO-1)

# ADVANCED INDUSTRIAL AUTOMATION

**Subject Code: EEE553**

**Credits: 2:0:1**

**Prerequisites: Nil**

**Contact Hours: 56**

**Course Coordinator/s: Smt. Mamatha G M**

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## Course content

### Unit I

**Programmable Logic Controllers:** Introduction, Comparison with other types of controllers, Architecture, Processor scan, Memory, Brief coverage of various Digital, Analog and Special I/O modules, Factors to consider while selecting I/O modules.

**PLC Programming:** Brief of various languages, IEC-61131 standard

### Unit II

**Ladder Language Programming:** Ladder structure, basic ladder elements, enhanced ladder elements, Scan cycle, speeding up PLC scan time, Developing Ladder program for given specification.

**Functional Block Diagram (FBD) Programming:** Overview, commonly available functional blocks, creating function blocks, Developing FBD for given specification.

### Unit III

**PLC Installation:** Panel Layout, Heating, Wiring, Grounding, Ringing the I/O Wiring  
**Safety:** Failsafe wiring of STOP switch, Emergency stop, Safety interlocks

**Maintenance Practices:** Visual Inspection, Continuity Check, Input/Output Wiring Check, Operational Testing, Troubleshooting, Hardware Failures, Software Errors

**Designing Systems:** Program development, Commissioning, System Documentation, PLC and PLC components selection for an application

### Unit IV

**Introduction to Human Machine Interface (HMI):** Overview, Graphics and controls, HMI hierarchy design, displays and navigation, Trending: historical data collection and presentation of live data, Alarms: alarm information, event data, alarm logger, alarm summary display. Reports: alarm, events and historical process data reports.

### Unit V

**SCADA Systems:** Overview of concepts, definitions, applications and architecture. Remote terminal Units (RTU), Master terminal Units (MTU).

## **Text books**

1. L. A. Bryan & E. A. Bryan, '*Programmable Controllers Theory and Implementation*', Second Edition, published by an industrial text company, 1997
2. W Bolton, '*Programmable Logic Controllers*', Fourth Edition, Elsevier newnes, 2006

## **Course Outcomes (COs):**

At the end of the course the student will be able to:

1. Understand the purpose, functions, and operations of a PLC. (PO-1) (PSO-1)
2. Identify the basic components of the PLC and how they function. (PO-1,5) (PSO-1)
3. Create a PLC project using PLC software and configure the I/O for a PLC project. (PO-1,2,4,5) (PSO-1,3)
4. Design HMI layout. (PO-1,4)(PSO-1)
5. Develop the knowledge of SCADA system. (PO-1) (PSO-1)

# DIGITAL SYSTEM DESIGN USING VERILOG HDL

**Subject Code:** EEE553

**Credits:** 2:0:1

**Prerequisites:** Knowledge of Digital Electronics

**Contact Hours:** 56

**Course Coordinator/s:** Dr. Kodeeswara Kumaran. G

## Course content

### Unit I

**Introduction to VLSI Design:** Introduction, conventional approach to digital design, VLSI design flow.

**Introduction to Verilog HDL:** Verilog as HDL, levels of design description, concurrency, simulation and synthesis, functional verification, system tasks, programming language interface (PLI), module, simulation and synthesis tools, test benches.

**Verilog HDL constructs and conventions:** Introduction, keywords, identifiers, white space characters, comments, numbers, strings, logic values, strengths, data types, scalars and vectors, parameters, memory, operators, system tasks.

### Unit II

**Gate level modeling:** Introduction, AND gate primitive, module structure, other gate primitives, tri-state gates, array of instances of primitives, design of flip-flops with gate primitives, delays, strengths and contention resolution, net types.

**Modeling at data flow level:** Introduction, continuous assignment structures, delays and continuous assignments, assignment to vectors, operators.

### Unit III

**Behavioral modeling-I:** Introduction, operations and assignments, functional bifurcation, initial construct, always construct, assignments with delays, wait construct, multiple always blocks, designs at behavioral level, blocking and non-blocking assignments, the case statement, simulation flow.

### Unit IV

**Behavioral modeling-II:** *if* and *if-else* constructs, assign-design construct, repeat construct, for loop, the disable construct, while loop, forever loop, parallel blocks, force-release construct, events.

**Modeling state machines** (detailed coverage)

### Unit V

**Functions, Tasks, And User-Defined Primitives:** Introduction, functions, tasks, user-defined primitives.



**Logic Synthesis:** Basics of synthesis, Impact of Logic Synthesis, Verilog HDL synthesis, Synthesis design flow, modeling tips for logic synthesis.

### LIST OF EXPERIMENTS

FPGA Implementation with Intel FPGA (Max10) and Quartus Prime Design Software:

1. Switches and Multiplexers
2. Number conversion and Displays
3. Latches, Flip Flops and Registers
4. Counters
5. Timers and Real Time Clocks
6. Adders, Subtractors and Multipliers
7. Finite State Machines
8. Memory Blocks
9. Implementation of a simple processor
10. Implementation of an enhanced processor
11. Implementing algorithms in hardware
12. Signal processing in hardware using an audio codec

### Text books

1. T.R. Padmanabhan and B. Bala Tripura Sundari, “*Design through Verilog HDL*”, Wiley-IEEE Press, 2003.
2. Samir Palnitkar, “*Verilog HDL: A Guide to Digital Design and Synthesis*”, Pearson, 2<sup>nd</sup> edition, 2003.

### Reference Books:

1. J. Bhasker, “*A Verilog HDL Synthesis- A Practical Primer*”, Star Galaxy Publishing, 1st edition, 1998.
2. Michael D. Ciletti, “*Advanced Digital Design with Verilog HDL*”, PHI, 2005.
3. <https://software.intel.com/content/www/us/en/develop/topics/fpga-academic/materials-digital-logic.html>

### Course Outcomes (COs):

At the end of the course the student will be able to:

1. Explain the fundamental aspects of Verilog HDL and VLSI design. (PO-1) (PSO-1)
2. Write Verilog HDL code to describe combinational and sequential logic circuits (PO-1,2,3) (PSO-1)
3. Design finite state machines and implement in circuitry(PO-1,2,3,5) (PSO-1,2).
4. Write, compile, synthesize, and download hardware designs for FPGAs (PO-1,2,3,5,9,10,12) (PSO-1,2,3,4)

## Department Electives 2 & 3

### MODERN CONTROL THEORY

Subject code: EEE631

Credits: 2:1:0

Prerequisites: Control Systems

Contact Hours: 70

Course Coordinator/s: Dr. B V Sumangala/Dr. S. Dawnee

#### Course content

##### Unit 1

**State Variable Analysis and Design:** Introduction, Concept of State, State Variables and State Model, State Modeling of Linear systems, Linearization of state equation. State space representation using Physical variables, Phase variables and Canonical variables. Derivation of Transfer Function from State Model.

##### Unit 2

Diagonalization, Eigen values, Eigen Vectors, Generalized Eigen Vectors. Solution of State Equation, State Transition Matrix and its Properties. Computation of State transition matrix using Laplace Transformation, Power series Method, Cayley Hamilton Method,

##### Unit 3

Concept of Controllability and Observability, Methods of determining the same. Derivation of CCF, OCF, DCF, JCF form, transformation to CCF, transformation to OCF,

**Pole placement Techniques:** Stability improvement by state feedback, Determination of value of K using Ackermann formula, direct substitution method.

##### Unit 4

Necessary and sufficient conditions for arbitrary pole placement, State Regulator Design, Design of State Observer. Reduced order observer design, Dual systems, relation between K and Ke. Determination of value of Ke using Ackermann formula, direct substitution method.

**Nonlinear Systems:** Introduction, behavior of non-linear system, Common Physical non-linearity – saturation, friction, backlash, dead zone, relay, multi variable non-linearity.

## Unit 5

Phase plane method, singular points, stability of non-linear system, limit cycles, construction of phase trajectories.

**Liapunov stability Analysis:** Liapunov function, direct method of Liapunov and the linear system. Construction of Liapunov functions for non-linear system by Krasovskii's method.

### Text Books

1. M.Gopal, "*Digital Control and State Variable Methods: Conventional and Intelligent Control Systems*", Tata McGraw-Hill, 2007.
2. I.J.Nagrath, M. Gopal, "*Control Systems Engineering*", New Age International Publishers, 3<sup>rd</sup> Edition.

### Reference Books

1. Katsuhiko Ogata, "*Modern Control Engineering*", PHI, 3<sup>rd</sup> Edition.

### Course Outcomes (COs):

At the end of the course the student will be able to:

1. Determine the state model for electrical, mechanical and electromechanical systems. (PO-1, 2) (PSO-1)
2. Solve the state equations by different methods. (PO-1, 2) (PSO-1)
3. Analyze and predict the controllability and observability of the system. (PO-1, 2) (PSO-1)
4. Design the controller and observer for any given system. (PO-1, 2) (PSO-1)
5. Evaluate the stability of nonlinear systems. (PO-1, 2) (PSO-1)

# ENERGY AUDIT

**Subject code: EEE632**

**Credits: 3:0:0**

**Prerequisites: Nil**

**Contact Hours: 42**

**Course Coordinator: Dr. Sridhar. S**

## Course content

### Unit I

**Energy Scenarios:** Energy Conservation, Energy Audit, Energy Scenarios, Energy Consumption, Energy Security, Energy Strategy, Clean Development Mechanism.

**Types of Energy Audits and Energy-Audit Methodology:** Definition of Energy Audit, Place of Audit, Energy – Audit Methodology, Financial Analysis, Sensitivity Analysis, Project Financing Options, Energy Monitoring and Training.

### Unit II

**Survey Instrumentation:** Electrical Measurement, Thermal Measurement, Light Measurement, Speed Measurement, Data Logger and Data – Acquisition System, Thermal Basis.

**Energy Audit of Boilers:** Classification of Boilers, Parts of Boiler, Efficiency of a Boiler, Role of excess Air in Boiler Efficiency, Energy Saving Methods.

### Unit III

**Energy Audit of Furnaces:** Parts of a Furnace, classification of Furnaces, Energy saving Measures in Furnaces, Furnace Efficiency.

**Energy Audit of HVAC Systems:** Introduction to HVAC, Components of Air – Conditioning System, Types of Air – Conditioning Systems, Human Comfort Zone and Psychrometry, Vapour – Compression Refrigeration Cycle, Energy Use Indices, Impact of Refrigerants on Environment and Global Warming, Energy – Saving Measures in HVAC, Star Rating and Labelling by BEE.

### Unit VI

**Electrical-Load Management:** Electrical Basics, Electrical Load Management, Variable- Frequency Drives, Harmonics and its Effects, Electricity Tariff, Power Factor, Transmission and Distribution Losses.

**Energy Audit of Motors:** Classification of Motors, Parameters related to Motors, Efficiency of a Motor, Energy Conservation in Motors, BEE Star Rating and Labelling.

## Unit V

**Energy Audit of Lighting Systems:** Fundamentals of Lighting, Different Lighting Systems, Ballasts, Fixtures (Luminaries), Reflectors, Lenses and Louvres, Lighting Control Systems, Lighting System Audit, Energy Saving Opportunities

**Energy Audit Applied to Buildings:** Energy – Saving Measures in New Buildings, Water Audit, Method of Audit, General Energy – Savings Tips Applicable to New as well as Existing Buildings.

### Text Book

1. Sonal Desai, '*Handbook of Energy Audit*', McGraw Hill, 2015.

### Reference Books

1. H.E. Jordan, '*Energy Efficient Electric Motors and Applications*', Plenum Pub. Corp

### Course Outcomes (Cos):

At the end of the course the student will be able to:

1. Understand the need of energy audit and energy audit methodology. (PO-1) (PSO-1)
2. Explain audit parameters and working principles of measuring instruments used to measure the parameters. (PO-1) (PSO-1)
3. Conduct energy audit of boilers, furnaces, power plant, steam distribution system and compressed air systems. (PO-8,9,10,11) (PSO-1,3,4)
4. Conduct energy audit HVAC systems, motors, pumps, blowers and cooling towers. (PO-8,9,10,11) (PSO-1,3,4)
5. Explain load management techniques, effects of harmonics, electricity tariff, improvement of power factor and losses in transmission. Conduct energy audit of lighting systems and buildings. (PO-2,8,9,10,11) (PSO-1,3,4)

# ELECTRIC VEHICLE TECHNOLOGY

**Subject code: EEE633**

**Credits: 3:0:0**

**Prerequisites: Nil**

**Contact Hours: 42**

**Course Coordinator: Dr. Hemachandra Gudimindla**

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## Course content

### Unit I

**Introduction:** IC Engines Basics, Energy Consumption for cycles, Limitations with present Technology – Fuel Shortage, Mechanical Efficiency along with hybrid & Electric Vehicle Systems. Introduction to Electric Vehicles: History of Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Social and Environmental Importance of Electric and Hybrid Electric Vehicles.

### Unit II

**Battery Technologies:** Types of Batteries, Architecture, Battery Charging & Discharging Cycles, Use of Batteries in Powertrain, Battery Modeling & Management Systems (BMS).

### Unit- III

**Charging Technologies:** Standards, Conductive Charging (AC & DC), Inductive Charging – (Static and Dynamic), Battery Swap Technology. Alternate Energy Storage Systems (Ultracapacitor, Solid-state battery), Hybrid Energy Management System.

### Unit IV

**Power Electronics:** Fundamentals of Wide-bandgap (WBG) semiconductors, Comparing WBG with Si Devices, Efficiency Comparison, Introduction to GaN and SiC devices – Band Gap, Critical Field, On-Resistance, Two-Dimensional Electron Gas Model. single phase and three phase DC-AC converters & AC-DC Converters.

### Unit V

**Electric Drivetrain:** Series Hybrid Electric Drive Train, Design Principles of a Series Hybrid Drive Train, Parallel Hybrid Electric Drive Train Design. Design of the Traction Motor and Generator for Specific Power Rating. Fundamentals of regenerative braking and dynamic braking in electric vehicles.

## **Text Books**

1. James Larminie, John Lowry, '*Electric Vehicle Technology Explained*', John Wiley & Sons Ltd, 2<sup>nd</sup> edition, 2012.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, '*Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*', CRC Press Taylor & Francis Group, 2004.

## **Reference Books:**

1. Iqbal Hussein, '*Electric and Hybrid Vehicles: Design Fundamentals*', CRC Press Taylor & Francis Group, 2003.
2. Fred Wang, Zheyu Zhang and Edward A. Jones, '*Characterization of Wide Bandgap Power Semiconductor Devices*', First Edition, Institution of Engineering and Technology Publications, 2018.
3. Alex Lidow, Johan Strydom, Michael de Rooij, David Reusch, '*GaN Transistors for Efficient Power Conversion*', Third Edition, Wiley, 2019.
4. John G Hayes and G Abas Goodarzi, '*Powertrain – Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles*', First Edition, Wiley, 2018.
5. Ali Emadi, '*Handbook of Automotive Power Electronics and Motor Drives*', CRC Press Taylor & Francis Group, 2005

## **Course Outcomes (COs):**

At the end of the course the student will be able to:

1. Recognize the evolution of electric vehicles and explain EV and HEV configurations. (PO1)(PSO1)
2. Familiarize with Battery Modelling & Management Systems (PO1,2)(PSO1)
3. Learn the fundamentals of EV charging (PO1)(PSO1)
4. Select semiconductors that can be used in EV power converters (PO1)(PSO1)
5. Recognize different aspects of Electrical machines and power electronic devices used in EV. (PO1)(PSO1)

# NANOFABRICATION AND CHARACTERIZATION

**Subject code: EEE641**

**Credits: 3:0:0**

**Prerequisites: Nil**

**Contact Hours: 42**

**Course Coordinator: Dr. S. Dawnee**

## Course content

### Unit I

Overview of Nanoelectronics devices and materials requirement, MOS capacitor as a building block of FET - MOSFET structure, SiO<sub>2</sub>-Si interface quality- RCA cleaning, Oxidation, Gate electrode, Forming gas anneal.

CMOS scaling -ideal scaling theory, non-scaling factors, various definitions for channel length, Transistor Design methodology, Short channel Effect-Channel Engineering, Drain Induced barrier Lowering

### Unit II

Energy Bands In Silicon (Review only), Ultrathin SiO<sub>2</sub> growth, gate-oxide scaling, electric field calculation ( $V_{FB}, V_{Si}$ ), Analysis with different examples, Flat band voltage Computation, Energy band diagram under thermal equilibrium,  $V_{Si}$  calculation under different conditions like accumulation, depletion etc. FN Tunneling, Time Dependent Dielectric Breakdown, Direct tunneling

### Unit III

High-k dielectrics, EOT, High-k dielectric requirements.

Metal gate transistor-Issues, Replacement gate, Fully Silicided gate technology.

Electrical characterization: HFCV and LFCV, Issues on scaling, sub-threshold leakage, Non-idealities in CV Transport enhanced transistor, I-V and reliability measurements.

### Unit IV

Non classical transistor structure, Silicon on Insulator (SOI) –PDSOI and FDSOI Processing and Characterization, Energy band diagram comparisons, SOI MOSFET operation with backchannel biased into Accumulation, Depletion and Inversion.

### Unit V

Introduction to other high performance nanoscale MOSFETs, Nano materials – Making and Characterisation, Introduction to CVD, ALD techniques, core-shell



structures, whiskers, SVS process. Analytical nano-characterization techniques: size, structure, composition, thickness measurement techniques.

**References:**

1. International Technology Roadmap for Semiconductors (ITRS)
2. Current literature from journals and conference proceedings

**Course Outcomes (COs):**

After the completion of the course the students will be able to:

1. Describe the different steps in the fabrication of scaled transistors. (PO-1) (PSO-1)
2. Develop a process flow for the fabrication of nano MOSFETs based on a particular specification, compute its threshold voltage. (PO-2) (PSO-1)
3. Implement the methodology for life time estimation and reliability. (PO-2) (PSO-1)
4. Analyze electrical characterization and perform parameter extraction from CV characteristics. (PO-2) (PSO-1)
5. Explain the different electrical and mechanical characterization techniques and making of nano materials. (PO-1) (PSO-1)

# MACHINE LEARNING

**Subject code: EEE642**

**Credits: 2:1:0**

**Prerequisites: Nil**

**Contact Hours: 56**

**Course Coordinator: Smt. Kusumika Krori Dutta**

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## Course content

### Unit I

#### **Introduction to Machine Learning:**

What is machine learning? Examples of machine learning applications –learning associations- classification-regression-unsupervised learning-reinforcement learning.

#### **Probability Theory:**

Probability densities, expectations and covariance, Bayesian probabilities, the Gaussian distribution, curve fitting, probability distribution, Decision tree.

#### **Linear algebra for Machine Learning:**

Basic Matrix identities, traces and determinants, matrix derivatives, Eigen value ,eigen vector equation.

### Unit II

#### **Supervised Learning:**

Learning a class from examples, Noise, Learning multiple classes, Regression, Model selection and generalization.

#### **Bayesian Decision Theory:**

Classification, Losses and risks, Utility theory. Naïve Bayes Classifier.

#### **Linear Model for Classification:**

Discriminant functions, Probabilistic Generative models, Probabilistic Discriminative models, Bayesian Logistic regression

### Unit III

#### **Dimensionality reduction:**

Subset selection, Principal Component Analysis (PCA), Fisher’s linear discriminant Analysis (LDA).

#### **Parametric Methods:**

Maximum likelihood Estimator (MLE), Bayes estimator, parametric classification.

#### **Multivariate methods:**

Multivariate data, Parameter Estimation, Estimation of Missing Values, Multivariate Normal Distribution, Multivariate Classification, Tuning Complexity.

## Unit IV

### Clustering:

Mixture densities, k-Mean clustering, Expectation-Maximization, Mixtures of Latent variable models, Supervised learning after clustering, Hierarchical clustering, Choosing the Number of Clusters.

### Non-parametric methods:

Non-parametric Density Estimation-Nearest Neighbor estimator- kernel estimator, nonparametric classification.

## Unit V

### Maximum margin classifiers:

SVM, Introduction to kernel methods, Overlapping class distributions, Relation to logistic regression, Multiclass SVMs, and SVRs.

### Multilayer Perceptron:

Understanding the Brain, Neural networks as a paradigm for Parallel Processing, training a perceptron, Back Propagation algorithm.

### Text books

1. Ethem Alpaydin, "*Introduction to Machine Learning*", Second Edition, PHI Learning Pvt. Ltd, 2010.
2. Christopher Bishop, "*Pattern Recognition and Machine Learning*", CBS Publishers & Distributors, 2010.

### Course Outcomes (COs):

At the end of the course the student will be able to:

1. Understand and apply different machine learning based learning techniques. (PO1) (PSO1)
2. Understand and apply dimensionality reduction method.(PO1,2)(PSO1)
3. Analyze different classifiers.(PO2) (PSO1)
4. Evaluate Bayesian learning algorithm.(PO1,2) (PSO1)
5. Understand and apply neural network based models.(PO1,2) (PSO1)

# VIRTUAL INSTRUMENTATION

**Subject code: EEE643**

**Credits: 0:1:2**

**Prerequisites: Nil**

**Contact Hours: 84**

**Course Coordinator: Dr. Kodeeswara Kumaran G**

## Course content

### TUTORIAL TOPICS

LabVIEW introduction, Navigating LabVIEW, VIs and Functions, Dataflow, LabVIEW data types, Tools for programming, cleaning, and organizing VIs, Building a basic VI, Correction of broken VIs, Debugging techniques, Error handling, Loops review, While loops, For loops, Timing a VI.

Data feedback in loops, Plotting data waveform chart, Arrays, Common array functions, Polymorphism, Auto-indexing, Clusters, Type definitions, Case structures.

Event driven programming, Understanding modularity, Icon, Connector Pane, Documentation, Using SubVIs, Measuring fundamentals with NI DAQ hardware, Accessing files form LabVIEW, High-level and low level file I/O functions, Comparing file formats, Using sequential programming, Using state programming, State machines.

Variables, Using variables appropriately, Race conditions, Communicating data between parallel loops, Implementing simple design patterns and multiple loop design patterns, Functional global variable design pattern, Error handlers, generating error codes and messages, Timing design pattern, VI server architecture, Property nodes.

Controlling user interfaces, File formats, Creating a file and folder paths, Write and read binary files, Working with multichannel text files with headers, Access TDMS files in LabVIEW and Excel, Refactoring codes, Creating and distributing applications.

### LIST OF EXPERIMENTS

1. (i) Getting familiar with LabVIEW environment  
(ii) Demonstration of document codes
2. (i) Programs to perform arithmetic operations  
(ii) Programs to understand dataflow
3. (i) Programs using *while* loops and *for* loops  
(ii) Programs to demonstrate data tunnels in loops
4. (i) Program to plot data waveforms
5. (ii) Program using n-dimensional arrays
6. (i) Programs using shift registers

- (ii) Programs using case structures
- 7. Programs to read data from and write data to a binary/ASCII/LVM file
- 8. (i) Programs to implement state machines  
(ii) Programs to execute sequential tasks
- 9. Program to acquire data and control processes with myDAQ/myRIO hardware devices
- 10. Implementation of voltmeter, ammeter and wattmeter functions using myDAQ/myRIO
- 11. Implementation of DC motor control using myRIO
- (12 to 14 ) Capstone project

### References:

1. LabVIEW fundamentals by National Instruments
2. LabVIEW Basics-I course manual by National Instruments
3. LabVIEW Basics-II course manual by National Instruments

### Course Outcomes (COs):

At the end of the course the student will be able to:

1. Demonstrate their understanding about the basic concepts of LabVIEW programming (PO-1)(PSO-1)
2. Develop VI programs in LabVIEW to meet given requirements. (PO-2,3,5) (PSO-1,2)
3. Debug and deploy LabVIEW programs on host computer / myRIO. (PO-4,5 )(PSO-1,2)
4. Deploy myDAQ for signal acquisition and processing. (PO-5)(PSO-1,2)
5. Develop a standalone system using myRIO for simple process control requirement. (PO-3,5)(PSO-1,2)

## Open Elective

### ARTIFICIAL NEURAL NETWORK

**Subject code:** EEOE03

**Credits:** 2:1:0

**Prerequisites:** Nil

**Contact Hours:** 56

**Course Coordinator:** Smt. Kusumika Krori Dutta

#### Course content

##### Unit I

**Introduction:** Fundamental concepts and Models of Artificial Neural systems, Biological Neural Networks, Typical Architectures, Setting the Weights, Common Activation Functions, Mc-Culloch –Pitts model- AND gate, OR gate, AND-NOT gate, XOR gate.

##### Unit II

**Fundamental Models of Artificial Neural Networks:** Simple neural nets for Pattern Classification, Hebb net, examples, Single Layer Perceptron Classifiers, Single Layer Feedback Networks, examples, Perceptron learning.

##### Unit III

**Associative memory networks:** Pattern associations, applications, Training algorithm, Hebb rule & Delta rule, Classification of associative memory, Hetero associative neural net architecture, Examples with missing and mistake data, Auto associative net architecture, Examples with missing and mistake data, Storage capacity.

##### Unit IV

**Feed Back Networks:** Recurrent linear auto associate, Examples, Discrete Hopfield net, Examples with missing and mistake data, Bidirectional associative net, architecture, Examples with missing and mistake data, Hamming distance, Fixed weight competitive nets, Architecture, applications.

**Feed forward Network:** Architecture, applications, examples of back propagation neural network (BPN), and Radial Basis Function Network (RBFN)

##### Unit V

**Special Networks:** Introduction to Boltzmann machines, Boltzmann machine with learning.

**Self-organizing Feature Map:** Kohonen Self-organizing Feature Map, Learning Vector Quantization, Max net, Mexican Hat, Hamming Net

**References:**

1. LaureneFausett, '*Fundamentals of Neural Networks: Architecture, Algorithms and Applications*', Person Education, 2004.
2. Simon Hayking, '*Neural Networks: A Comprehensive Foundation*', 2<sup>nd</sup> Ed., PHI.
3. S.N Sivanandam, S Sumathi, S.N Deepa '*Introduction to Neural Net using Matlab 6.0*', TMH, 2008

**Course Outcomes (COs):**

The course enables the students to:

1. Describe the relation between real brains and simple artificial neural network models. (PO-1) (PSO-1)
2. Design basic model of logic gates and circuits using Perceptron, Hebbian algorithm and McCulloch -Pitt's models and verify the same using MATLAB. (PO-1,3) (PSO-1,2)
3. Identify the main implementation issues for common neural network systems (PO-1) (PSO-1)
4. Apply the models of ANN in different areas like optimization of efficiency (PO-1) (PSO-1)
5. Apply ANN models to data compression, pattern identification, etc. (PO-1) (PSO-1)

## WIND ENERGY AND DESIGN ASPECTS

**Subject code:** EEOE04

**Credits:** 3:0:0

**Prerequisites:** Nil

**Contact Hours:** 42

**Course Coordinator:** Dr. Sridhar. S

### Course content

#### Unit I

**Wind resources Assessment:** Introduction, estimation of power production, evaluation of sites, wind data for prospective sites, feasibility study, micro- siting of wind power plants, visual impact, pitfalls.

**Components of wind power plants:** rotor, Nacelle, Towers, Electric Substation, Tower foundations.

**Types of wind power plants:** Types of axis, stand – alone and grid connected WPPs, upwind and downwind WPPs, blade count, power ratings of WPPs, aerodynamic power regulation method, types of electrical generators in WPPs, constant speed and variable speed WPPs, geared, direct drive and semi-geared/ hybrid WPPs, WPP with single gearbox and multiple generators.

#### Unit II

**Specifications of wind power plants:** General data, rotor, hub, lightning protection, pitching system, breaking system, drive train, electrical generator, electrical system, electronic controller, yaw system, nacelle, tower, specific power of WPP, standards and specifications.

**Choice of wind turbines:** Wind turbines options, size of wind turbines, types of wind turbines, wind turbines tailored to wind climate, nominal power vs rotor diameter, IEC wind classes, configuration, grid compatibility, suppliers.

**Working of wind power plants:** physical principle of modern wind turbine, wind turbine rotor blade characteristics, hub and main shaft functions, working of geared WPP, working principle of direct drive WPP, semi-geared/ hybrid WPP working principle, breaking of WPP, yawing, cable untwisting, electric substation and grid

#### Unit III

**Grid integration of wind power plants:** Introduction, functions of an electric power system, functional requirements of WPPs in an electric grid, embedded generation, types of WPP and wind farm grid connections, integration issues, operational issues, siting WPPs for effective grid integration, grid integration issues in India, challenges for grid integration, wind power integration standards, supergrid strategy.



**Wind power and environment:** Introduction, impact of wind power on environment, benefit of wind power for environment, land demand, local impacts, visual impact on the landscape,

#### Unit IV

**Wind power policy:** Introduction, permission inquiry, conflicting interests, permission process, wind power politics, wind power on the power market, support schemes for renewable energy, evaluation, independent power producers, competition on equal terms, energy subsidies, policy recommendations.

**Wind power planning:** Introduction, targets for wind power development, areas of national interest, positive planning, regional and municipal planning, planning tools, secondary generation planning, planning methods.

#### Unit V

**Operation and maintenance issues of wind power plants:** Introduction, availability of WPPs, general WPP maintenance, unscheduled maintenance, unscheduled maintenance levels, scheduled maintenance, tower maintenance, SCADA for WPP applications, condition monitoring systems, WPP maintenance costs, warranty and insurance.

#### Text books

1. Joshua Earnest, Tore Wizelius “*Wind Power Plants and Project Development*”, PHI Learning Private Limited, 2011.
2. G. D. Rai, “*Non-Conventional Energy Sources*”, Khanna Publications.

#### Reference Books

1. Bibek Samantaray & Kaushik Patnaik, “*A study of wind energy potential in India*”, 2010.
2. “Ministry of New and Renewable Energy (MNRE)”, Developmental Impacts and Sustainable Governance Aspects of Renewable Energy Projects, September 2013.
3. Dr. Gray. L. Johhanson, “*Wind Energy Systems*”, 2001.
4. B. H. Khan, “*Non-Conventional Energy Sources*”, TMH, 3<sup>rd</sup> edition.

### **Course Outcomes (COs):**

At the end of the course the student will be able to:

1. Understand the basics of wind energy, components and types of wind power plants. (PO-1) (PSO-1)
2. Understand the choice of wind turbine and working of wind power plant. (PO-1) (PSO-1)
3. Understand the grid integration of wind power plant and impact of wind power on environment. (PO-1) (PSO-1)
4. Understand the policy and planning of wind power plants. (PO-1) (PSO-1)
5. Understand the operation and maintenance issues of wind power plant. (PO-1) (PSO-1)

# MATERIALS AND SENSORS FOR ELECTRICAL APPLICATIONS

**Subject code:** EEOE06

**Credits:** 3:0:0

**Prerequisites:** Nil

**Contact Hours:** 42

**Course Coordinator:** Dr. Pradipkumar Dixit

## Course content

### Unit I

**Introduction to Electrical and Electronics Materials:** Importance of materials, Classification of electrical and electronic materials, Scope of electrical and electronic materials, Requirement of Engineering materials, Operational requirements of electrical and electronic materials, Classification of solids on the basis of energy gap, Products – working principle and materials, Types of engineering materials, Levels of material structure. Spintronic and Spintronic materials, Ferromagnetic semiconductors, Left handed materials.

**Conductors:** Conductor materials, Factors affecting conductivity, Thermal conductivity, Heating effect of current, Thermoelectric effect.

### Unit II

**Conductive Materials and Applications:** Mechanically processed forms of electrical materials, Types of conducting materials, Low resistivity materials, High resistivity materials, Contact materials, Fusible materials, Filament materials, Carbon as filamentary and brush material, Material for conductors, cables, wires, solder, sheathing and sealing.

**Dielectrics:** Introduction to dielectric materials, classification of dielectric materials, Dielectric constant, Dielectric strength and Dielectric loss. Polarization, Mechanisms of polarization, Comparison of different polarization process, Factors affecting polarization, Spontaneous polarization, Behaviour of polarization under impulse and frequency switching, Decay and build-up of polarization under ac field, Complex dielectric constant

### Unit III

**Insulating Materials:** Insulating materials and applications – Ceramic, Mica, Porcelain, Glass, Micanite and Glass bonded mica. Polymeric materials – Bakelite, Polyethylene. Natural and synthetic rubber. Paper. Choice of solid insulating material for different applications, Liquid insulating materials – Requirements, Transformer oil, Bubble theory, Aging of mineral insulating oils. Gaseous insulating Materials – Air, Nitrogen, Vacuum.

**Magnetic Materials:** Origin of permanent magnetic dipole, Magnetic terminology, Relation between relative permeability and magnetic susceptibility. Classification of magnetic materials, Diamagnetic, Paramagnetism, Ferromagnetism, Antiferromagnetic and the corresponding materials. Ferrimagnetism and ferrites – properties and applications, Soft and hard ferrites. Curie temperature, Laws of magnetic materials. Magnetization curve, Initial and maximum permeability. Hysteresis loop and loss, Eddy current loss. Types of magnetic materials, Soft and hard magnetic materials, High energy magnetic materials, Commercial grade soft and hard magnetic materials.

#### Unit IV

**Introduction to Nano materials for electrical applications:** Historical background, Classification of Nanomaterials, Dielectrics and Nano dielectrics, Nano fluids development, Nano tech electrical applications.

**Equipment for characterisation of materials:** Use of each equipment with example Fourier Transform Infrared Spectroscopy, Scanning Electron Microscopy, Dynamic light scattering, Temperature gravimetric Analysis, X-ray diffraction, Impedance analyser, Dilatometer, Surface roughness tester, Thermal conductivity tester. Contact angle meter

#### Unit V

**Introduction to sensors for electrical applications:** General properties of sensors, Voltage and Current sensors, Electric field sensors, Temperature sensors- Contact and non-contact type, Position sensor, Speed sensors.

#### Text Book:

1. Advanced Electrical and Electronics Materials; Processes and Applications by K M Gupta and Nishu Gupta, First edition, Wiley Publisher,2015

#### Reference Books:

1. Electrical Engineering Materials by A J Dekker, Pearson Publisher,2016
2. Introduction to Sensors for Electrical and Mechanical Engineering by Martin Novak, First edition, CRC Press,2020
3. Handbook of Material Characterization, Springer, 2018
4. An Introduction to Electrical Engineering Materials by C S Indulkur and Thiruvengadam S 6<sup>th</sup> revised edition, 2011
5. Emerging Nanotechnology Applications in Electrical Engineering by Ahmed Thabet Mohamed · IGI Global, 2021

### **Course Outcomes (COs):**

At the end of the course, student will be able to,

1. Classify Materials for electrical applications (PO-1, PSO-1)
2. Apprehend conductive materials and dielectrics for electrical applications (PO-1, PSO-1)
3. Recognize the need of insulating and magnetic materials in various electrical applications (PO-1, 6, PSO-1)
4. Assimilate the role of Nano-materials and Equipment for characterization (PO-1, PSO-1)
5. Recognize type of sensor for given application (PO-1,6, PSO-1)