SEMESTER VI

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1U30E	LINEAR CONTROL SYSTEMS	PCC	2	2	0	4	2020

i) **PRE-REQUISITE:** EE1U20A Basic Circuits and Networks, EE1U30C Signals and Systems

ii) **COURSE OVERVIEW**: This course aims to provide a strong foundation on classical control theory. Modelling, time domain analysis, frequency domain analysis and stability analysis of linear systems based on transfer function approach will be discussed.

iii) **COURSE OUTCOMES**

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

CO 1	Describe the role of various control blocks and components in feedback systems.	Understand
CO 2	Analyze the time domain responses of the linear systems.	Analyze
CO 3	Apply Root locus technique to assess the performance of linear systems.	Apply
CO 4	Analyze the stability of the given LTI systems.	Analyze
CO 5	Analyze the frequency domain response of the given LTI systems.	Analyze

iv) SYLLABUS

Terminology and basic structure of Open loop and Closed loop control systems- Transfer function approach to feed back control systems- Control system components: Transfer functions of DC and AC servo motors –Control applications of Tacho generator, Synchro, Gyroscope and Stepper motor- Need for controllers- types of controllers and compensators.

Time domain analysis of control systems- time domain specifications- Impulses and step responses of second order systems- Steady state error analysis- Stability analysis- Application of Routh's stability analysis.

Root locus Analysis- Design of compensators using root locus method- PID controller- Design of P, PI, PID controllers using Zeigler-Nichols tuning method- Simulation based analysis- MATLAB/SCILAB.

Frequency domain analysis- Polar Plot-concept of gain margin and phase margin- Bode plot- transportation lag- non-minimum phase system.

Nyquist stability criterion- compensator design using Bode plot- Simulation based analysis- MATLAB/SCILAB.

v) (a) TEXT BOOKS

1) Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age International Private Limited, 2021.

2) Ogata K, Modern Control Engineering, 5/e, Pearson, 2009.
3) Nise N. S, Control Systems Engineering, 6/e, Pearson, 2009.
4) Dorf R. C. and Bishop R. H, Modern Control Systems, 12/e, Pearson Education, 2010.

(b) Reference Books

1) Kao B. C, Automatic Control Systems, 7/e, Prentice Hall of India, 1995.
2) Desai M. D., Control System Components, Prentice Hall of India, 2008
3) Gopal M., Control Systems Principles and Design, 4/e, McGraw Hill Education Private Limited, 2016.
4) Imthias Ahamed T. P, Control Systems, Phasor Books, 2016.
5) Heuring V. P. and Jordan H. F., Computer System Design and Architecture, Pearson Education, 2/e, 2008.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Feedback Control Systems**: Open loop and closed loop control systems - Examples of automatic control systems – Transfer function approach to feed-back control systems – Effect of feedback. Control system components – Control applications of DC and AC servo motors, Tacho generator, Synchro, Gyroscope and Stepper motor. Controllers - Types of controllers & Compensators –Transfer function and basic characteristics of lag, lead and lag-lead phase compensators.	10
II	**Performance Analysis of Control Systems:** Time domain analysis of control systems: Time domain specifications of transient and steady state responses- Impulse and Step responses of first and second order systems-Pole dominance for higher order systems. Error analysis: Steady state error analysis and error constants -Dynamic error coefficients. Stability Analysis: Concept of BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems - Routh's stability criterion- Relative stability.	10
III	**Root Locus Analysis and Compensator Design** Root locus technique: Construction of Root locus- stability analysis- effect of addition of poles and zeroes- Effect of positive feedback systems on Root locus. Design of Compensators: Design of lag, lead and lag-lead compensators using Root locus technique. PID controllers: PID tuning using Ziegler-Nichol's methods. Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent for Root locus-based analysis (Demo/Assignment only)	14
IV	**Frequency domain analysis** Frequency domain specifications- correlation between time domain and frequency domain responses.	13

	Polar plot: Concepts of gain margin and phase margin- stability analysis. Bode Plot: Construction- Concepts of gain margin and phase margin- stability analysis, Effect of Transportation lag and non-minimum phase systems.	
V	**Nyquist stability criterion and Compensator Design using Bode Plot** Nyquist criterion: Nyquist plot- Stability criterion- Analysis Introduction to Log magnitude vs. phase plot and Nichol's chart (concepts only) - Compensator design using Bode plot: Design of lag, lead and lag-lead compensator using Bode plot. Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent for various frequency domain plots and analysis (Demo/Assignment only).	**13**
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1U30F	POWER SYSTEMS II	PCC	3	1	0	4	2020

i) PRE-REQUISITE: ES0U10A Power Systems I.

ii) COURSE OVERVIEW:

The goal of this course is to expose the students to the fundamental concepts of Per unit systems, Fault calculations and Load flow Analyzes of electric power system. The course also intends to deliver the basic concepts of power system stability and Optimal scheduling of electric power Generation

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Apply the per unit scheme for any power system network and compute the fault levels.	Apply
CO 2	Analyze the voltage profile of any given power system network using iterative methods.	Analyze
CO 3	Model the control scheme of power systems.	Apply
CO 4	Analyze the steady state and transient stability of power system networks.	Analyze
CO 5	Schedule optimal generation scheme.	Apply

iv) SYLLABUS

Per unit quantities- Symmetrical components- sequence networks- Fault calculations-symmetrical fault- Unsymmetrical faults - Contingency ranking.

Load flow studies -network model formulation and admittance matrix, Gauss-Siedel (two iterations), Newton-Raphson and Fast Decoupled method (Qualitative analysis only) - principle of DC load flow

Turbines and speed governors-Inertia-Automatic Generation Control: Load frequency control: single area and two area systems - Automatic voltage control - Exciter Control - SCADA systems

Power system stability - steady state, dynamic and transient stability-power angle curve-steady state stability limit -mechanics of angular motion-swing equation - solution of swing equation - Equal area criterion application - methods of improving stability.

Economic Operation - Distribution of load between units within a plant - penalty factors and loss coefficients. Unit commitment: Introduction — constraints on unit commitments: spinning reserve, thermal unit constraints- hydro constraints.

v) (a) TEXT BOOKS

1) Hadi Saadat, *Power System Analysis*, 2/e, McGraw Hill, 2002.
2) D. P. Kothari and I. J. Nagrath, *Modern Power System Analysis*, 2/e, TMH, 2009.
3) Kundur P., *Power system Stability and Control*, McGraw Hill, 2006.

4) Allen J. Wood and Bruce F. Wollenberg., *Power Generation, Operation, and Control,* Wiley, 2nd Edition, 1996.
5) Cotton H. and H. Barbera, Transmission & Distribution of Electrical Energy, 3/e, Hodder and Stoughton, 1978.
6) Gupta B. R., *Power System Analysis and Design*, S. Chand, New Delhi, 2006.
7) Gupta J.B., Transmission *& Distribution of Electrical Power*, S.K. Kataria & Sons, 2009.
8) Soni, M.L., P. V. Gupta and U. S. Bhatnagar, *A Course in Electrical Power*, Dhanpat Rai& Sons, New Delhi, 1984.

(b) REFERENCES

1) John J Grainger and William D Stevenson, *Power System Analysis*, 4/e, McGraw Hill, 1994.
2) Uppal S. L. and S. Rao, *Electrical Power Systems*, Khanna Publishers, 2009.
3) Wadhwa C. L., *Electrical Power Systems*, 33/e, New Age International, 2004.
4) Weedy B. M., B. J. Cory, N. Jenkins, J. B. Ekanayake and G. Strbac, *Electric Power System*, John Wiley & Sons, 2012.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Per unit quantities-single phase and three phase- Symmetrical components- sequence networks- Fault calculations-symmetrical fault- Unsymmetrical faults - single line to ground, line to line, double line to ground faults- Fault level of installations- Limiters - Contingency ranking.	**13**
II	Load flow studies – Introduction-types-network model formulation and admittance matrix, Gauss-Siedel (two iterations), Newton-Raphson and Fast Decoupled method (Qualitative analysis only) - principle of DC load flow - Introduction to distribution flow.	**12**
III	Turbines and speed governors-Inertia-Automatic Generation Control: Load frequency control: single area and two area systems - Subsynchronous Resonance - Automatic voltage control -Exciter Control- SCADA systems	**11**
IV	Power system stability - steady state, dynamic and transient stability- power angle curve-steady state stability limit -mechanics of angular motion-swing equation - solution of swing equation - Point by Point method - RK method - Equal area criterion application - methods of improving stability limits - Phasor Measurement Units- Wide Area Monitoring Systems	**13**
V	Economic Operation - Distribution of load between units within a plant - transmission loss as a function of plant generation - distribution of load between plants - method of computing penalty factors and loss coefficients. Unit commitment: Introduction — constraints on unit commitments: spinning reserve, thermal unit constraints- hydro constraints.	**11**
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1U30G	POWER ELECTRONICS	PCC	3	1	0	4	2020

i) PRE-REQUISITE:

ii) COURSE OVERVIEW:

The goal of this course is to expose the students to the fundamental concepts of Power Electronic Devices. It also includes the circuit analysis of various power converter circuits. The course also provides an insight on the basic concepts of AC & DC drives.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Explain the operation of modern power semiconductor devices and its characteristics.	Understand
CO 2	Analyze the working of controlled rectifiers.	Apply
CO 3	Explain the working of AC voltage controllers, inverters and PWM techniques.	Understand
CO 4	Compare the performance of different dc-dc converters.	Apply
CO 5	Describe basic drive schemes for ac and dc motors.	Understand

iv) SYLLABUS

Structure and principle of operation of power devices: Power diode, Power MOSFET & IGBT – switching characteristics - comparison, SiC, GaN.

SCR- Structure, Static characteristics & Switching (turn-on & turn-off) characteristics - di/dt & dv/dt protection – Turn-on methods of SCR - Two transistor analogy.

Gate drive circuit: Triggering circuit-gate drive circuit-Isolation.

AC-DC converters: Single phase half wave controlled, fully controlled, semi controlled ac-dc converter.

Three Phase AC-DC converters: Three phase half wave Controlled, fully controlled, semi controlled ac-dc converter.

AC voltage controllers: Single phase AC voltage controller with R & RL load.

Inverters – Single phase half bridge and full bridge inverter, Three Phase inverters- PWM Techniques.

DC choppers – Step up chopper –step down chopper - buck-boost & buck boost-switching regulators.

Electric Drives - Block diagram - concept of DC drive & AC drives.

v) (a) TEXT BOOKS

1) Ned Mohan, Tore M. Undeland, William P. Robbins, *Power Electronics: Converters, Applications, and Design*, Wiley India, 3rd Edition, 2018.
2) Dubey G K, *Fundamentals of Electrical Drives*, Narosa Publishing House, New Delhi,

2nd Edition, 2012.
3) Robert W. Erickson, Dragan Maksimovic, *Fundamentals of Power Electronics*, Springer, 3rd Edition, 2001.

(b) REFERENCES

1) Rashid M H, *Power Electronics – Circuits, Devices and Applications*, Prentice Hall of India, New Delhi, 4th edition, 2014.
2) Robert Bausiere, FrancisLabrique, GuySeguier, *Power Electronic Converters: DC-DC Conversion*, Springer, 2013.
3) P.S.Bimbhra, *Power Electronics*, Khanna Publishers, New Delhi, 6th edition, 2010.
4) Joseph Vithayathil, *Power Electronics*, Tata McGraw-Hill, New Delhi, 2010.
5) M.D.Singh and K.B.Khanchandani, *Power Electronics*, Tata McGraw Hills Publishing Company Limited, 2006.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Power Electronics**: Scope and applications-power electronics vs signal electronics. **Structure and principle of operation of power devices**- Power Diode, Power MOSFET & IGBT – Comparison-Basic principles of wideband gap devices-SiC, GaN **SCR-** Structure, Static characteristics & Switching (turn-on & turn-off) characteristics - di/dt& dv/dt protection – Turn-on methods of SCR - Two transistor analogy **Gate triggering circuits**- Requirements of isolation and synchronization in gate drive circuits, Opto and pulse transformer based isolation.	**11**
II	**Controlled Rectifiers (Single Phase)** – Half-wave controlled rectifier with R load– Fully controlled and half controlled bridge rectifier with R, RL and RLE loads (continuous & discontinuous conduction) – Output voltage equation- related simple problems **Controlled Rectifiers (3-Phase)** - 3-phase half-wave controlled rectifier with R load – Fully controlled & half-controlled bridge converter with RLE load (continuous conduction, ripple free) – Output voltage equation-Waveforms for various triggering angles (detailed mathematical analysis not required)	**12**
III	**AC voltage controllers (ACVC)** – 1-phase full-wave ACVC with R, & RL loads – Waveforms – RMS output voltage, Input power factor with R load **Inverters** – Voltage Source Inverters– 1-phase half-bridge & full bridge inverter with R and RL loads – THD in output voltage – 3-phase bridge inverter with R load – 120° and 180° conduction modes– Current Source Inverters-1-phase capacitor commutated CSI. **Voltage control in 1-phase inverters** – Pulse width modulation – Single pulse width, Multiple pulse width and Sine-triangle PWM– Modulation Index - Frequency modulation ratio.	**12**

IV	**DC-DC converters** – Step down and Step up choppers – Single-quadrant, Two-quadrant and Four quadrant chopper – Pulse width modulation & current limit control in dc-dc converters. **Switching regulators** – Buck, Boost & Buck-boost –Operation with continuous conduction mode – Waveforms – Design of Power circuits (switch selection, filter inductance and capacitance)	**12**
V	**Electric Drive**: Introduction to electric drives – Block diagram – advantages of electric drives- types of load – classification of load torque **DC Drives**: Single phase semi converter and single phase fully controlled converter drives. Dual Converters for Speed control of DC motor-1-phase and 3-phase configurations; Simultaneous and Non-simultaneous operation. Chopper controlled DC drives- Single quadrant chopper drives- Regenerative braking control **AC Drives**: Three phase induction motor speed control. Stator voltage control – stator frequency control - Stator voltage and frequency control (v/f)	**13**
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1U31A	BIOMEDICAL INSTRUMENTATION	PEC	3	0	0	3	2020

i) PRE-REQUISITE: Measurements and Instrumentation.

ii) COURSE OVERVIEW:

Goal of this course is to provide an overview of instrumentation systems used in clinical medicine and biomedical research. The course is designed to give the basic concepts of Instrumentation involved in the medical field and human physiology. Biomedical Instrumentation is application of technology for Medical field. During the course, students will explore Electro- physiological measurements, medical imaging etc. The course will make the students understand the devices used in diagnosing diseases.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Explain the basics of anatomy and physiology of the human body.	Understand
CO 2	Explain different techniques for the measurement of various physiological parameters.	Understand
CO 3	Illustrate modern imaging techniques for medical diagnosis.	Understand
CO 4	Identify the various therapeutic equipments used in biomedical field.	Apply
CO 5	Discuss the patient safety measures and recent advancements in the medical field.	Understand

iv) SYLLABUS

Introduction to biomedical instrumentation - man instrumentation system - Problems encountered in measuring living systems,

Brief discussion of Heart and Cardio-vascular system-Physiology of Respiratory system - Anatomy of Nervous and Muscular systems -

Bioelectric potential: Resting and action potential - Generation and propagation - Bio potential Electrodes: Theory – Surface electrode – Microelectrode - Needle electrodes.

Transducers for biomedical applications.

Direct and indirect measurement of blood pressure, Measurement of blood flow and cardiac output - Plethysmography, Measurement of heart sounds –Phonocardiography.

Electro-conduction system of the heart - ECG machine – block diagram

Neuronal communication - EEG waveforms and features - EEG Block diagram – Brain - Computer interfacing.

Electromyography- Block diagram of EMG recorders – Nerve conduction velocity measurement, Measurements of respiratory parameters.

Modern Imaging Systems: Basic X-ray machines - CAT scanner - Ultrasonic Imaging principle - MRI and PET scanning (Principle only).

Therapeutic equipment: Cardiac Pacemakers - Defibrillators - Hemodialysis machines - Artificial kidney – Lithotripsy - Shortwave and Microwave Diathermy machines.

Ventilators - Heart Lung machine - Infant Incubators, Test on blood cells – Chemical tests.

Physiological effects of electric current – Shock hazards from electrical equipment – Method of accident prevention, Introduction to Tele- medicine - Introduction to medical robotics.

v) (a) TEXT BOOKS

1) Leslie Cromwell and F.J. Weibell, E.A. Pfeiffer, *Biomedical Instrumentation and Measurements*, Prentice Hall India, 2nd edition, 1980.
2) Carr & Brown*, Biomedical Equipment Technology*, 4th edition, Pearson, 2002.
3) R.S. Khandpur, *HandBook of Biomedical instrumentation,* 1st edition, Tata McGraw Hill Publishing Co Ltd., 2004.

(b) REFERENCES

1) John G Webster, *Medical Instrumentation - Application and Design*, 4th edition, John Wiley and Sons, 2007.
2) L.A. Geddes and L.E. Baker, *Principles of Applied Biomedical Instrumentation*, John Wiley & Sons, 1975.
3) Andrew G Webb, *Principles of Biomedical Instrumentation,* Cambridge university press, 2018.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to biomedical instrumentation:** Man instrumentation system - Problems encountered in measuring living systems, **Human Physiological systems:** Brief discussion of Heart and Cardio-vascular system-Physiology of Respiratory system - Anatomy of Nervous and Muscular systems - **Bioelectric potential:** Resting and action potential - Generation and propagation - Bioelectric potentials associated with physiology systems (ECG, EEG and EMG). **Bio potential Electrodes:** Theory – Surface electrode – Microelectrode - Needle electrodes. **Transducers for biomedical applications:** Transducers for the measurement of pressure, temperature and respiration rate.	9

II	**Measurement of blood pressure:** Direct and indirect measurement – Oscillometric method –Ultrasonic method - Measurement of blood flow and cardiac output - Plethysmography –Photoelectric and Impedance Plethysmography - Measurement of heart sounds –Phonocardiography. **Cardiac measurements:** Electro-conduction system of the heart - Electro-cardiography – Electrodes and leads – Einthoven triangle- ECG read out devices - ECG machine – block diagram.	**9**
III	**Measurements from the nervous system:** Neuronal communication - EEG waveforms and features - 10-20 electrode measurement - EEG Block diagram – Brain - Computer interfacing. **Muscle response:** Electromyography- Block diagram of EMG recorders – Nerve conduction velocity measurement **Measurements of respiratory parameters:** Spiro meter – Pneumograph.	**9**
IV	**Modern Imaging Systems:** Basic X-ray machines - CAT scanner - Principle of operation -scanning components - Ultrasonic Imaging principle - types of Ultrasound Imaging - MRI and PET scanning (Principle only). **Therapeutic equipment:** Cardiac Pacemakers - De-fibrillators - Hemodialysis machines - Artificial kidney – Lithotripsy - Short wave and Micro wave Diathermy machines, Ventilators - Heart Lung machine - Infant Incubators.	**10**
V	**Instruments for clinical laboratory:** Test on blood cells – Chemical tests **Electrical safety:** Physiological effects of electric current – Shock hazards from electrical equipment – Method of accident prevention. Introduction to Tele- medicine - Introduction to medical robotics.	**8**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1U31B	RENEWABLE ENERGY SOURCES	PEC	2	1	0	3	2020

i) PRE-REQUISITE: Power System I

ii) COURSE OVERVIEW:

Goal of this course is to expose the students to the fundamental concepts of renewable energy sources available, its working principle and advantages. It also includes the design of a solar PV system. This course also imparts knowledge about various types of energy storage systems.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Describe the environmental aspects of renewable energy resources.	Understand
CO 2	Explain the operation of various renewable energy systems.	Understand
CO 3	Design solar PV systems.	Apply
CO 4	Explain different emerging energy conversion technologies and storage.	Understand

iv) SYLLABUS

Environmental aspects of Energy -Energy resources-conventional-non-conventional-advantages & limitations- World & Indian Energy Scenario.

Solar thermal systems-solar thermal collectors-Solar concentrators- Solar Thermal Electric Systems – Applications.

Wind Energy-basic principle-energy in wind-wind turbines - Wind Turbine power curve - Betz's Law- Small hydro power

Ocean Energy - Principles of wave and tidal energy conversion, Principle and methods of Ocean Thermal Energy Conversion.

Biomass Energy: Biomass conversion technologies, Biomass Gasification, Types of biogas plants.

Emerging Technologies of power generation and energy storage devices.

v) (a) TEXT BOOKS

1) C.S.Solanki, *Solar Photovoltaic: Fundamentals Technologies And Applications*, Prentice-Hall Of India Pvt. Limited, 3rd Edition, 2015.
2) Rai. G.D, *Non-conventional Energy Sources*, Khanna publishers,6th Edition, 2017.
3) Joshua Earnest, Tore Wizelius, *Wind Power Plants and Project Development*, PHI Learning, 2nd Edition, 2015.
4) Joseph P O'Connor. *Off Grid Solar: A handbook for Photovoltaics with Lead-Acid or Lithium-Ion batteries*, 2nd edition, 2016.

(b) REFERENCES

1) Rai. G.D, *Solar Energy Utilization*, Khanna Publishers, 5th edition, 2014.
2) Ahmed: *Wind energy Theory and Practice*, PHI, Eastern Economy Edition, 2012.

3) Rashid M.H., *Power Electronics Circuits, Devices and Applications*, 3rdedition, Prentice Hall a. India, New Delhi, 2004.
4) Kothari: *Renewable Energy Sources and Emerging Technologies*, PHI, Eastern Economy Edition, 2012.
5) Abbasi S. A. and N. Abbasi, *Renewable Energy Sources and Their Environmental Impact*, Prentice Hall of India, 2001.
6) Earnest J. and T. Wizelius, Wind Power Plants and Project Development, PHI Learning, 2011.
7) G.N. Tiwari: *Solar Energy-Fundamentals, Design, Modelling and Applications*, Narosa Publishers, 2002.
8) Khan B. H., Non-Conventional Energy Resources, Tata McGraw Hill, 2009.
9) A.A.M. Saigh(Ed): Solar Energy Engineering, Academic Press, 1977.
10) Thomas E. Kissell, David M. Buchla, Thomas L. Floyd, Renewable energy systems, Pearson, 2017.
11) Boyle G. (ed.), Renewable Energy -Power for Sustainable Future, Oxford University Press, 1996.
12) F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 1978.
13) J.A. Duffie and W.A. Beckman: Solar Energy Thermal Processes, J. Wiley, 1994.
14) Johansson T. B., H. Kelly, A. K. N. Reddy and R. H. Williams, Renewable Energy – Sources for Fuel and Electricity, Earth scan Publications, London, 1993.
15) D. P. Kothari, K. C. Singal, Rakesh Ranjan, Renewable Energy Sources and Emerging Technologies, Prentice Hall of India, New Delhi, 2009.
16) Rao S. and B. B. Parulekar, Energy Technology, Khanna Publishers, 1999.
17) Sab S. L., Renewable and Novel Energy Sources, MI. Publications, 1995.
18) Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction, Environmental Aspects Of Energy-Ecology-Greenhouse Effect-Global Warming-Pollution-Various Pollutants and their Harmful Effects-Green Power-The United Nations Framework Convention On Climate Change (UNFCC)-Environment-Economy-Energy and Sustainable development-Kyoto Protocol -Classification of Energy Resources; Conventional Energy Resources -Availability and their limitations; Non-Conventional Energy Resources –Classification, Advantages, Limitations; Comparison of Conventional and Non-Conventional Energy Resources; World Energy Scenario; Indian Energy Scenario.	**9**
II	SOLAR THERMAL SYSTEMS: Introduction, Solar Constant, Basic Sun-Earth Angles, Measurement of Solar Radiation Data (Numerical Problems)–Pyranometer and Pyrheliometer -Solar Thermal Collectors –General description and characteristics –Flat plate collectors –Heat transfer processes –Solar concentrators (Parabolic trough, Parabolic dish, Central Tower Collector) SOLAR ELECTRIC SYSTEMS: Introduction- Solar Photovoltaic – Solar Cell fundamentals, characteristics, classification, construction	**9**

	of Module, Panel and Array-Effect of shadowing - Maximum Power Point Tracker (MPPT) using buck-boost converter. Solar PV Systems –stand-alone and grid connected-Design steps for a Stand-Alone system; Applications –Street lighting, Domestic lighting and Solar Water pumping systems.	
III	Wind Energy–Introduction–Wind Turbine Types (HAWT and VAWT) and their construction- Wind power curve-Betz's Law-Power from a wind turbine (Numerical Problems)-Wind energy conversion system (WECS) – Fixed–speed drive scheme-Variable speed drive scheme - Effect of wind speed and grid condition (system integration). Small hydro power: Classification as micro, mini and small hydro projects -Basic concepts and types of turbines - Classification, Characteristics and Selection	**9**
IV	ENERGY FROM OCEAN: Tidal Energy –Principle of Tidal Power, Components of Tidal Power Plant (TPP), Classification of Tidal Power Plants, Advantages and Limitations of TPP. Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation –Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle (block diagram description of OTEC); Site-selection criteria, Biofouling, Advantages & Limitations of OTEC.	**9**
V	BIOMASS ENERGY: Introduction, Photosynthesis process, Biomass fuels, Biomass conversion technologies, factors affecting biogas generation, types of biogas plants –KVIC and Janata model. EMERGING TECHNOLOGIES: Fuel Cell, Hydrogen Energy, alcohol energy and power from satellite stations, Urban waste to Energy Conversion. ENERGY STORAGE: Necessity of Energy Storage-Pumped storage - Compressed air storage-Flywheel storage - Batteries storage - Hydrogen storage, Supercapacitors and SMES.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1U31C	COMPUTER ORGANIZATION	PEC	3	0	0	3	2020

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW: The basic objective of this course is to lay the foundation of hardware organization of digital computers. The basic organizational concepts of Processor, Control Unit, Memory and I/O units are systematically included in this course. The knowledge on interplay between various building blocks of computer is also covered in this syllabus.

iii) COURSE OUTCOMES

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

CO 1	Identify the functional units of a digital computer and understand the bus structure to do data transfer.	Understand
CO 2	Illustrate the pros and cons of different types of control unit design for various architectures.	Understand
CO 3	Explain the principle of operation of ALU for typical arithmetic and logic operations	Understand
CO 4	Identify memory organization, Cache memory and virtual memory techniques.	Apply
CO 5	Select appropriate interfacing standards for I/O devices.	Apply

iv) SYLLABUS

Basic Structure of Computers- functional units-basic operational concepts- Introduction to buses, Performance of computer- Representation of Instructions: Machine Instructions- Operands-Addressing modes- Instruction formats, Instruction sets, Instruction set architectures- CISC and RISC architectures.

Processor and Control Unit: Some Fundamental Concepts- Execution of a Complete Instruction -Multiple Bus Organization- Hardwired Control, Microprogrammed Control.

Computer arithmetic: Signed and unsigned numbers - Addition and subtraction- Booth's algorithm- Division algorithm- Floating point representation.

Memory Organization: - Memory cells- Basic Organization- Memory hierarchy - Caches - Cache performance- Virtual memory- Introduction to pipelining-pipeline Hazards.

Input-Output Organization: Characteristics, data transfer schemes- Organization of interrupts - vectored interrupts- Polling and daisy chaining schemes- Direct memory accessing (DMA).

v) (a) TEXT BOOKS

1) Hamacher C., Z. Vranesic and S. Zaky, Computer Organization, 5/e, McGraw Hill, 2011.
2) William Stallings, Computer Organization and Architecture: Designing for Performance, Pearson, 9/e, 2013.

(b) Reference Books

1) Patterson D.A. and J. L. Hennessey, Computer Organization and Design, 5/e, Morgan Kauffmann Publishers, 2013.
2) Heuring V. P. and Jordan H. F., Computer System Design and Architecture, Addison Wesley, 2/e, 2008.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Basic Structure of Computers - functional units -Von-Neumann architecture - basic operational concepts, Introduction to buses. Performance: Processor Clock, Basic Performance equation, clock rate, Performance Measurement Representation of Instructions: Instruction formats – Operands – Addressing modes, Instruction set architectures - CISC and RISC architectures.	9
II	Processor and Control Unit: Fundamental Concepts, multiple bus organization of CPU, memory read and memory write operations - Data transfer using registers. Execution of a complete instruction -sequencing of control signals. Hardwired Control, Micro programmed Control.	9
III	Data representation: Signed number representation, fixed and floating-point representations, character representation. Computer Arithmetic: Integer Addition and Subtraction - Booths Multiplication- Division- non- restoring and restoring techniques.	9
IV	Memory Organization: - Memory cells- Basic Organization. Memory hierarchy - Caches - Cache performance - Virtual memory - Common framework for memory hierarchies. Introduction to Pipelining- Pipeline Hazards	9
V	Input/output organization - Characteristics of I/O devices, Data transfer schemes - Programmed controlled I/O transfer, Interrupt controlled I/O transfer. Organization of interrupts - vectored interrupts – Servicing of multiple input/output devices – Polling and daisy chaining schemes. Direct memory accessing (DMA).	9
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EET1U31D	HIGH VOLTAGE ENGINEERING	PEC	3	0	0	3	2020

i) PRE-REQUISITE: Power Systems I

ii) COURSE OVERVIEW:

This course introduces basic terms and techniques applicable to high voltage ac and dc networks. Generation of different type of High voltage waveforms, their measurement and analysis including the insulation coordination of different equipments and machinery used in HV applications. It also provides a basic idea of FACTS devices and testing with the help of different testing circuits.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Identify different high voltage and current waveform generation circuits.	Understand
CO 2	Implement different sensing & measurement techniques for high voltage and current measurement	Understand
CO 3	Describe insulation coordination and surge arrestor design	Understand
CO 4	Identify different FACTS devices and their application in HV systems	Apply
CO 5	Implement different testing methods for equipments and applications of HV systems	Apply

iv) SYLLABUS

Generation of High DC and AC Voltages - Generation of impulse voltages – High voltage and high current measurements.

High voltage testing - Measurement of dielectric constant and loss factor- Partial discharge measurements.

Insulation Coordination and surge arresters - Classification of Voltages and Over voltages - Insulation Coordination Procedure.

HVDC and FACTS - HVDC transmission - - Static var compensators (SVCs), STATCOM, Series compensators, Unified power flow controller (UPFC).

Testing of insulators, bushings, air break switches, isolators, circuit breakers, power transformers, surge diverters, cables - Insulation Systems for AC Voltages - Lightning Protection.

v) (a) TEXT BOOKS

1) C.L Wadhwa, *High voltage Engineering*, New age international (P) Ltd, 3rd edition, 2012.
2) Andreas Kuchler, High Voltage Engineering Fundamentals – Technology – Applications, Springer, 2018.

(b) REFERENCES

1) Naidu M.S. and Kamaraju V., High voltage Engineering, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2004.
2) Farouk A.M. Rizk & Giao N. Trinh, High Voltage Engineering, CRC Press, 2014.
3) Kuffel, E., Zaengl, W.S. and Kuffel J., High Voltage Engineering Fundamentals, Elsvier India P Ltd, 2005.
4) Hugh M. Ryan, High-Voltage Engineering and Testing, IET Power and energy series, 2013.
5) N.G. Hingorani and L.Gyugyi, Understanding FACTS,IEEE Press, 2000.
6) Dieter Kind, Kurt Feser, High voltage test techniques, Elsevier Science, 2nd edition, 2001.
7) Khalil Denno, High Voltage Engineering in Power Systems, CRC Press, Newyork, 1992.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Generation of High Voltage and Currents. Generation of High DC and AC Voltages- half-wave rectifier circuit – Cockroft - Walton voltage multiplier circuit - Electrostatic generator - Generation of high AC voltages - Cascaded Transformers- Series resonant circuit. Generation of Impulse Voltages and Currents - Impulse voltage- Impulse generator circuits - Multistage impulse generator circuit - Construction of impulse generator - Triggering of impulse generator - Impulse current generation.	**9**
II	HV measuring techniques High Voltage Measurement Techniques -Measuring Spark Gaps - Sphere-to-sphere Spark Gap - Rod-to-rod Spark Gap - Electrostatic Voltmeter- Field Sensors - Electrically Short Sensors, Electrically Long Sensors, Potential-free Probes, Generator-mode Sensors, Electro-optical and Magneto-optical Field Sensors - Voltage Dividers - Instrument Transformers - Measurements of R.M.S. Value, Peak Value and Harmonics - Current Measurement. Dielectric measurements - Dissipation Factor and Capacitance, Insulation Resistance, Conductivity, Dielectric System Response- Partial discharge measuring technique - Requirements on a partial discharge measuring system - Measuring systems for apparent charge – Partial discharge measurements on high-voltage transformers, high-voltage cables, high-voltage gas-insulated substations.	**9**
III	Insulation Coordination and surge arresters Classification of Voltages and Overvoltages - Origin of Overvoltages – Representative Over voltages - Performance Criterion –Withstand voltage.	**9**

	Insulation Coordination Procedure- Determination of Representative Voltages and Overvoltages - Continuous Power Frequency Voltage, Temporary Overvoltages, Slow-Front Overvoltages, Fast-Front Overvoltages. Determination of Coordination Withstand Voltage-Deterministic Approach, Statistical Approach: Risk of Failure - Determination of Required Withstand Voltage - Altitude Correction Factor, Safety Factor (Ks) - Selection of Standard Withstand Voltage Surge Arresters- Rated Voltage- Discharge Current - Impulse Current Tests- Residual Voltages - Arrester Durability Requirements.	
IV	HVDC and FACTS HVDC transmission –General principles-VSC HVDC-Main components of HVDC links- Thyristor valves, Converter transformer, Control equipment, AC filters and reactive power control, Smoothing reactor and DC filter, Switchgear, Surge arresters, Valve cooling, Auxiliary supplies. Converter building - Power electronic support for AC systems - Static var compensators (SVCs), STATCOM, Series compensators, Unified power flow controller (UPFC).	**9**
V	Testing of HV Systems High voltage Testing of insulators, bushings, isolators, circuit breakers, transformers, surge diverters, cables. Insulation Systems for AC Voltages -Cables, bushings and transformers-Insulation Systems for DC Voltages- Capacitors, HVDC bushings and Cables-Insulation Systems for Impulse Voltages - Electrical Stress and Strength -Energy Storage -Impulse Capacitors (Energy Storage or Surge Capacitors). Lightning Protection - Light and Laser Technology- X-ray Technology - Electrostatic Particle Precipitation, Ionization - Spark plugs.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance : 10 marks

CA Exams (2 numbers) : 25 marks

Assignment/Project/Case study etc. : 15 marks

Total : **50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1U31E	OBJECT ORIENTED PROGRAMMING	PEC	3	0	0	3	2020

i) PREREQUISITE: EST160 Problem Solving and Programming in C

ii) COURSE OVERVIEW:

The goal of this course is to introduce the Object-Oriented Programming paradigm using JAVA as the language. It introduces concepts of inheritance and method overriding and overloading. This course discusses the concepts of File management and multi thread programming. The course helps the students to get an idea about Database Programming and Query execution.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Interpret the fundamental concepts in object-oriented approach and programming in JAVA.	Understand
CO 2	Apply the principles of inheritance and interfaces in the software design process.	Apply
CO 3	Outline the I/O streams that develop Applet in JAVA.	Understand
CO 4	Illustrate the advanced features of JAVA such as Multithreading and Error Management.	Understand
CO 5	Express the concepts of Database Management.	Understand

iv) SYLLABUS

Object- oriented thinking-History of object-oriented programming, overview of JAVA, Object- oriented design, Structure of JAVA program. Types and modifiers, Classes, declaring objects in classes, Methods, constructors.

Inheritance-various forms and types of inheritance, Method overloading, method overriding, Applications of method overriding, abstract classes, Interfaces and implementation.

Streams and Files -Object Streams, Applets- methods, creation, designing and examples.

File Management, Multithreaded programming, Managing Errors and Exceptions.

Database Programming and Query Execution.

v) (a) TEXT BOOKS

1) Cay S. Horstmann and Gary Cornell, *CORE JAVA: Volume I & II– Fundamentals*, Pearson Education, 2013.
2) Herbert Schildt, *Java-The Complete Reference*, Tata McGraw Hill ,10th Edition, 2017.
3) Timothy Budd, *Understanding Object-oriented programming with JAVA*, Pearson Education, 3rd Edition, 2001.

(b) REFERENCES

1) Harvey M., Paul J. Deitel., *Java how to program*,10th Edition, Pearson Education (2012): 390- 420.
2) Doug Lea, *Concurrent programming in Java Design Principles and Patterns*, Pearson Education, 2nd Edition, 2000.
3) K. Arnold and J. Gosling, *The JAVA programming language*, Pearson Education, 4th Edition, 2005.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Concepts of OOP** – Introduction to OOP, Procedural Vs. Object Oriented Programming, Principles of OOP, Benefits and applications of OOP. **Programming with JAVA** – Overview of JAVA Language- Objects, classes and Methods in JAVA – defining classes – methods – access specifiers – static methods– constructors, Arrays – Strings -Packages – JavaDoc comments	9
II	**Inheritance** – class hierarchy – polymorphism – dynamic binding – final keyword – abstract classes – the Object class – Reflection – interfaces – object cloning – inner classes Method Overloading, Overriding Methods, Final Variables and Methods.	9
III	**Streams and Files** -Use of Streams, Object Streams. Applet Basics-The Applet HTML Tags and Attributes, Multimedia, The Applet Context, JAR Files.	9
IV	**File Management**- Multithreaded programming– Thread properties – Creating a thread -Interrupting threads –Thread priority- thread synchronization – Synchronized method -Inter thread communication, Managing Errors and Exceptions	9
V	**Database Programming** -The Design of JDBC, The Structured Query Language, JDBC Installation, Basic JDBC Programming Concepts, Query Execution	9
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EET1U31F	MATERIAL SCIENCE	PEC	3	0	0	3	2020

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW: This course introduces different types of materials used in electrical engineering such as conductors, semiconductors, insulators, solar energy materials, biomaterials, nanomaterials, superconducting materials and magnetic materials. Also, this gives a detailed explanation on dielectrics, polarisation, modern techniques in material science and their applications.

iii) COURSE OUTCOMES

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

CO 1	Describe the characteristics of conductor, semiconductor and solar energy materials.	Understand
CO 2	Classify different insulating materials and describe polarisation in dielectrics.	Understand
CO 3	Explain the mechanisms of breakdown in solids, liquids and gases.	Understand
CO 4	Classify and describe magnetic materials and superconducting materials.	Understand
CO 5	Explain the recent developments in materials science, modern techniques and their applications in important walks of life.	Understand

iv) SYLLABUS

Conducting materials- dependence of conductance on temperature and composition; Semiconductor materials-concepts, classifications and properties; Solar energy materials-Solar selective coatings- Organic solar cells.

Dielectrics – Polarization – Classification - Clausius-Mossotti relation; Insulating materials-classification-capacitor materials; Electronegative gases- Ferroelectricity.

Dielectric breakdown- Breakdown in solid, liquid and gaseous dielectrics- Vacuum insulation-Testing and treatment of transformer oil.

Magnetic materials- Curie- Weiss laws- Iron and its alloys; Superconductor materials- types-characteristics and application.

Biomaterials- Nanomaterials- Growth techniques; Modern techniques for material studies.

v) (a) TEXT BOOKS

1) Dekker A.J., Electrical Engineering Materials, First Edition, Pearson Education India, 2015.
2) G.K. Mithal, Electrical Engineering Material Science. Khanna Publishers, 1991.
3) K.K. Chattopadhyay, A. N. Banerjee: Introduction to nanoscience and nanotechnology, PHI Learning Pvt. Ltd., 2009.

(b) Reference Books

1) Naidu M. S. and V. Kamaraju, *High Voltage Engineering*, Tata McGraw Hill, 2004.

2) Indulkar C.S. & Thiruvegadam S., An Introduction to Electrical Engineering Materials, S.Chand, 2015.
3) Joon Bu Park, Biomaterials Science and Engineering, Plenum Press, New York, 1984.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Conducting Materials: Conductivity- dependence on temperature and composition – Materials for electrical applications such as resistance, machines, solders etc. Semiconductor Materials: Concept, materials and properties– Basic ideas of Compound semiconductors, amorphous and organic semiconductors-applications. Solar Energy Materials: Solar selective coatings for enhanced solar thermal energy collection. Solar cells -Silicon, Cadmium sulphide and Gallium arsenic – Organic solar cells.	9
II	Dielectrics: Introduction to Dielectric polarization and classification– Clausius-Mossotti relation. Insulating materials and classification- properties- Common insulating materials used in electrical apparatus-Inorganic, organic, liquid and gaseous insulators- capacitor materials. Electro-negative gases- properties and applications of SF6 gas and its mixtures with nitrogen Ferro electricity.	9
III	Dielectric Breakdown: Mechanism of breakdown in gases, liquids and solids –basic theories including Townsend's criterion, Streamer mechanism. Mechanism of breakdown in liquids and solids - suspended particle theory, Bubble theory, Stressed oil Volume Theory, intrinsic breakdown, electro-mechanical breakdown, Thermal breakdown, Treeing and Tracking. Application of vacuum insulation- Breakdown in high vacuum. Basics of treatment and testing of transformer oil.	10
IV	Magnetic Materials: Classification of magnetic materials -Curie-Weiss law-Application of iron and its alloys- Hard and soft magnetic materials– Ferrites- Magnetic materials used in electrical apparatus. Superconductor Materials:- Basic Concept- types, characteristics-applications.	8
V	Novel materials: Introduction to Biomaterials, Nano-materials and their significance. Growth techniques of nano-materials – Top-down and Bottom-up techniques, Lithographic and Non-lithographic processes (qualitative study only). Modern Techniques for materials studies: Optical microscopy – Electron microscopy – Photo electron spectroscopy – Atomic absorption spectroscopy.	9
	Total hours (Approx.)	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1U31G	SOFT COMPUTING	PEC	3	0	0	3	2020

i) PRE-REQUISITE: Digital Electronics

ii) COURSE OVERVIEW: Goal of this course is to provide an exposure to the students on the fundamental concepts of different soft computing techniques, including the basics of Artificial Neural Networks, Fuzzy logic, Genetic algorithms and Machine learning. It gives an insight into the different types of Artificial Neural Network architectures, the learning processes and algorithms, the properties and operations of fuzzy logic, the working of a fuzzy logic system, the operators of Genetic Algorithms and some hybrid systems. This course also provides a broad introduction to machine learning, data clustering algorithms and support vector machines.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Describe the basics of Fuzzy Logic, Artificial Neural Networks and Genetic Algorithm.	Understand
CO 2	Apply fuzzy logic techniques to control a system.	Apply
CO 3	Distinguish the different Artificial Neural Network architectures and the different learning methods for training of ANNs.	Understand
CO 4	Utilize genetic algorithm techniques to find the optimal solution of a given problem.	Understand
CO 5	Explain the basics of machine learning, data clustering algorithms and support vector machines.	Understand

iv) SYLLABUS

Basic Introduction – Difference between soft computing and hard computing; artificial intelligence.

Fuzzy logic - Fuzzy set properties and operations; membership functions, Fuzzy logic systems; Applications.

Artificial Neural Networks - Biological foundations; ANN models; architecture; Learning process; Supervised and unsupervised learning; Back propagation network, Radial Basis Function.

Genetic Algorithm – basic concepts, operators, steps.

Hybrid Systems - Adaptive Neuro-fuzzy Inference System (ANF1S), Genetic algorithm based back propagation networks, fuzzy back propagation networks.

Machine Learning- Machine learning model, Machine learning architecture- Data Clustering Algorithms.

Support Vector Machines for Learning – Linear Learning Machines – Support Vector Classification – Support Vector Regression.

v) (a) TEXT BOOKS

1) Timothy J. Ross, *Fuzzy logic with Engineering Applications*, Wiley Publications, 3rd edition, 2010.
2) S. Rajasekharan, G. A. Vijayalakshmi Pai, *Neural Network, Fuzzy Logic and Genetic Algorithms Synthesis and Applications*, Prentice Hall India, 2003.
3) S. N. Sivanandan, S. N. Deepa, *Principles of Soft Computing*, Wiley India, 2007.
4) Simon Haykin, *Neural Networks a Comprehensive foundation*, Pearson Education, 1999.
5) Suran Goonatilake & Sukhdev Khebbal (Eds.), *Intelligent Hybrid Systems*, John Wiley, 1995.
6) D. E. Goldberg, *Genetic Algorithms in Search Optimisation and Machine Learning*, Pearson Education, 1989.
7) Tom Mitchell, *Machine Learning*, McGraw Hill, 1997.

(b) REFERENCES

1) Bart Kosko, *Neural Network and Fuzzy Systems*, Prentice Hall of India, 2002.
2) Zurada J. M., *Introduction to Artificial Neural Systems*, Jaico Publishers, 2003.
3) Hassoun Mohammed H., *Fundamentals of Artificial Neural Networks*, Prentice Hall of India, 2002.
4) J. S. R. Jang, C. T. Sun, E. Mizutani, *Neuro-Fuzzy and Soft Computing*, Prentice Hall, 1997.
5) Driankov D., Hellendoorn H., Reinfrank M, *An Introduction to Fuzzy Control*, Narosa Publications, 1993.
6) Ronald R. Yager and Dimitar P. Filev, *Essentials of Fuzzy Modelling & Control*, John Wiley & Sons, Inc, 2002.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction**: Conventional and Modern Control System, Soft and Hard Computing, Artificial Intelligence. **Fuzzy Logic**: Introduction to crisp sets and fuzzy sets, Properties, Basic fuzzy set operations, examples. Membership function, types - triangular, trapezoidal, bell shaped, gaussian, sigmoidal etc. Fuzzy relations - Cardinality of Fuzzy relations - Operations on Fuzzy relations - Properties of Fuzzy relations.	8
II	**Fuzzy logic controller**: Block diagram -Fuzzification, rule base, inference engine and defuzzification - Max-membership principle, Centroid method, Weighted Average Method, Mean-Max membership, Center of Sums, and Center of Largest area, First and Last of Maxima - simple fuzzy logic controllers with examples.	8
III	**Artificial Neural Networks**: Biological foundations – ANN models - Characteristics of ANN - Types of activation function - McCulloch-Pitts neuron model, Logic implementations using McCulloch-Pitts neuron model.	9

	Neural network architecture and learning: Single layer, multilayer, recurrent network architectures. Knowledge representation - Learning process - Supervised and unsupervised learning.	
IV	**Learning algorithms**: Error correction learning - Hebbian learning – Boltzmann learning - competitive learning. Linear Separability, Pattern Classification: Perceptrons. Back propagation network and its architecture, Derivation of the back-propagation algorithm – Case study. Radial basis function networks.	**10**
V	**Genetic Algorithm**: Introduction - basic concepts of Genetic Algorithm, encoding, fitness function, reproduction, cross over, mutation operator, bit-wise operators, generational cycle. **Hybrid Systems**: Adaptive Neuro-fuzzy Inference System (ANF1S), Genetic algorithm based back propagation networks, fuzzy back propagation networks, examples. **Machine Learning:** Machine learning model-Approaches to machine learning - Machine learning architecture - Data Clustering Algorithms - Hierarchical clustering, K-Means Clustering. Support Vector Machines for Learning – Linear Learning Machines – Support Vector Classification – Support Vector Regression - Applications.	**10**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance : 10 marks

CA Exams (2 numbers) : 25 marks

Assignment/Project/Case study etc. : 15 marks

Total : **50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
HS0U30A	INDUSTRIAL ECONOMICS AND FOREIGN TRADE	HSC	3	0	0	3	2020

i) PRE-REQUISITE: NIL

ii) COURSE OVERVIEW:

The course enables students to make better economic decisions in wage employment and entrepreneurship using economic alternatives and investment alternatives.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Learning Level
CO 1	Explain the problem of scarcity of resources, consumer behaviour and the equilibrium condition of demand and supply.	Understand
CO 2	Demonstrate the production function and equilibrium condition of a producer	Understand
CO 3	Survey the impact of market competition in the functional requirement of a firm and pricing of goods and services.	Analyze
CO 4	Infer the overall performance of the economy, the regulation of economic fluctuations and its impact on various sections in the society.	Analyze
CO 5	Compare the profitability of projects and economic performance of business with the help of capital budgeting methods.	Evaluate
CO 6	Determine the current impact of global economic policies on the business opportunities of a firm	Analyze

iv) SYLLABUS

Scarcity and choice - Basic economic problems- PPC – Firms and its objectives – types of firms – Utility – Law of diminishing marginal utility – Demand and its determinants – law of demand – elasticity of demand – measurement of elasticity and its applications – Supply, law of supply and determinants of supply – Equilibrium – Changes in demand and supply and its effects – Consumer surplus and producer surplus (Concepts) – Taxation and deadweight loss.

Production function – law of variable proportion – economies of scale – internal and external economies – Isoquants, isocost line and producer's equilibrium – Expansion path – Technical progress and its implications – Cobb-Douglas production function - Cost concepts – Social cost: private cost and external cost – Explicit and implicit cost – sunk cost - Short run cost curves - long run cost curves – Revenue (concepts) – Shutdown point – Break-even point.

Perfect and imperfect competition – monopoly, regulation of monopoly, monopolistic completion (features and equilibrium of a firm) – oligopoly – Kinked demand curve – Collusive oligopoly (meaning) – Non-price competition – Product pricing – Cost plus pricing – Target return pricing – Penetration pricing – Predatory pricing – Going rate pricing – Price skimming. Principles of taxation - Direct Tax – Indirect Tax – GST. Concepts of demonetization. Cryptocurrency

Circular flow of economic activities – Stock and flow Gross. National Income – Concepts - Methods of measuring national income – Inflation- causes and effects – Measures to control inflation. Monetary and fiscal policies – Business financing- Bonds and shares - Money market and Capital market – Stock market – Demat account and Trading account - SENSEX and NIFTY. Capital Budgeting - Methods of Investment analysis - Pay back, ARR, NPV, IRR and B/C ratio

Advantages and disadvantages of international trade - Absolute and Comparative advantage theory - Heckscher - Ohlin theory - Balance of payments – Components – Balance of Payments deficit and devaluation – Trade policy – Free trade versus protection – Tariff and non-tariff barriers.

v) REFERENCE BOOKS

1) Gregory N Mankiw, 'Principles of Micro Economics', Cengage Publications, 2015.
2) Gregory N Mankiw, 'Principles of Macro Economics', Cengage Publications, 2012.
3) Dwivedi D.N., 'Macro Economics', Tata McGraw Hill, New Delhi, 2018.
4) Mithani D M, 'Managerial Economics', Himalaya Publishing House, Mumbai, 2017.
5) Tulsian, 'Financial Management' S Chand & Company 2017.
6) Francis Cherunilam, 'International Economics', McGraw Hill, New Delhi, 2017.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Scarcity and choice - Basic economic problems- PPC – Firms and its objectives – types of firms – Utility – Law of diminishing marginal utility – Demand and its determinants – law of demand – elasticity of demand – measurement of elasticity and its applications – Supply, law of supply and determinants of supply – Equilibrium – Changes in demand and supply and its effects – Consumer surplus and producer surplus (Concepts) – Taxation and deadweight loss.	8
II	Production function – law of variable proportion – economies of scale – internal and external economies – Isoquants, isocost line and producer's equilibrium – Expansion path – Technical progress and its implications – Cobb-Douglas production function - Cost concepts – Social cost: private cost and external cost – Explicit and implicit cost – sunk cost - Short run cost curves - long run cost curves – Revenue (concepts) – Shutdown point – Break-even point.	8
III	Perfect and imperfect competition – monopoly, regulation of monopoly, monopolistic completion (features and equilibrium of a firm) – oligopoly – Kinked demand curve – Collusive oligopoly (meaning) – Non-price competition – Product pricing – Cost plus pricing – Target return pricing – Penetration pricing – Predatory	9

	pricing – Going rate pricing – Price skimming. Principles of taxation - Direct Tax – Indirect Tax – GST. Concepts of demonetization. Cryptocurrency	
IV	Circular flow of economic activities – Stock and flow Gross. National Income – Concepts - Methods of measuring national income – Inflation- causes and effects – Measures to control inflation. Monetary and fiscal policies – Business financing- Bonds and shares -Money market and Capital market – Stock market – Demat account and Trading account - SENSEX and NIFTY. Capital Budgeting - Methods of Investment analysis - Pay back, ARR, NPV, IRR and B/C ratio.	**11**
V	Advantages and disadvantages of international trade - Absolute and Comparative advantage theory - Heckscher - Ohlin theory - Balance of payments – Components – Balance of Payments deficit and devaluation – Trade policy – Free trade versus protection – Tariff and non-tariff barriers.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance : 10 marks

CA Exams (2 numbers) : 25 marks

Assignment/Project/Case study etc. : 15 marks

Total : 50 marks

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1U30H	COMPREHENSIVE COURSE WORK	PCC	1	0	0	1	2020

i) COURSE OVERVIEW:

The goal of this course is to assess the comprehensive knowledge gained by a student in core courses relevant to the branch of study

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Discuss the fundamental aspects of any engineering problem or situation relevant to the branch of study.	Understand

iii) SYLLABUS

The comprehensive course work will be conducted covering the following core courses studied from third to fifth semester.

Sl. No.	Course Code	Course Name
1	EET201	Electrical Circuit Analysis
2	EET205	Analog Electronic Circuits
3	EET202	DC Machines and Transformers
4	EET206	Digital Electronics and Logic Design
5	EET301	Power Systems I
6	EET307	Synchronous and Induction Machines

iv) MARK DISTRIBUTION

Total Marks	ESE	ESE Duration
50	50	1 hour

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1U38C	POWER SYSTEMS LAB	PCC	0	0	3	2	2020

i) PRE-REQUISITE: EE1U30F Power Systems I.

ii) COURSE OVERVIEW:

Objective of the course is to train the students to perform load flow studies, short circuit studies, stability studies and automatic generation control using software. This course also imparts practical knowledge in testing Ferranti effect in transmission line, testing various power system components as per the standards, plotting relay characteristics, improving power factor of induction motor, measuring earth electrode.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Perform load flow studies and short circuit studies and stability studies on a given power system network, using software.	Apply
CO 2	Perform AGC of single area and two area system using MATLAB Simulink.	Apply
CO 3	Measure the dielectric strength of a material or medium.	Apply
CO 4	Demonstrate Ferranti effect on a transmission line.	Apply
CO 5	Improve the power factor of an inductive load to a desired value.	Apply
CO 6	Measure Earth electrode resistance of an Earthing system	Apply

iv) SYLLABUS

Software Experiments: Load flow studies, short circuit studies, transient stability studies, AGC, distribution system with solar PV arrays, Ferranti effect, reactive power control, VI Characteristics of PV module, MPPT control.

Hardware Experiments: high voltage testing, Ferranti effect, relay testing, insulation testing, Earth electrode resistance, testing of CT and PT, Testing of dielectric strength, power factor improvement.

v) REFERENCES

1) Hadi Saadat, *Power System Analysis*, 2/e, McGraw Hill, 2002.
2) Kothari D. P. and I. J. Nagrath, *Modern Power System Analysis*, 2/e, TMH, 2009.
3) M. S. Naidu, V. Kamaraju, *High Voltage Engineering*, Tata McGraw-Hill Education, 2004.
4) Wadhwa C. L., *Electrical Power Systems*, 3/e, New Age International, 2009.
5) IEC 61850.
6) IEEE 1547 and 2030 Standards.
7) IS Codes for Testing of Power System components.
8) IEC 61724-1:2017 Performance of Solar Power Plants.

vi) COURSE PLAN

At least 12 experiments (6 hardware experiments are mandatory)

Expt No.	List of exercises/experiments	No. of hours
Part A: POWER SYSTEM SIMULATION EXPERIMENTS		
I	Load Flow Studies –Gauss- Siedel Method, Newton- Raphson Method, Fast Decoupled Method – Effect of change in load/generation schedule	**3**
II	Load Flow Studies –Gauss- Siedel Method, Newton- Raphson Method, Fast Decoupled Method – Effect of change in real power/reactive power limits	**3**
III	Short Circuit Studies – Symmetrical Faults	**3**
IV	Short Circuit Studies –Unsymmetrical Faults	**3**
V	Contingency Ranking	**3**
VI	Transient Stability Studies	**3**
VII	Automatic Generation Control – Single Area, Two Area	**3**
VIII	Distribution Systems with Solar PV units	**3**
IX	Ferranti Effect and Reactive Power Compensation.	**3**
X	Plot the IV characteristics of a PV module and determine Maximum Power Point.	**3**
Part B: POWER SYSTEM COMPONENT TESTING (Hardware experiments)		
I	High voltage testing -Power frequency/Impulse	**3**
II	High voltage testing –DC	**3**
III	Ferranti Effect	**3**
IV	Relay Testing - Over current relay/Earth fault (Electromechanical/Static/Numerical)	**3**
V	Relay Testing –Voltage relay/ Impedance Relay (Electromechanical/Static/Numerical)	**3**
VI	Insulation Testing – LT & HT Cable	**3**
VII	Earth Electrode Resistance	**3**
VIII	Testing of CT and PT	**3**
IX	Testing of transformer oil	**3**
X	Testing of dielectric strength of solid insulating materials	**3**
XI	Testing of dielectric strength of air	**3**
XII	Power factor improvement	**3**
	Total Hours	**30**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	15 marks
CA Exams (1 number)	:	30 marks
Assignment/Project/Case study etc.	:	30 marks
Total	:	**75 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	75	75	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1U38D	POWER ELECTRONICS LAB	PCC	0	0	3	2	2020

i) COURSE OVERVIEW:

The main objective of the course is to expose the students to design and implementation of triggering circuit. It also includes design and implementation of converter circuits and MATLAB simulation of closed loop control of DC and AC drives

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Determine the characteristics of SCR and design triggering circuits for SCR based circuits	Apply
CO 2	Design, set up and analyze single phase AC voltage controllers.	Apply
CO 3	Design, set up and test suitable gate drives for MOSFET/IGBT.	Apply
CO 4	Design, set up and test basic inverter topologies.	Apply
CO 5	Design and set up dc-dc converters.	Apply
CO 6	Develop simulation models of dc-dc converters, rectifiers and inverters using modern simulation tools.	Apply

iii) SYLLABUS

- Study of Characteristics of SCR
- Triggering Circuits for SCR – 2 Sessions
- AC Voltage Controller using TRIAC
- Design and Analysis of AC-DC, DC-AC and DC-DC circuits – 3 Sessions
- Gate Driver Circuits for MOSFET/IGBT
- Speed control of DC motor using converters
- Implementation of Speed control Techniques for a separately excited DC Motor using MATLAB/SIMULINK- 2 Sessions
- Design and Simulation of PWM based DC-AC Converter using MATLAB/SIMULINK
- Design and simulation of Buck, Boost & Buck-Boost Converter in MATLAB/SIMULINK
- Simulation of 3-phase fully-controlled converter with R, RL, RLE loads in MATLAB/SIMULINK -3 Sessions
- Comparative study of PWM and Square wave inverters.in MATLAB/SIMULINK.

iv) REFERENCES

1) Rashid M.H., *Power Electronics – Circuits, Devices and Applications*, Prentice Hall of India, New Delhi, 4th edition, 2014.

2) Ned Mohan, Tore M. Undeland, William P. Robbins, *Power Electronics: Converters, Applications, and Design*, Wiley India, 3rd Edition, 2018.
3) Dubey G. K. *Power Semiconductor Control Drives,* Prentice Hall, Englewood Cliffs, New Jersey, 1989.

v) COURSE PLAN

12 experiments are mandatory (8 Hardware & 4 Software)

Experiment No	List of exercises/experiments	No of hours
1	Static characteristics of SCR	**3**
2	R and RC firing scheme for SCR control	**3**
3	Line Synchronised Triggering Circuits of SCR	**3**
4	AC Voltage Controller	**3**
5	Gate Driver Circuits for MOSFET/IGBT	**3**
6	Single Phase fully Controlled SCR bridge rectifier	**3**
7	Design of Inductor/Transformer	**3**
8	Single-phase half bridge/full bridge inverter using power MOSFET/IGBT	**3**
9	Three phase sine PWM Inverter using IGBT	**3**
10	Speed control of DC motor using chopper	**3**
11	Speed control of 3-phase induction motor	**3**
12	Design and set-up buck/ boost / buck-boost converters	**3**
13	Simulation of 1-phase fully-controlled and half-controlled rectifier fed separately excited DC motor	**3**
14	Simulation of buck/boost/buck-boost converters	**3**
15	Simulation of Dual Converter – 4 quadrant operation of separately excited DC motor	**3**
16	Simulation of single phase & three phase sine PWM inverters.	**3**
17	Simulation of 3-phase fully-controlled converter with R, RL, RLE loads	**3**
18	Comparative study of PWM and Square wave inverters.	**3**
	Total hours	**30**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	15 marks
CA Exams (1 number)	:	30 marks
Assignment/Project/Case study etc.	:	30 marks
Total	:	**75 marks**

vii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	75	75	3 hours

B.Tech (S5 - MINOR)

Basket	Course Number	Course	L-T-P	Credit
I	EE0M30A	Solid State Power Conversion	3-1-0	4
II	EE0M30B	Solar and Wind Energy Conversion Systems	3-1-0	4
III	EE0M30C	Control Systems	3-1-0	4
IV	EE0M30D	Energy efficiency in Buildings	4-0-0	4

B.Tech Minor offered by the Department of Science & Humanities

Course Number	Course	L-T-P	Credit
MA0M30A	Random Process and Queuing Theory	3-1-0	4

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE0M30A	SOLID STATE POWER CONVERSION	VAC	3	1	0	4	2020

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

To impart knowledge about the power semiconductor devices, operation and performance of different power converters and its applications

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Explain the operation of various power semiconductor devices and its characteristics	Understand
CO 2	Select appropriate triggering circuit for thyristor	Understand
CO 3	Analyze the working of various power converters	Understand
CO 4	Describe the principle of operation and voltage control of inverters	Understand
CO 5	Compare the features and performance of different dc-dc converters.	Understand

iv) SYLLABUS

Power semiconductor devices-specifications of switches, steady state characteristics of Power MOSFET and IGBT. SCR – Operation, V-I characteristics, steady state and switching characteristics, two transistor model, power diodes, operation of TRIAC, series and parallel connection of SCRs.

Gate triggering circuits – R and RC triggering circuits – isolation circuits using opto-isolators and pulse transformers.

Controlled rectifiers – half-wave controlled rectifier with R load – single phase fully controlled & half controlled bridge rectifier with R, RL and RLE loads– output voltage equation.

Three phase half-wave-controlled rectifier with R load – three phase fully controlled & halfcontrolled converter with RLE load– output voltage equation, waveforms for various triggering angles – single phase and three phase dual converter.

AC voltage controllers (ACVC) – 1-phase full-wave ACVC with R, & RL loads – waveforms – RMS output voltage, sequence control (two stage) with R load.

Inverters – voltage source inverters – single phase half-bridge & full bridge inverter with R & RL loads – 3-phase bridge inverter with R load – 120° & 180° conduction mode, current source inverters.

Voltage control in inverters – Pulse Width Modulation – single pulse width, multiple pulse width & sine PWM – modulation index & frequency modulation ratio.

DC-DC converters – step down and step up choppers – quadrN – pulse width modulation & current limit control in dc-dc converters.

Switching regulators – buck, boost & buck-boost – operation in continuous conduction mode – steady state waveforms – selection of components.

v) (a) TEXT BOOKS

1) Muhammad H. Rashid, Power Electronics Devices, Circuits and Applications, Pearson Education, Fourth edition, 2017.
2) P.S. Bimbhra, Power Electronics, Khanna Publishers, New Delhi, 2018.

(b) REFERENCES

1) Mohan N., T. M. Undeland and W. P. Robbins., Power Electronics, Converters, Applications & Design, Wiley-India, 3rd Edition, 2002.
2) Krein P. T., Elements of Power Electronics, Oxford University Press, 1998.
3) L. Umanand, Power Electronics – Essentials & Applications, Wiley-India, 2009.
4) Alok Jain, Power Electronics and its Applications, Penram International Publishing (I) Ltd, 2016.
5) Singh M. D. and K. B. Khanchandani, Power Electronics, Tata McGraw Hill, New Delhi, 2008.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Power semiconductor devices**, their symbols and static characteristics, specifications of switches, steady state characteristics of Power MOSFET and IGBT. **SCR** – Operation, V-I characteristics, steady state and switching characteristics, two transistor model, methods of turn-on, power diodes, operation of TRIAC, series and parallel connection of SCRs	12
II	**Gate triggering circuits** – R and RC triggering circuits – isolation circuits using opto-isolators and pulse transformers. **Controlled rectifiers** – half-wave controlled rectifier with R load – single phase fully controlled bridge rectifier with R, RL and RLE loads (continuous conduction) – output voltage equation – single phase half controlled bridge rectifier with R, RL and RLE loads.	12
III	**Three phase Rectifiers** - three phase half-wave-controlled rectifier with R load – three phase fully controlled & half controlled converter with RLE load (continuous conduction) – output voltage equation waveforms for various triggering angles (analysis not required) – single phase and three phase dual converter. **AC voltage controllers** (ACVC) – 1-phase full-wave ACVC with R, & RL loads – waveforms – RMS output voltage, sequence control (two stage) with R load.	12
IV	**Inverters** – voltage source inverters – single phase half-bridge & full bridge inverter with R & RL loads – 3-phase bridge inverter with R load – 120° & 180° conduction mode, current source inverters. **Voltage control in inverters** – Pulse Width Modulation – single pulse width, multiple pulse width & sine PWM – modulation index & frequency modulation ratio.	12

V	**DC-DC converters** – step down and step up choppers – single-quadrant, two-quadrant & four quadrant chopper – pulse width modulation & current limit control in dc-dc converters. **Switching regulators** – buck, boost & buck-boost – operation in continuous conduction mode – steady state waveforms – selection of components	**12**
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance : 10 marks

CA Exams (2 numbers) : 25 marks

Assignment/Project/Case study etc. : 15 marks

Total : 50 marks

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE0M30B	SOLAR AND WIND ENERGY CONVERSION SYSTEMS	VAC	3	1	0	4	2020

i) PRE-REQUISITE: ES0U10D Basics of Electrical and Electronics Engineering, EE0M20C Sustainable Energy Systems.

ii) COURSE OVERVIEW:

This course aims to impart the knowledge of renewable energy sources as sustainable development. The students will be familiarised with the major aspects of solar and wind energy conversion systems. This course also aims at providing the fundamental information in modelling the energy conversion systems.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Explain the basics of solar energy conversion systems.	Understand
CO 2	Explain the principle behind solar thermal systems and its applications.	Understand
CO 3	Apply the design aspects of solar photovoltaic systems in sizing its components.	Apply
CO 4	Describe the concepts involved in wind energy systems.	Understand
CO 5	Classify various Wind Energy Conversion and Wind Electric Generation Systems and discuss the issues with hybrid energy conversion systems.	Understand

iv) SYLLABUS

Solar Energy - Solar radiation – Solar Radiation on an Inclined/Tilted Surface.
Solar Thermal Systems – Solar Concentrators – Applications.
Solar photovoltaic systems - Characteristics - Types of solar cells - PV Module - Block diagram of SPV system – MPPT – Design of SPV - Modelling of SPV.
Wind Energy - Wind power and its sources - Modes of wind power generation.
Wind Energy Conversion Systems WECS – Principles - Classification of WECS - Wind Electric Generation Systems - Effects of Wind Speed and Grid Condition.

v) (a) TEXT BOOKS

1) Earnest J. and T. Wizelius, *Wind Power Plants and Project Development*, Prentice Hall of India, Learning Private Limited, 2nd edition, 2015.
2) Godfrey Boyle, *Renewable Energy: Power for a sustainable future*, Oxford University Press, 2012.
3) Rai. G.D, *Non-conventional Energy Sources*, Khanna publishers, 2011.
4) A.A.M. Saigh (Ed): *Solar Energy Engineering*, Academic Press, 1977.

5) G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers, 2002.

(b) REFERENCES

1) Gary, L. Johnson, *Wind Energy System*, Prentice Hall, 1985.
2) C. S. Solanki, *Solar Photovoltaics: Fundamentals Technologies and Applications*, Prentice-Hall of India Pvt. Limited, 3rd edition, 2015.
3) Rai. G.D, *Solar Energy Utilization*, Khanna Publishers, 1995.
4) Kastha D, Banerjee S and Bhadra S N, *Wind Electrical Systems*, Oxford University Press, New Delhi, 2005.
5) Rashid M.H., *Power Electronics Circuits, Devices and Applications*, 4th edition, Pearson Education, 2017.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction** - Basic Concept of Energy - Source of Solar Energy - Formation of the Atmosphere - Solar Spectrum. Solar Constant - Air Mass - Solar Time-Sun – Earth Angles - Solar Radiation - Instruments to Measure Solar Radiation - Pyrheliometer – Pyranometer - Sunshine Recorder -Solar Radiation on a Horizontal Surface - Extra-terrestrial Region - Terrestrial Region - Solar Radiation on an Inclined Surface - Conversion Factors - Total Solar Radiation on an Inclined/Tilted Surface - Monthly Average Daily Solar Radiation on Inclined Surfaces.	12
II	**Solar Thermal System** - Principle of Conversion of Solar Radiation into Heat, – Solar thermal collectors – General description and characteristics – Flat plate collectors – Heat transfer processes – Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) – performance evaluation. Applications - Solar heating system, Air conditioning and Refrigeration system, Pumping system, solar cooker, Solar Furnace, Solar Greenhouse -Design of solar water heater.	11
III	**Solar PV Systems** - Introduction - Fundamentals of Semiconductor and Solar Cells - Photovoltaic Effect - Solar Cell (Photovoltaic) Materials - Basic Parameters of the Solar Cell - Generation of Solar Cell (Photovoltaic) Materials-.Photovoltaic (PV) Module and PV Array - Single-Crystal Solar Cell Module, Thin-Film PV Modules, III- V Single Junction and Multijunction PV Modules - Emerging and New PV Systems - Packing Factor of the PV Module - Efficiency of the PV Module - Energy Balance Equations for PV Modules -Series and Parallel Combination of PV Modules - Effect of shadowing-Maximum Power Point Tracker (MPPT) using buck-boost converter. Solar PV Systems – stand-alone and grid connected - Design steps for a Stand-Alone system – Storage batteries and Ultra capacitors.	13
IV	**Wind Turbines** – Introduction - Origin of Winds - Nature of Winds – Classification of Wind Turbines - Wind Turbine Aerodynamics - Basic principles of wind energy extraction – Extraction of wind turbine power (Numerical problems) - Weibull distribution - Wind power generation curve-Betz's Law - Modes of wind power generation.	12

V	**Wind Energy Conversion Systems** – Introduction - Components of WECS - Fixed speed drive scheme - Variable speed drive scheme - Wind–Diesel Hybrid System – Induction generators - Doubly Fed Induction Generator (DFIG) - Squirrel Cage Induction Generator (SCIG) - Power converters in renewable energy system - AC-DC Converters, DC-DC Converters, DC-AC Converters (Block Diagram Only) - Effects of Wind Speed and Grid Condition (System Integration) - Environmental Aspects - Wind Energy Program in India.	**12**
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE0M30C	CONTROL SYSTEMS	VAC	4	0	0	4	2020

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

This course aims to introduce the concepts of controls and modelling of physical systems. It also helps to give an idea on system response analysis and stability of systems and also to use different methods to Analyze stability of control systems.

iii) COURSE OUTCOMES

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

CO 1	Describe the types of control systems and controllers used in feedback systems.	Understand
CO 2	Describe the various control system components.	Understand
CO 3	Analyze the time domain response of the given LTI systems.	Apply
CO 4	Apply time domain techniques to check the stability of LTI systems.	Apply
CO 5	Analyze the frequency domain response of the given LTI systems.	Apply

iv) SYLLABUS

Elementary ideas on types of control systems, Elementary ideas on types of controls, Mathematical models of physical systems.

Control system components.

Block diagram, signal flow graphs, Time response of first and second order systems.

Effect of pole locations, Routh's stability criterion.

Root locus method of analysis and design.

Bode's plot, Polar plots, Nyquist stability criterion, Stability in frequency domain, Gain margin and Phase margin.

v) (a) TEXT BOOKS

1) Kuo B. C., Automatic Control Systems, Prentice Hall, 2012.
2) Thaler and Brown, Analysis and Design of Feedback Control Systems, McGraw Hill, 1960.
3) Nagrath I J and Gopal M, Control Systems Engineering, New Age India Pvt Limited, 2009.
4) Dorf R. C. and Bishop R. H, Modern Control Systems, 12th edition, Pearson Education, 2011.

(b) Reference Books

1) Ogata, K., Modern Control Engineering, Pearson Education, 2004.
2) Gopal M., Control Systems Principles and Design, 4/e, Tata McGraw Hill, 2014.

3) Imthias Ahamed T. P, Control Systems, Phasor Books, 2016.
4) Heuring V. P. and Jordan H. F., Computer System Design and Architecture, Pearson, 2nd edition, 2004.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to control systems: Elementary ideas on types of control systems - Open loop and closed loop systems, Servo systems, Automatic regulating systems, Process control systems, Adaptive control systems, Learning control systems, Discrete control systems, Multivariable control systems, Linear and Non-linear systems. Elementary ideas on types of controls - proportional, integral, proportional integral, proportional integral derivative controls. Direct and indirect controls. Mathematical models of physical systems – typical examples of mechanical, thermal, electrical, hydraulic and pneumatic systems, Transfer function.	12
II	Control system components – servomotors, stepper motor, synchros, hydraulic pumps and motors, hydraulic valves, pneumatic bellows, pneumatic valve, pneumatic relay, pneumatic actuator, gyroscopes (elementary ideas only. No derivations).	12
III	Block diagram, reduction of block diagrams, signal flow graphs: Manson's gain formula. System response - Time response of first and second order systems, steady state errors and error constants, specifications in time domain.	12
IV	Effect of pole locations, Concept of stability, Routh's stability criterion. Root locus method of analysis and design.	12
V	Frequency response analysis - Bode's plot, stability in frequency domain, Gain margin and Phase margin. Polar plots, Nyquist stability criterion, Stability analysis, Relative stability concepts.	12
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE0M30D	ENERGY EFFICIENCY IN BUILDINGS	VAC	4	0	0	4	2020

i) PRE-REQUISITE: Basics of Illumination Science & Lighting Design, Introduction to Electric Power Supply and Distribution Systems.

ii) COURSE OVERVIEW:

Goal of this course is to expose the students to the fundamental concepts of energy efficient design of buildings such as lighting, heating, ventilation etc. This course also intends to make student aware of ECBC, LEED, GRIHA etc.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Identify building services and factors for optimum design of energy efficient buildings.	Apply
CO 2	Discuss the concepts of energy efficient heating and ventilation.	Understand
CO 3	Explain the energy efficiency in pumps, blowers, fans, air conditioning etc.	Understand
CO 4	Discuss the concepts of energy efficient design of buildings.	Understand
CO 5	Identify different energy codes and ratings.	Apply

iv) SYLLABUS

Building Services- Climate adapted and climate rejecting buildings – Bioclimatic zones - Heat Transfer - Thermal Storage- Environmental Factors, Site Planning and Development

Energy efficient heating and ventilation– Terminology – Requirements Thermal performance of Building sections- Natural Ventilation – Purpose of ventilation- Design for Natural Ventilation

Energy efficient lighting-Day Lighting- Lighting principles and fundamentals- Lighting control for day lighted buildings – Switching controls- Power Adjustment Factors

Energy efficiency in pumps, blowers, fans, compressed air system, refrigeration and air conditioning system-Cooling towers- DG sets-Energy efficient HVAC systems

Energy Efficient Design of Buildings - Green Buildings - Energy efficient materials for buildings – Design - Operational energy reduction and net zero building

Energy codes ECBC (ECBC 2007) requirement, Concepts of OTTV etc, Green Performance rating, requirements of LEED, GRIHA etc.

v) (a) TEXT BOOKS

1) Givoni B., *Passive and Low Energy Cooling of Building*s, John Wiley & Sons, Inc, 1994.
2) Callaghn P.W.*, Design and Management for Energy Conservation*, Pergamon Press, John Wiley and Sons Inc, Oxford, 2001.
3) *Energy Conservation Building Code*, Bureau of Energy Efficiency, New Delhi, Bureau of Energy Efficiency Publications-Rating System, TERI Publications- GRIHA Rating System.

(b) REFERENCES

1) Part 1 to 4 SP: 41,1987, *Handbook on Functional Requirements of Buildings*, Bureau of Indian Standards Publication, 1st reprint, 1995.
2) Majumdar M., *Energy - Efficient Buildings in India*, Tata Energy Research Institute, Ministry of Non-Conventional Energy Sources, 2002.
3) Moore, F., *Environmental Control System*, McGraw Hill Inc. 2002
4) Tyagi, A. K., *Handbook on Energy Audits and Management*, Tata Energy Research Institute, 2000.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction- Building Services- Climate adapted and climate rejecting buildings – Heat Transfer – Measuring Conduction – Thermal Storage – Measurement of Radiation –Greenhouse Effect – Convection – Measuring latent and sensible heat – Thermal Comfort – Microclimate, Environmental Factors, Site Planning and Development – Temperature – Humidity – Wind – Steady and Periodic Heat Transfer-Optimum Site Locations.	**12**
II	Energy efficient heating and ventilation- Hourly Solar radiation – Heat insulation – Terminology – Requirements – Heat transmission through building sections – Thermal performance of Building sections – Orientation of buildings – Building characteristics for various climates – Thermal Design of buildings – Influence of Design Parameters – Mechanical controls – Examples. Natural Ventilation – Purpose of ventilation – Minimum standards for ventilation – Ventilation Design – Mechanisms- Energy Conservation in Ventilating systems – Design for Natural Ventilation.	**12**
III	Energy efficient lighting- Day Lighting- Lighting principles and fundamentals- Daylight Factor - Daylight Analysis - Daylight and Shading Devices- Materials, components and details – Insulation – Optical materials – Radiant Barriers – Glazing materials – Glazing Spectral Response-Electric Lighting – Light Distribution – Electric Lighting control for day lighted buildings – Switching controls – Coefficient of utilization – Electric Task Lighting – Electric Light Zones – Power Adjustment Factors.	**12**

IV	Energy efficiency in pumps, blowers, fans, compressed air system, refrigeration and air conditioning system-Cooling towers- DG sets-Energy efficient HVAC systems	**12**
V	Energy Efficient Design of Buildings-Green Buildings-Design-Operational energy reduction and net zero building, Optimization for design of building for energy efficiency and example of optimization through use of Evolutionary genetic algorithm- Effects of trees and microclimatic modification through greening, Use of Building Integrated Photo Voltaic (BIPV) and other renewable energy in buildings, basic concepts and efficiency. Energy codes ECBC (ECBC 2007) requirement, Concepts of OTTV etc, Green Performance rating, requirements of LEED, GRIHA etc.	**12**
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course code	Course Name	Category	L	T	P	Credit	Year of Introduction
MA0M30A	RANDOM PROCESS AND QUEUING THEORY	VAC	3	1	0	4	2022

i) PREREQUISITE: A basic knowledge in calculus and matrix algebra.

ii) COURSE OVERVIEW:

This course introduces learners to the applications of probability theory in the modelling and analysis of stochastic systems, covering important models of random processes such as Poisson Process, Markov chain and queueing systems. The tools and models introduced here have important applications in engineering and are indispensable tools in signal analysis, reliability theory, network queues and decision analysis.

iii) COURSE OUTCOMES:

After the completion of the course the student will be able to

CO 1	Characterize phenomena which evolve probabilistically in time using the tools autocorrelation and power spectrum.	Understand
CO 2	Characterize stationary processes using ergodic property and Analyze processes using poisson model wherever appropriate.	Apply
CO 3	Model and analyze random phenomena using discrete time Markov chains.	Apply
CO 4	Explain basic characteristic features of a queuing system and Analyze queuing models.	Apply
CO 5	Analyze complex queueing systems by applying basic principles of queueing theory.	Apply

iv) SYLLABUS

(Random processes and stationarity) Random processes-definition and classification, mean, autocorrelation, stationarity-strict sense and wide sense, properties of autocorrelation function of WSS processes. Power spectral density of WSS processes and its properties- relation to autocorrelation function. White noise.

(Poisson processes) Ergodic processes-ergodic in the mean and autocorrelation. Mean ergodic theorems (without proof). Poisson processes-definition based on independent increments and stationarity, distribution of inter-arrival times, sum of independent Poisson processes, splitting of Poisson processes.

(Markov chains) Discrete time Markov chain -Transition probability matrix, Chapman Kolmogorov theorem (without proof), computation of probability distribution, steady state probabilities. Classification of states of finite state chains, irreducible and ergodic chains.

(Queueing theory-I) Queueing systems, Little's formula (without proof), Steady state probabilities for Poisson queue systems, M/M/1 queues with infinite capacity and finite capacity and their characteristics-expected number of customers in queue and system, average waiting time of a customer in the queue and system.

(Queueing theory-II) Multiple server queue models, M/M/s queues with infinite capacity, M/M/s queues with finite capacity-in all cases steady state distributions and system characteristics-expected number of customers in queue and system, average waiting time of a customer in the queue and system.

v) TEXT BOOKS

1) Alberto leon Garciai, Probability and random processes for electrical engineering, Pearson Education, Second edition, 1994.
2) V Sundarapandian, Probability statistics and queueing theory, Prentice-Hall of India, 2009.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Random processes and stationarity Random-process, classification, Mean, variance, autocorrelation, auto covariance Strict sense stationary processes WSS processes WSS processes Properties of autocorrelation of a WSS process Power spectral density, relation to autocorrelation Delta function, white noise.	12
II	Ergodicity, Poisson process Ergodic property, definition, examples Mean ergodic theorems and applications Mean ergodic theorems and applications Poisson process-independent increments, stationarity Poisson process-independent increments, stationarity Mean, variance, autocorrelation, autocovariance of Poisson process Distribution of inter-arrival times Splitting (thinning) of Poisson processes Merging of Poisson process.	12
III	Discrete time Markov chain-memorylessness, examplesition probability matrix, Chapman-Kolmogorov theorem Transition probabilities and transition matrices Chapman-Kolmogorov theorem and applications Computation of transient probabilities Computation of transient probabilities classification of states of finite-state chains, irreducible and ergodic chains classification of states of finite-state chains, irreducible and ergodic chains Steady state probability distribution of ergodic chains Steady state probability distribution of ergodic chains.	12
IV	Basic elements of Queueing systems, Little's formula, Steady state probabilities for Poisson queue systems Steady state probabilities for Poisson queue systems M/M/1 queues with infinite capacity, steady state probabilities M/M/1 queues with infinite capacity- computating system characteristics M/M/1 queues with infinite capacity-computating system characteristics M/M/1 queues with finite capacity, steady state probabilities M/M/1 queues with finite capacity-computating system characteristics M/M/1 queues with finite capacity-computating system characteristics.	12
V	Basic elements of multiple server queues M/M/s queues with infinite capacity, steady state probabilities M/M/s queues with infinite capacity, steady state probabilities M/M/s queues with infinite capacity-computing system characteristics M/M/s queues with infinite capacity-computing system characteristics M/M/s queues with finite capacity, steady state probabilities M/M/s queues with finite capacity, steady	12

	state probabilities M/M/s queues with finite capacity- computing system characteristics M/M/s queues with finite capacity- computing system characteristics.	
	Total Hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance : 10 marks

CA Exams (2 numbers) : 25 marks

Assignment/Project/Case study etc. : 15 marks

Total : **50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

B.Tech (S6 - MINOR)

Basket	Course Number	Course	L-T-P	Credit
I	EE0M30E	Power Semiconductor Drives	3-1-0	4
II	EE0M30F	Instrumentation and Automation of Power Plants	4-0-0	4
III	EE0M30G	Digital Control	4-0-0	4
IV	EE0M30H	Electrical System Design and Building services	3-1-0	4

B.Tech Minor offered by the Department of Science & Humanities

Course Number	Course	L-T-P	Credit
MA0M30B	Algebra and Number Theory	3-1-0	4

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE0M30E	POWER SEMICONDUCTOR DRIVES	VAC	3	1	0	4	2020

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

This course is intended to provide fundamental knowledge in dynamics and control of Electric Drives, to justify the selection of Drives for various applications and to familiarize the various semiconductor controlled drives employing various motors

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Explain dynamics and control of electric drives.	Understand
CO 2	Explain the performance of DC motor drives used in various applications	Understand
CO 3	Explain control strategies for three phase induction motor drives.	Understand
CO 4	Explain variable speed synchronous motor drives.	Understand
CO 5	Choose an appropriate drive system for a specific application.	Apply

iv) SYLLABUS

Block diagram of Electric Drives – Dynamics of motor load system-Steady state stability. Introduction to closed loop control of drives.

DC motor drives- separately excited dc motor drives using controlled rectifiers, single phase and Three phase semi converter and fully controlled converter drives. Chopper controlled DC drives.

Induction Motor Drives- Stator voltage control – stator frequency control – Stator voltage and frequency control (v/f) - Voltage source inverter control - Current source inverter control. Rotor chopper speed control – slip power recovery control schemes

Synchronous motor drives – Synchronous motor variable speed drives- variable frequency control- Closed loop speed control of load commutated inverter fed synchronous motor drive. Concept of space vector – Basic transformation in reference frame theory.

Permanent Magnet and variable reluctance motor drives – Sinusoidal PMAC drives-Brushless DC motor drives-Microcontroller based permanent magnet synchronous motor drives. Switched Reluctance motor drive.

v) (a) TEXT BOOKS

1) Bimal K. Bose “Modern power electronics and AC drives” Pearson Education, Asia 2003.

2) Gopal K. Dubey. “Fundamentals of Electric Drives”, second edition, Narosa Publishing house, 2001.

(b) REFERENCES

1) Dewan S.B., G. R. Slemon, A. Strauvhen, “Power semiconductor drives”, John Wiley and sons, 1987.
2) Dr. P. S. Bimbra “Power electronics”, Khanna publishers. 3. Dubey G. K. “Power semiconductor control drives” Prentice Hall, Englewood Cliffs, New Jersey, 1989.
3) N. K. De, P. K. Sen “Electric drives” Prentice Hall of India, 2002.
4) Ned Mohan, Tore M. Undeland, William P Robbins, “Power electronics converters applications and design”, John Wiley and Sons, 2003.
5) Pillai S. K. “A first course on electric drives”, Wiley Eastern Ltd, New Delhi, 3rd edition, 2000.
6) Vedam Subrahmanyam, “Electric Drives”, Mc Graw Hill Education, New Delhi, 2013.
7) R. Krishnan, “Electric Motor Drives Modeling, Analysis and Control”, Prentice Hall of India, 2007.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to electric drives –** Block diagram – advantages of electric drives – Dynamics of motor load system, fundamental equations, and types of load – classification of load torque, four quadrant operation of drives. Steady state stability. Introduction to closed loop control of drives.	**11**
II	**DC motor drives**- constant torque and constant power operation, separately excited dc motor drives using controlled rectifiers, single phase semi converter and single phase fully controlled converter drives. Three phase semi converter and fully controlled converter drives. **Chopper controlled DC drives**. Analysis of single quadrant chopper drives. Regenerative braking control. Two quadrant chopper drives. Four quadrant chopper drives.	**12**
III	**Induction Motor Drives**-Three phase induction motor speed control using semiconductor devices. Stator voltage control – stator frequency control – Stator voltage and frequency control (v/f) - Voltage source inverter control - Current source inverter control. Rotor chopper speed control – slip power recovery control schemes – sub synchronous and super synchronous speed variations.	**12**
IV	**Synchronous motor drives** – Synchronous motor variable speed drives-variable frequency control- modes of variable frequency control. Closed loop speed control of load commutated inverter fed synchronous motor drive. Concept of space vector – Basic transformation in reference frame theory – field orientation principle.	**12**
V	**Permanent Magnet and variable reluctance motor drives –** different types –Sinusoidal PMAC drives-Brushless DC motor drives- control requirements, converter circuits, modes of operation. Microcontroller based permanent magnet synchronous motor drives (schematic only). Switched Reluctance motor drive- converter circuits- modes of operation.	**13**
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE0M30F	INSTRUMENTATION AND AUTOMATION OF POWER PLANTS	VAC	4	0	0	4	2020

i) PRE-REQUISITE: Nil.

ii) COURSE OVERVIEW:

The goal of this course is to expose the students to the fundamental concepts and basics of Power generation The course also intends to deliver the basic concepts to enable the design of power plant control using various methods

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Explain the various power generation plants and the thermal power plant processes.	Understand
CO 2	Illustrate the types of boilers, boiler processes and other associated components of power plants.	Understand
CO 3	Describe the various measurement schemes of turbines and boilers.	Understand
CO 4	Explain the various measurement schemes associated with power plants.	Understand
CO 5	Explain the fundamentals of SCADA and its classification to various applications.	Understand

iv) SYLLABUS

Introduction to thermal power plant processes – building blocks - ideal steam cycles.

Boiler – types, Boiler - turbine units and its range systems, feed water systems, steam circuits. Importance of instrumentation in power generation – details of boiler processes, combined cycle power plant.

Measurement in boiler and turbine: Metal temperature measurement in boilers, piping, System for pressure measuring devices.

Measurements in power plants: Electrical measurements – current, voltage, power, frequency, power factor etc.

SCADA fundamentals: Introduction – Building Blocks of SCADA - application functions in Generation, Transmission and Distribution – Advantages of SCADA – SCADA Communication systems - Classification of SCADA systems.

v) (a) TEXT BOOKS

1) Gill A.B, "*Power Plant Performance*", Butterworth, London, 1984.
2) P.C Martin, I.W Hannah, "*Modern Power Station Practice*", British Electricity International Vol. 1 & VI, Pergamon Press, London, 1992.
3) Sam G. Dukelow, "*The Control of Boilers*", 2nd Edition, ISA Press, New York, 1991.
4) Power system SCADA and smart grids, Mini S Thomas, John D Mcdonald, CRC Press, 2015.

(b) REFERENCES

1) David Lindsley, "*Boiler Control Systems*", McGraw Hill, New York, 1991.
2) Jervis M.J, "*Power Station Instrumentation*", Butterworth Heinemann, Oxford, 1993.
3) Modern Power Station Practice, Vol.6*, "Instrumentation, Controls and Testing*", Pergamon Press, Oxford, 1971.
4) PLCs and SCADA- Theory and Practice, Rajesh Mehra, Vikrant Vij, Laxmi Publications, First edition, 2016.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Brief survey of methods of power generation-hydro, thermal, nuclear, solar and wind power Introduction to thermal power plant processes – building blocks - ideal steam cycles	9
II	Boiler – types, Boiler - turbine units and its range systems, feed water systems, steam circuits, air preheating. Soot blowers, combustion process, products of combustion, fuel systems, treatment of flue gases, smoke density measurements, steam turbine, condensate systems, alternator, feed water conditioning, turbine bypass valves. Importance of instrumentation in power generation – details of boiler processes, combined cycle power plant, power generation and distribution, burner tilting, and bypass damper.	13
III	Measurement in boiler and turbine: Metal temperature measurement in boilers, piping System for pressure measuring devices, smoke and dust monitor, flame monitoring. Introduction toturbine supervising system, pedestal vibration, shaft vibration, eccentricity measurement. Installation of non-contracting transducers for speed measurement.	12
IV	Measurements in power plants: Electrical measurements – current, voltage, power, frequency, power factor etc. – non electrical parameters – flow of feed water, fuel, air and steam with correction factor for temperature – steam pressure and steam temperature – drum level measurement– radiation detector – smoke density measurement – dust monitor.	12
V	SCADA fundamentals: Introduction – Building Blocks of SCADA - SCADA in power systems – Its application functions in Generation, Transmission and Distribution – Advantages of SCADA – SCADA Communication systems - RTUs – Components of RTUs – Communication Protocols – Advanced RTU functionalities, IEDs, Data concentrators and merging units, Human Machine Interface, Classification of SCADA systems Single master–single remote, Single master–multiple RTU, Multiple master–multiple RTUs, Single master, multiple submaster, multiple remote.	14
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance : 10 marks

CA Exams (2 numbers) : 25 marks

Assignment/Project/Case study etc. : 15 marks

Total : 50 marks

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE0M30G	DIGITAL CONTROL	VAC	4	0	0	4	2020

i) PRE-REQUISITE: EE0M30C Control Systems

ii) COURSE OVERVIEW:

This objective of this course is to familiarize students with the cutting edge of practice in control systems design and analysis, almost all of which involves digital implementation. The students will gain familiarity with sampling and quantization, z-transform, the state space and input/output representation and other analysis tools that are used to analyze and design digital control systems.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Represent discrete time systems under the form of z-domain transfer functions and state-space models	Understand
CO 2	Analyze stability, transient response and steady state behaviour of linear discrete-time systems, analytically and numerically using tools such as MATLAB and Simulink.	Understand
CO 3	Design digital control systems using transform techniques and state-space methods.	Understand
CO 4	Describe and test controllability and observability of linear systems.	Understand

iv) SYLLABUS

Basic digital control system-Pulse transfer function-Steady state performance-stability analysis - compensator design using frequency response - compensator design using root locus - Dead-beat controller design - State space analysis and controller design

v) (a) TEXT BOOKS

1) Gene F. Franklin, J. David Powell, Michael Workman, Digital Control of Dynamic Systems, Third Edition, Pearson, 1997.
2) Benjamin C. Kuo, Digital Control Systems, Second Edition, Oxford University Press, 2007.
3) Ogata K., Discrete-Time Control Systems, Second Edition, Pearson Education, 2015.
4) M. Gopal, Digital Control and State Variable Methods, Fourth Edition, Tata McGraw-Hill, 2017.
5) C. L. Philips, H. T. Nagle, Digital Control Systems, Third Edition, Prentice-Hall, 1994.

(b) REFERENCES

1) Liegh J. R., Applied Digital Control, Dover Publications Inc., Second Edition, 2006.
2) C. H. Houpis and G.B. Lamont, Digital Control Systems, McGraw-Hill Inc., US, Second Edition, 1992.
3) V. I. George, C.P. Kurian, Digital Control Systems, First Edition, Cengage Learning, 2012.

4) Kavita Singh, Rashmi Vashisth, Digital Control System, Galgotia Publications, 2012.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to digital control: Introduction, Discrete time system representation, Mathematical modelling of sampling process. Data reconstruction: The Sampling operation, The Hold operation, Practical Sample-and-Hold Circuit, Sampled Spectra and Aliasing, Reconstruction of Analog Signals, Practical Aspects of the Choice of Sampling Rate, Principles of Discretization.	12
II	Modelling discrete-time systems by pulse transfer function: Revisiting Z-transform, Mapping of s-plane to z-plane, Pulse transfer function, Pulse transfer function of closed loop system. Stability analysis of discrete time systems: Jury stability test, Stability analysis using bi-linear transformation	12
III	Time response of discrete systems: Transient and steady state responses, Time response parameters of a prototype second order system. Digital Compensator Design using Root Locus Plots, z-Plane Synthesis.	12
IV	Lead and Lag compensator design using Bode plot. Simulation of Controller design based on Root locus and Bode plot techniques in MATLAB. Deadbeat response design, Design of digital control systems with deadbeat response, Practical issues with deadbeat response design, Sampled data control systems with deadbeat response.	12
V	Control System Analysis using State Variable Methods. Introduction to State Variable Model, relation between transfer function and state space model for a discrete time system. Various standard or canonical state variable models, Characteristic Equation, Eigenvalues and Eigen vectors, Controllability and Observability, Pole placement by state feedback.	12
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE0M30H	ELECTRICAL SYSTEM DESIGN AND BUILDING SERVICES	VAC	3	1	0	4	2020

i) PRE-REQUISITE: Illumination Engineering, Electric Power supply and Distribution Systems, Energy efficiency in Buildings

ii) COURSE OVERVIEW:

Goal of this course is to expose the students to the fundamental concepts of Electrical System Design for Buildings, the methodology of design, the Regulatory standards and essential building services. It introduces the students to the efficient use of Computer aided design with Ms Excel and use of software tools like AutoCAD for the preparation of Single Line Diagrams.

iii) COURSE OUTCOMES

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

CO 1	Explain the significance of Electricity Act 2003 and National Electric Code (NEC-2011) in the design of Electrical installations.	Understand
CO 2	Develop the basis of design (BOD) for the project as per the given floor layout.	Apply
CO 3	Design a simple electric installation for domestic building and select main distribution board, sub distribution board, MCB, ELCB, MCCB as per the design.	Create
CO 4	Develop the design requirements of electrical installations in high-rise buildings and substations.	Apply
CO 5	Describe the importance of Lightning protection in a building and explain its components.	Understand

iv) SYLLABUS

Electrical System Design in Building Construction - The Indian Electricity Act 2003, National Electric Code (NEC 2011), National Building Code (NBC 2016)- Classification of voltages.

Design phase for electrical systems and develop the basis of design (BOD) for the project as per the given floor layout. Space requirements for a proper electrical installation as per NEC.

Design of electrical installations for domestic buildings - selection of main distribution board, sub distribution board, MCB, ELCB, MCCB - Electrical system layout designing.

Design requirements for high rise apartments and substation - Metering Panels - Cabling - Auxiliary and Emergency Power Supply.

Lightning protection system for a building – components - Code of practice for the protection of buildings.

v) (a) TEXT BOOKS

1) Theodore R. Bosela, *Electrical Systems Design*, Prentice Hall; 1st edition, 2002.
2) Giridharan M. K., *Electrical Systems Design*, I K International Publishers, New Delhi, 2nd edition, 2016.

3) Aleksandar Mratinkovic & Co., *Design of Electrical Services for Buildings*, 3G E-Learning LLC, 2017.

(b) REFERENCES

1) Steven J. Marrano, '*Electrical System Design and Specification Handbook for Industrial Facilities'*, Fairmont Press, 1998.
2) Jain V. K., Amitabh Bajaj, *Design of Electrical Installations*, Lakshmi Publications Pvt. Ltd., 2016.
3) Ruzhu Wang, Xiaoqiang Zhai, *Handbook of Energy Systems in Green Buildings*, Springer; 1st edition, 2018.
4) Solanki C. S., *Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers*, Prentice Hall India Learning Private Limited, 2013.
5) *National Electric Code*, Bureau of Indian Standards publications, 2011.
6) Relevant Indian Standard – Specifications (IS – 732, IS – 746, IS – 3043, IS – 900), etc.

DATA BOOK (Approved for use in the examination):

1) Giridharan M. K., *Electrical Systems Design Data Hand book,* I K International Publishers, New Delhi, 2011.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Electrical System Design in Building Construction. Role of Statutes: The Indian Electricity Act 2003, National Electric Code (NEC 2011), National Building Code (NBC 2016), Classification of Building services – Major and Minor building services – Design aspects of building services, Classification of voltages, standards and specifications.	10
II	Design phase for electrical systems based on project size and develop the basis of design (BOD) for the project. Procedures of calculating and designing the electrical system based on Plot area, Floor Area Ratio (FAR), Load Power Density (LPD), Total Connected Load (TCL), Transformer and Generator Capacity. Need of MS Excel tool for efficient design methodology. Space requirements for electrical installation as per NEC, room spaces to house electrical equipment-need for cable duct and cable trays- structural reinforcement for heavy equipment, clearances around electrical equipment.	13
III	General aspects of the design of electrical installations for domestic dwellings as per NEC guidelines–connected load calculation, sub circuits, selection of main distribution board, sub distribution board, MCB, ELCB- selection of cables for sub circuit. Electrical drawings for the given project including floor plans and schematic diagrams. Practical Exercise – Design of electrical system of residential building using MS Excel	13

IV	Design requirements for high rise apartments- commercial and residential – Substations, Primary and Secondary protection, Earthing calculations - Metering Panels – Cabling – Auxiliary and Emergency Power Supply arrangements. Introduction to Solar PV installations and its statutory requirements.	**12**
V	Lightning protection system for a building and building services, Role of grounding in lightning protection systems, Main components of a lightning protection system, IS 2309 (2010): Code of practice for the protection of buildings and allied structures against lightning. NBC – IS / IEC 62305.	**12**
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance : 10 marks

CA Exams (2 numbers) : 25 marks

Assignment/Project/Case study etc. : 15 marks

Total : **50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
MA0M30B	ALGEBRA AND NUMBER THEORY	VAC	3	1	0	4	2020

i) PRE-REQUISITE: A basic understanding of set theory and logic.

ii) COURSE OVERVIEW:

This is an introductory course in algebra and number theory with special emphasis on applications including RSA, prime factorization and the interplay between rings and numbers.

iii) COURSE OUTCOMES

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

CO 1	Solve number theoretic problems by applying the concept and properties of natural numbers and applications of division algorithm and related results.	Apply
CO 2	Utilise the concepts and properties learned about prime numbers and basic factorisation algorithms to solve number theoretic problems.	Apply
CO 3	Solve algebraic problems using the concepts and properties of groups and group structures.	Apply
CO 4	Utilise the concept, properties and applications of cyclic groups, permutations and symmetric groups to solve algebraic problems.	Apply
CO 5	Solve algebraic problems using the concept, properties and applications of rings and ring.	Apply

iv) SYLLABUS

Division with remainder, congruences, greatest common divisor, Euclidean algorithm, Chinese remainder theorem, Euler's theorem (Sections 1.2-1.7)

Prime Numbers- basic results, unique factorisation, computing Euler function, RSA explained, Fermat's little theorem, pseudoprimes, Algorithms for prime factorisation Fermat's and Fermat-Kraitchik algorithms (evaluation only), Quadratic residues. (Relevant topics from sections 1.8-1.11)

Groups- Definition- basic properties and examples, subgroups and cosets, normal subgroups, group homomorphisms. Isomorphism theorem (Sections 2.1- 2.5)

Order of a group element, Cyclic groups, symmetric groups, cycles, simple transpositions and bubble sort, alternating groups. (Sections 2.6-2.7, 2.9.1, 2.9.2, 2.9.3)

Rings- Definition, ideals, principal ideal domain, Quotient rings, Prime and maximal ideals, Ring homomorphisms, unique factorisation domain, irreducible and prime elements, Euclidean domain. (Sections 3.1, 3.2, 3.3, 3.3.1, 3.5.1-3.5.4).

v) (a) TEXT BOOKS

1) Niels Lauritzen, "Concrete Abstract Algebra", Cambridge University Press, 2003.

(b) REFERENCES

1) David M Burton, "Elementary Number Theory", 7th edition, McGraw Hill, 2011.

2) John B Fraleigh, "A first course in Abstract Algebra". 7th edition, Pearson Education India, 2013.
3) Joseph A Gallian, "Contemporary Abstract Algebra", 9th edition, Cengage Learning India Pvt. Ltd., 2019.

vi) COURSE PLAN

Module	**Contents**	**No. of hours**
I	Elementary Number Theory: Division with remainder, Congruence, Properties of Congruence, Greatest Common divisor, Euclidean algorithm, Relatively prime numbers, Chinese Remainder Theorem, Euler's Theorem.	**12**
II	Prime Numbers, Basic Results, unique factorisation, RSA explained Fermat's Little theorem, Pseudoprimes, Factorisation algorithms- Fermat's algorithm Fermat-Kraitchik algorithm, Quadratic residue, Quadratic residue applications.	**12**
III	Introduction to Groups, Definition, Basic Properties, Examples, Subgroups, Cosets, Computing, φ−function, Normal Subgroups, Quotient Groups, Group homomorphisms, Isomorphism theorem.	**12**
IV	Further topics in Group Theory, Order of a group element, Cyclic Groups, Properties, Symmetric groups, Cycles, Properties, Simple transpositions, Bubble sort, Alternating groups.	**12**
V	Ring Theory Definition, basic properties, ideals Quotient rings, Prime and Maximal ideals, Ring homomorphisms, Unique factorisation, Irreducible elements, prime elements, Euclidean domain.	**12**
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	**CIE**	**ESE**	**ESE Duration**
150	50	100	3 hours

B.TECH S5 HONOURS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1H30A	DIGITAL SIMULATION	VAC	4	0	0	4	2020

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

Numerical simulation using digital computers is an indispensable tool for electrical engineers. This honours course is designed with the objective of providing a foundation to the theory behind Numerical Simulation of electrical engineering systems and to give an overview of different styles of simulation tools and methodologies. This course would help students to explore and effectively use simulation tools with a clear understanding of their inner engines. This course also prepares students to explore and use the industrystandard tools like MATLAB and SPICE different power converters and its applications.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Formulate circuit analysis matrices for computer solution.	Apply
CO 2	Apply numerical methods for transient simulation.	Apply
CO 3	Develop circuit files for SPICE simulation of circuits.	Apply
CO 4	Develop MATLAB/Simulink programs for simulation of simple dynamic systems.	Apply

iv) SYLLABUS

Introduction to Simulation: Types of simulation problems -Problem formulation for circuit simulation:

Nodal Analysis - Modified Nodal Analysis (MNA) - General Rules/Steps to form the admittance matrix. Sparse Tableau Approach - Formulation of STA matrix. Features and comparison with MNA approach. Formulation Examples.

Non-linear Circuits: Application of the Newton-Raphson method - General procedure for n-th order system of equations - Formulation of Jacobian - Examples - Resources required for simulation: Computation time. Convergence issues - Practical Limits due to finite precision. Damping.

Fundamental Theory behind Transient Simulation: Introduction to transient simulation-

Basic ideas of Accuracy and Stability -Basic ideas of Explicit and Implicit methods:

Application to Circuit Simulation: Using BE and TRZ methods. - Basic ideas behind Adaptive/variable step-size. (Qualitative treatment only).

Introduction to SPICE: Types of simulation tools: Circuit simulation tools: SPICE, equation solvers: MATLAB®/Scilab®/Octave.

Performing different kinds of simulation and analysis - Developing circuit files for simple circuits

Developing component models, subcircuits in SPICE. Simulation Demonstration with simple circuits.

Introduction to equation solver tools -Introduction to scripting using MATLAB

Operations - Basic Operators and Special Characters Variables and Arrays -

Numerical Integration - Simulation Demonstration with different integration algorithms /step-sizes.

v) (a) TEXT BOOKS

1) M. B. Patil, V. Ramanarayanan and V. T. Ranganathan, "Simulation of Power Electronic Circuits", Narosa Publishing House, 2009.
2) Steven C. Chapra and Raymond P. Canale, "Numerical Methods for Engineers", Tata McGraw Hill, New Delhi, 2000.
3) Rudra Pratap, "Getting Started with MATLAB®: A Quick Introduction for Scientists & Engineers", 2010, Oxford University Press.

(b) REFERENCES

1) Mohan N., T. M. Undeland and W. P. Robbins., Power Electronics: Converters, Applications & Design, Wiley-India, 3rd Edition, 2002.
2) Krein P. T., Elements of Power Electronics, Oxford University Press, 1998.
3) L. Umanand, Power Electronics – Essentials & Applications, Wiley-India, 2009.
4) Alok Jain, Power Electronics and its Applications, Penram International Publishing (I) Ltd, 2016.
5) Singh M. D. and K. B. Khanchandani, Power Electronics, Tata McGraw Hill, New Delhi, 2008.

v) COURSE PLAN

Module	Contents	No. of hours
I	Nodal Analysis - General Rules/Steps to form the admittance matrix. Sample problems on formulation of the matrix. Modified Nodal Analysis (MNA) - General Rules/Steps to form the admittance matrix. Sample problems on formulation of the matrix. (Assignments/Course projects may be assigned for writing code to formulate the Matrix using any high-level language). Formulation Examples. Sparse Tableau Approach - Formulation of STA matrix. Features and comparison with MNA approach. Formulation Examples. Non-linear Circuits: Application of the Newton-Raphson method - General procedure for n-th order system of equations - Formulation of Jacobian - Examples - Resources required for simulation: Computation time. Convergence issues - Practical Limits due to finite precision. Damping	12
II	Introduction to transient simulation: Discretization of time, idea of time - step. - Review of backward Euler, forward Euler and trapezoidal methods. Basic ideas of Accuracy and Stability (Qualitative description only) of methods of transient analysis using numerical techniques. Basic ideas of Explicit and Implicit methods: Concept of 'order' of a numerical method, Local Error (LE), Local Truncation Error (LTE) and Global Error. (No detailed derivations needed).	12

III	Application to circuit simulation: Using BE and TRZ methods. - Second order Backward Difference Formula (BDF-2/Gear Formula, no derivation required). Equivalent Circuit Approach- Stiff systems - Features - Simple Examples. Basic ideas behind Adaptive/variable step-size. (Qualitative treatment only). Practical aspects in choosing numerical methods: Artificial damping and ringing induced by numerical algorithms - Assessment of accuracy -- The issue of Singular Matrix in initial/startup condition.	**12**
IV	Types of simulation tools: Circuit simulation tools: SPICE, equation solvers: MATLAB®/Scilab®/Octave - Features, similarities and differences. Circuit Simulation using SPICE. Writing SPICE circuit files: SPICE Syntax - SPICE directives (Dot commands: .END, .FUNC, .NET .OPTIONS) Performing different kinds of simulation and analysis - DC, DC sweep, AC, Transient and noise analyses. (Use of .OP, .PARAM, .TRAN, .DC, .STEP, .IC .MEASURE, .FOUR, .NOISE, .TEMP, .WAVE) Developing circuit files for simple circuits like CE amplifiers, passive linear/non-linear circuits (Familiar Circuits with R, L, C, Diodes, Transistors). Developing component models, subcircuits in SPICE. (Use of .MODEL, .SUBCKT, .LIB, .INC, .ENDS directives) - examples (BJTs/MOSFETs). Simulation Demonstration with simple circuits. Setting-up simulation, and different types of simulation etc. shall be demonstrated by the course instructor. [LTspice®, a free SPICE version, is chosen here as reference due to wide availability, however, PSpice®, LTspice®, ngSpice, eSim or any available SPICE variants may be used for assignments/demonstrations, based on availability].	**12**
V	Introduction to scripting using MATLAB®: Language constructs - Basic Arithmetic Operations - Basic Operators and Special Characters Variables and Arrays - Complex numbers -Basic Handling of Arrays (Vectors and Matrices). Control Structures (Conditional, looping - for loop, while loop, switch-case-otherwise - break -return) - functions. Numerical Integration - ODE solvers - ode23, ode23t and ode45 - Examples - User-written functions to solve ODEs to implement the algorithms BE, FE, and TRZ only). Application examples. (Performance comparison of different solvers may be given as assignments). Visual Modelling: Introduction to Simulink/Similar Causal modelling tools. Developing causal simulation diagrams using fundamental blocks (Gain, sum/difference, integrators, etc) for simple circuit models - first-order/second-order circuits, Separately excited DC Motor, from the ODE descriptions. Non-linear examples: DC Series Motor, Simple passive networks with switches. Simulation Demonstration with different integration algorithms /step-sizes. [Only for practice/assignments]. (Instead of MATLAB/Simulink®, Octave and Scilab®/XCos® may be used for assignments/demonstrations).	**12**
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance : 10 marks

CA Exams (2 numbers) : 25 marks

Assignment/Project/Case study etc. : 15 marks

Total : 50 marks

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

B.Tech (S6 - HONOUR)

Basket	Course Number	Course	L-T-P	Credit
I	EE1H30B	Generalized Machine Theory	3-1-0	4
II	EE1H30C	Analysis of Power Electronic Circuits	3-1-0	4
III	EE1H30D	Operation and Control of Power Systems	3-1-0	4
IV	EE1H30E	Electric Vehicle Technology	4-0-0	4

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1H30B	GENERALIZED MACHINE THEORY	VAC	3	1	0	4	2020

i) PRE-REQUISITE: EET202 DC Machines and Transformers, EET307 Synchronous and Induction Machines

ii) COURSE OVERVIEW:

Goal of this course is to expose the students to Analyze electrical machine behaviour based on the voltage and torque equations of the machine and its transformation using different methods. This course also provides the concept of generalized machine theory and its application in DC generator, motor, Synchronous motor and three phase Induction motor. This course also imparts knowledge about the analysis of transient and steady state behaviour of rotating machines.

iii) COURSE OUTCOMES

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

CO 1	Develop the basic two pole model representation of electrical machines using the basic concepts of generalized theory.	Understand
CO 2	Develop the linear transformation equations of rotating electrical machines incorporating the concept of power invariance.	Understand
CO 3	Apply linear transformation for the steady state analysis of different types of rotating electrical machines.	Apply
CO 4	Apply linear transformation for the steady state analysis of different types of rotating electrical machines.	Apply

iv) SYLLABUS

Unified approach to the analysis of electrical machine performance - basic two pole model of rotating machines- per unit system.

Primitive machine - transformer and rotational voltages in the armature voltage and torque equations resistance, inductance and torque matrix.

Transformations - passive linear transformation in machines- Park's transformation-invariance of power.

DC Machines- Application of generalized theory to separately excited, shunt and series machines- Steady state and transient analysis, transfer functions.

Synchronous Machines: synchronous machine reactance and time constants-Primitive machine model, Balanced steady state analysis-power angle curves.

Induction Machines- Primitive machine representation- Steady State Operation-Equivalent circuit. Single phase induction motor- Voltage and Torque equations.

v) (a) TEXT BOOKS

1) Bhimbra P. S., *Generalized Theory of Electrical Machines*, Khanna Publishers,6th edition, Delhi 2017.
2) Charles V. Johnes, *Unified Theory of Electrical Machines*. New York, Plenum Press, 1985.
3) Bernad Adkins, Ronald G. Harley, *General theory of ac Machines*. London, Springer Publications, 2013.
4) Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, *Analysis of Electrical Machines and Drive Systems*, John Wiley & Sons, 2013.

(b) REFERENCES

1) Charles Concordia, *Synchronous Machines- Theory and Performance*, John Wiley and Sons Incorporate, Newyork, 1988.
2) Say M. G., *Introduction to Unified Theory of Electrical Machines,* Pitman Publishing, 1978.
3) Langsdorf M. N., *Theory of Alternating Current Machinery*, Tata McGraw Hill, 2001.
4) NPTEL: http://nptel.ac.in/courses/108106023/

vi) COURSE PLAN

Module	Contents	No. of hours
I	Unified approach to the analysis of electrical machine performance - per unit system - Basic two pole model of rotating machines- Primitive machine -Conventions -transformer and rotational voltages in the armature voltage and torque equations, resistance, inductance and torque matrix.	12
II	Transformations-passive linear transformation in machines-invariance of power transformation from a displaced brush axis-transformation from three phase to two phase and from rotating axes to stationary axes-Physical concept of Park's transformation.	12
III	DC Machines: Application of generalized theory to separately excited DC generator: steady state and transient analysis, Separately excited DC motor- steady state and transient analysis, Transfer function of separately excited DC generator and motor- DC shunt and series motors: Steady state analysis and characteristics.	13
IV	Synchronous Machines: synchronous machine reactance and time constants-Primitive machine model of synchronous machine with damper windings on both axes. Balanced steady state analysis-power angle curves. Induction Machines: Primitive machine representation. Transformation-Steady state operation-Equivalent circuit. Torque slip characteristics.	13
V	Single phase induction motor- Revolving Field Theory equivalent circuit-Voltage and Torque equations - Cross field theory-Comparison between single phase and poly phase induction motor.	10
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1H30C	ANALYSIS OF POWER ELECTRONIC CIRCUITS	VAC	3	1	0	4	2020

i) COURSE OVERVIEW:

The Goal of this course is to expose the students to Analyze the working of different AC-DC converters and its performance parameters. It also includes the analysis and design of different DC-DC converters. It also includes the harmonic reduction of DC-AC converters using pulse width modulation techniques.

ii) COURSE OUTCOMES

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

CO 1	Describe the operation of AC Voltage Controllers and PWM rectifiers.	Understand
CO 2	Choose appropriate power semiconductor device along with its driver circuits and protection for various applications.	Apply
CO 3	Analyze the operation of controlled rectifier circuits.	Apply
CO 4	Analyze inverter circuits with different modulation strategies.	Apply
CO 5	Analyze the operation of different DC-DC converters.	Apply

iii) SYLLABUS

Characteristics of Ideal and Real switches - Static and Dynamic Characteristics Driver circuit and Snubbers – Conduction and Switching loss - Power dissipation and selection of heat sink

Single-phase converter - full converter and semi converter Three-phase converter - Full converter & semi converter – analysis with RLE loads continuous conduction only – inversion mode - effect of source inductance

Single phase full Bridge Inverters –Analysis with RL load - Three phase bridge inverter Common mode voltage; PWM principle - Sinusoidal pulse width modulation- Unipolar and Bipolar modulation,

Multilevel Inverters Introduction to Multilevel Inverters – Types – Diode clamped, flying capacitor and cascaded multilevel inverters

Analysis of DC choppers; Single quadrant, two quadrant and four quadrant choppers, PWM control-Time ratio control – Current limit control, Source filter and its design, multiphase chopper.

AC voltage controllers Three phase AC Voltage Controllers-Principle, operation and analysis with R loads Current Regulated PWM Voltage Source Inverters - Hysteresis Control - Fixed Switching Frequency Current Control

PWM rectifiers Single phase PWM rectifiers –Basic topologies and control.

iv) (a) TEXT BOOKS

1) Ned Mohan, Tore M. Undeland, William P. Robbins, *Power Electronics: Converters, Applications, and Design*, Wiley India, 3rd edition, 2018.
2) Robert W Erickson, Dragan Maksimovic, *Fundamentals of Power Electronics*, Springer,3rd edition, 2001.

(b) REFERENCES

1) Rashid M H, *Power Electronics – Circuits, Devices and Applications*, Prentice Hall of India, New Delhi, 4th edition, 2014.
2) Robert Bausiere, FrancisLabrique, Guy Seguier, *Power Electronic Converters: DC-DC Conversion*, Springer, 2013.
3) P.S. Bimbhra, *Power Electronics*, Khanna Publishers, New Delhi,5th edition, 2014.
4) Joseph Vithayathil, *Power Electronics*, Tata McGraw-Hill, New Delhi, 2010.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Overview of solid-state devices** Characteristics of Ideal and Real switches - Static and Dynamic Characteristics for MOSFET and IGBT, Driver circuit and Snubbers for MOSFET and IGBT – Conduction and Switching loss - Power dissipation and selection of heat sink.	12
II	**Phase controlled Rectifiers** Single-phase converter - full converter and semi converter - analysis with RLE loads – input PF with continuous and ripple free load current - inversion mode – effect of source inductance – Effect of single-phase rectifiers on neutral currents in three phase four wire systems. Three-phase converter - Full converter & semi converter – analysis with RLE loads – continuous conduction only – inversion mode - effect of source inductance –line notching and distortion.	13
III	**Inverters** Single phase full Bridge Inverters –Analysis with RL load - Three phase bridge inverter - Analysis with delta and star connected RL loads – Common mode voltage; PWM principle - Sinusoidal pulse width modulation- Unipolar and Bipolar modulation, Effect of blanking time on voltage of PWM inverter, output filter design. **Multilevel Inverters** Introduction to Multilevel Inverters – Types – Diode clamped, flying capacitor and cascaded multilevel Inverters	12
IV	**DC Choppers** Analysis of DC choppers; Single quadrant, two quadrant and four quadrant choppers, PWM control - Time ratio control – Current limit control, Source filter and its design, multiphase chopper.	11
V	**AC voltage controllers**: Three phase AC Voltage Controllers-Principle, operation and analysis with R loads. **Current control of VSI:** Current Regulated PWM Voltage Source Inverters - Hysteresis Control - Variable Band Hysteresis Control, Fixed Switching Frequency Current Control PWM rectifiers. **Single phase PWM rectifiers** –Basic topologies and control.	12
	Total hours	**60**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

vii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1H30D	OPERATION AND CONTROL OF POWER SYSTEMS	VAC	3	1	0	4	2020

i) PRE-REQUISITE: EE1U30A Power Systems I

ii) COURSE OVERVIEW:

The goal of this course is to make the students aware of the importance of economic operation as well as control of power system. It deals with economic dispatch and unit commitment problems. This course gives a good insight into power system security. It gives knowledge in automatic generation control. It provides information about different voltage control methods in power system.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Explain economical dispatch of power system.	Understand
CO 2	Analyse the performance of hydel plant using its computational model.	Analyze
CO 3	Explain the importance of power system security.	Understand
CO 4	Model Automatic Generation Control of power system.	Apply
CO 5	Explain different voltage control strategies in power system.	Understand

iv) SYLLABUS

Economic operation: Optimum load dispatch-Unit Commitment constraints. The Lambda iteration method, First order gradient method, Economic dispatch versus unit commitment.

Modelling of Hydro-electric power plants: Hydro-electric plant models-scheduling problems - Pumped storage hydro plants.

Interchange evaluation: Inter change evaluation and power pools- Economy interchange evaluation with unit commitments, types of interchange.

Power system security: System monitoring-contingency analysis- security constrained optimal power flow.

State Estimation in power system and AGC: Introduction to State estimation in power system, AGC implementation, Modelling exercise using SIMULINK, AGC with optimal dispatch of Generation

Voltage control- Voltage control using transformer- control by mid-line boosters- compensation of transmission line- MVAR control, Application of voltage regulator – synchronous condenser – transformer taps – static VAR compensators.

v) (a) TEXT BOOKS

1) Allen J. Wood, Wollenberg B.F., *Power Generation Operation and Control*, John Wiley & Sons, 2nd edition, 1996.
2) Vadhera S. S., *Power System Analysis and Stability*, Khanna Publishers, 5th edition, 2013.
3) Kirchmayer L. K., *Economic Control of Interconnected Systems*, John Wiley & Sons, 1959.
4) Nagrath I. J., Kothari D. P., *Modern Power System Analysis*, Tata McGraw-Hill, 3rd edition, 2003.
5) Weedy B. M., *Electric Power Systems*, John Wiley and Sons, New York, 1987.
6) Hadi Sadat, *Power System Analysis*, Tata McGraw-Hill, 2nd edition, 2003.

(b) REFERENCES

1) Montieelli A., *State Estimation in Electric Power System-A Generalised Approach* Springer, 1999.
2) Ali Abur, Antonio Gomez Exposito, Marcel Dekkerjnc, *Power System State Estimation-Theory and Implementation*, Taylor and Francis, 2004.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Economic operation:** Optimum load dispatch- Unit Commitment constraints. Review of Thermal units- The Lambda iteration method (with and without losses), First order gradient method base point and participation factors. Economic dispatch versus unit commitment.	12
II	**Modelling of Hydro-electric power plants:** Hydro-electric plant models-scheduling problems, types of scheduling problems- Scheduling energy -short-term hydrothermal scheduling problem, Pumped storage hydro plants- pumped storage hydro scheduling λ-γ iteration.	12
III	**Interchange evaluation:** Inter change evaluation and power pools - Economy interchange evaluation with unit commitments. Types of interchange, Energy banking-power pools. **Power system security:** System monitoring-contingency analysis-security constrained optimal power flow- Factors affecting power system security.	13
IV	**State Estimation in power system and AGC:** Introduction to State estimation in power system, Control of Generation-Automatic Generation Control Review-AGC implementation, AGC features - Modeling exercise using SIMULINK, AGC with optimal dispatch of Generation.	12
V	**Voltage control:** Voltage control using transformer- control by mid-line boosters-compensation of transmission line-AGC including excitation system, MVAR control, Application of voltage regulator – synchronous condenser – transformer taps – static VAR compensators.	11
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1H30E	ELECTRIC VEHICLE TECHNOLOGY	VAC	4	0	0	4	2020

i) PRE-REQUISITE: DC Machines and Transformers (EE1U20E), Power Electronics (EE1U30A), Synchronous and Induction machines (EE1U30C)

ii) COURSE OVERVIEW:

The main goal of this course is to expose the students to the fundamental concepts and trends in electric vehicles and hybrid electric vehicles and it also discusses how to choose proper energy storage systems for vehicle applications. It gives an insight into the electric propulsion unit and its control for application of electric vehicles. It also intends to deliver various energy management strategies, charging technologies and standards used in vehicle networks.

iii) COURSE OUTCOMES

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

CO 1	Apply the concept of hybrid electric vehicles in determining the vehicle performance.	Understand
CO 2	Explain the configuration and control of motor drives used in electric propulsion systems.	Understand
CO 3	Compare the proper energy storage systems for vehicle applications.	Understand
CO 4	Choose the suitable system components for developing an electric and hybrid vehicle.	Apply
CO 5	Explain various communication protocols and technologies used in hybrid and electric vehicles.	Understand

iv) SYLLABUS

Conventional Vehicles, Basics of vehicle performance, Basic Architecture of hybrid traction, Power flow control.

Electric Propulsion unit, Configuration and control of DC motor drives, Induction Motor drives, PM and SRM motor drives.

Energy Storage Requirements in Hybrid and Electric Vehicles, Battery, fuel cell, flywheel and supercapacitor-based energy storage.

Design of electric and hybrid electric vehicle, sizing of components.

Communication Systems, Energy Management Strategies, EV charging technologies and policies.

v) (a) TEXT BOOKS

1) Iqbal Husain: *Electric and Hybrid vehicles: Design Fundamentals,* CRC press, 2003.
2) Ehsani M., *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press, 2005.
3) Gianfranco Pistoia, *Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market,* Elsevier, 2010.

4) Chan C. C. and Chau K. T., *Modern Electric Vehicle Technology,* OXFORD University Press, 2001.

(b) REFERENCES

1) James Larminie, John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2003.
2) Fuhs A. E., *Hybrid Vehicles and the Future of Personal Transportation,* CRC Press, 2009.
3) Chris Mi , Abul Masrur M., *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives,* Second Edition, John Wiley & Sons Ltd, 2017.
4) Sheldon S. Williamson, *Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles*, Springer, 2013.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Electric and Hybrid Electric Vehicles**: Hybrid and Electric Vehicles Components, Power transmission path, Social and environmental impacts of Electric and Hybrid vehicles. **Basics of Vehicle Propulsion:** Dynamic equation, Maximum tractive effort, Vehicle Power Plant and Transmission characteristics, vehicle performance factors. **Hybrid Electric Drive-trains:** Architecture of Hybrid Electric Drive Trains, various topologies, Power flow control in Series Hybrid Electric Drive Trains and Parallel hybrid electric drive trains.	12
II	**Electric propulsion:** Electric components used in electric and hybrid drives, Classification of Electric Motors in EV, DC motor drives and speed control, Induction motor drives, Permanent Magnet Motor Drives, BLDC Drive, Switched Reluctance Motor Drive for Electric Vehicles, Configuration, and control of Drives.	12
III	**Energy Storage for EV and HEV:** Energy storage requirements, Battery parameters, Battery based energy storage and its analysis, Li-ion batteries, Cell balancing and cooling, Battery Management System, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.	12
IV	**Design of Electric and Hybrid Electric Vehicles:** Sizing of major components - Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology. **Case studies:** Performance analysis of a Hybrid Electric Vehicle (HEV), Performance analysis of a Battery Electric Vehicle (BEV).	12
V	**Communications**: In vehicle networks - CAN **Energy management strategies:** Energy Management Strategies used in Electric and Hybrid Vehicles, Concept of V2G, G2V, V2B, V2V. **EV Charging Technologies:** Standards, Conductive and Inductive charging methods, EV Charging infrastructure - Policy, Impacts of integration of EVs in Smart Grid.	12
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours