CURRICULUM
&
SYLLABUS
2020 Scheme
(Revised in 2022)
(Autonomous)
Version 1.0

B.TECH
ELECTRICAL AND ELECTRONICS ENGINEERING

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

Mar Ivanios Vidyanagar, Nalanchira, Thiruvananthapuram – 695015

CURRICULUM AND DETAILED SYLLABI

FOR

B. TECH DEGREE PROGRAMME

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

SEMESTERS V & VI

2020 SCHEME (REVISED IN 2022)

(AUTONOMOUS)

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY
(Approved by AICTE, Autonomous Institution Affiliated to APJ Abdul Kalam Technological University)
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MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

B. TECH DEGREE PROGRAMME

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

THIRD YEAR SYLLABUS

2020 SCHEME (REVISED IN 2022)

Items	Board of Studies (BOS)	Academic Council (AC)
Date of Approval	01.04.2024	19.06.2024

Head of Department
Chairman, Board of Studies

Principal
Chairman, Academic Council

MAR BASELIOS COLLEGE OF ENGINEERING & TECHNOLOGY
(Autonomous)
Mar Ivanios Vidyanagar
Nalanchira
Thiruvananthapuram-695015

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

Vision and Mission of the Institution

Vision:

To be an Institution moulding globally competent professionals as epitomes of Noble Values.

Mission:

To transform the Youth as technically competent, ethically sound and socially committed professionals, by providing a vibrant learning ambience for the welfare of humanity.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Vision and Mission of the Department

Vision:

To be a Centre of Excellence in Electrical & Electronics Engineering Education, Research and Application of knowledge to benefit the society at large.

Mission:

To mould quality Electrical Engineers, fostering creativity and innovation to address global issues.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates will succeed as Engineering Professionals in Industry or as Entrepreneurs in Electrical and Computer Engineering and the related disciplines and exhibit an urge for innovation.

PEO2: Graduates will be able to adapt to the advances in Technology by acquiring knowledge and skills manifested through continuous learning and higher qualifications.

PEO3: Graduates will be serving community as socially committed individuals, exhibiting professional ethics in addressing the technical and engineering challenges.

PROGRAMME OUTCOMES (POs)

Engineering graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1: To apply the knowledge in Electrical and Electronics Engineering for the design of Power Generation, Transmission, Distribution and Utilization systems.

PSO2: To demonstrate the knowledge required to design, develop, test, and implement Electrical & Electronics systems.

CURRICULUM

SEMESTER V						
Slot	**Cate-gory**	**Course Code**	**Courses**	**L-T-P**	**Hours**	**Credit**
A	PCC	EE1U30D	Synchronous and Induction Machines	3-1-0	4	4
B	PCC	EE1U30I	Introduction to Control Engineering	3-1-0	4	4
C	PCC	EE1U30G	Power Electronics	3-1-0	4	4
D	PEC	EE1UXXX	Program Elective I	3-0-0	3	3
E	HSC	HS0U30B	Management for Engineers	3-0-0	3	3
F	MNC	NC0U30A	Disaster Management	2-0-0	2	-
S	PCC	EE1U38E	Electrical Machines Lab	0-0-3	3	2
T	PCC	EE1U38D	Power Electronics Lab	0-0-3	3	2
R/M/H	VAC		Remedial/Minor/Honours Course	4-0-0/ 3-1-0	4	4
TOTAL					**26/30**	**22/26**

PROGRAM ELECTIVE I

Slot	**Cate-gory**	**Course Code**	**Course**	**L-T-P**	**Hours**	**Credit**
D	PEC	EE1U31A	Biomedical Instrumentation	3-0-0	3	3
		EE1U31B	Renewable Energy Sources	3-0-0	3	3
		EE1U31Z	Electrical Drawing with CAD	2-1-0	3	3
		EE1U31Y	Illumination Engineering	3-0-0	3	3
		EE1U31E	Object Oriented Programming	3-0-0	3	3
		EE1U31F	Material Science	3-0-0	3	3
		EE1U31X	Fundamentals of Soft Computing	3-0-0	3	3

SEMESTER VI						
Slot	**Cate-gory**	**Course Code**	**Courses**	**L-T-P**	**Hours**	**Credit**
A	PCC	EE1U30A	Power Systems I	3-1-0	4	4
B	PCC	EE1U30J	Engineering Electromagnetics	3-1-0	4	4
C	PCC	EE1U30K	Introduction to Signals and Systems	3-1-0	4	4
D	PEC	EE1UXXX	Program Elective II	3-0-0/ 2-1-0	3	3
E	OEC	EE0UXXX	Open Elective I	3-0-0	3	3
F	PCC	EE1U30L	Comprehensive Course work	1-0-0	1	1
S	PCC	EE1U38F	Control Systems Lab	0-0-3	3	2
T	PWS	EE1U39A	Mini Project	0-0-3	3	2
R/M/H	VAC		Remedial/Minor/Honours Course	4-0-0/ 3-1-0	4	4
TOTAL					**25/29**	**23/27**

PROGRAM ELECTIVE II

Slot	**Cate-gory**	**Course Code**	**Course**	**L-T-P**	**Hours**	**Credit**
D	PEC	EE1U32Z	Electrical Machine Design	2-1-0	3	3
		EE1U32Y	Advanced Control Systems	2-1-0	3	3
		EE1U32X	Fundamentals of Machine Learning	3-0-0	3	3
		EE1U32W	Digital Signal Processing	2-1-0	3	3
		EE1U32V	Electric Drives	3-0-0	3	3
		EE1U32U	Sensors and Sensing Techniques	3-0-0	3	3
		EE1U32T	Embedded Systems	3-0-0	3	3

OPEN ELECTIVE I

Slot	**Cate gory**	**Course Code**	**Course**	**L-T-P**	**Hour s**	**Credit**
E	OEC	EE0U33Z	Introduction to Flight Dynamics and Control	3-0-0	3	3
		EE0U33Y	Introduction to Power Processing	3-0-0	3	3
		EE0U33X	Sports Engineering	3-0-0	3	3
		EE0U33W	Electrical Drives and Control for Automation	3-0-0	3	3
		EE0U33V	Renewable Energy Systems	3-0-0	3	3

B.Tech (MINOR)

SEMESTER 5

Course Code	Courses	L-T-P	Credit
EE0M30I	Raspberry Pi - Python Interface for Electrical Engineering	4-0-0	4
EE0M30J	Energy efficiency in Buildings	4-0-0	4
EE0M30K	Solar and Wind Energy Conversion Systems	3-1-0	4
EE0M30L	Hybrid and Electric Vehicles	4-0-0	4

SEMESTER 6

Course Code	Courses	L-T-P	Credit
EE0M30M	Cloud Computing for Internet of Things	4-0-0	4
EE0M30N	Electrical System Design and Building services	3-1-0	4
EE0M30P	Smart Grid and Energy Storage Systems	4-0-0	4
EE0M30Q	Introduction to Automotive Electrical & Electronic systems	4-0-0	4

B.Tech (HONOURS)

SEMESTER 5

Course Code	Courses	L-T-P	Credit
EE1H30I	Non- Conventional Energy Resources	4-0-0	4
EE1H30J	Elements of Solar Energy Conversion	4-0-0	4
EE1H30K	Solar Photovoltaics Fundamentals	4-0-0	4

SEMESTER 6

Course Code	Courses	L-T-P	Credit
EE1H30L	Analysis of Electrical Machines	3-1-0	4
EE1H30C	Analysis of Power Electronic Circuits	3-1-0	4
EE1H30D	Operation and Control of Power Systems	4-0-0	4

SYLLABUS

SEMESTER V

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1U30D	SYNCHRONOUS AND INDUCTION MACHINES	PCC	3	1	0	4	2020

i) PRE-REQUISITE: EE1U20D DC Machines and Transformers.

ii) COURSE OVERVIEW:

The goal of this course is to expose the students to the fundamental concepts of synchronous and induction machines including principle of operation, performance analysis and applications. It also introduces students to cognitive learning and develops problem solving skills with both theoretical and engineering oriented problems.

iii) COURSE OUTCOMES

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

CO1	Describe the principle of operation and classification of alternators and synchronous motors.	Understand
CO2	Develop phasor diagrams and equivalent circuit of an alternator and synchronous motor.	Apply
CO3	Apply various methods to determine the voltage regulation of alternators.	Apply
CO4	Develop the power, torque equations and performance parameters of synchronous and induction machines.	Apply
CO5	Explain the principle of operation and types of single phase and three phase induction motors.	Understand
CO6	Illustrate the various techniques of starting, braking and speed control of three phase induction motors.	Understand

iv) SYLLABUS

Alternators - basic principle, constructional features, Armature windings, EMF Equation - phasor diagram. Power Flow Equations - Direct Loading, EMF, MMF and ZPF methods.

Theory of salient pole machine – Blondel's two reaction theory -Analysis of phasor diagram under lagging power factor- slip test. Power Developed -Parallel operation of alternators.

Synchronous motor – construction and principle-torque and power relationship, phasor diagram, losses and efficiency.

Induction Motors–-constructional features-slip ring and cage types. Phasor diagram, power and torque relations, equivalent circuit. Circle diagrams.

Starting, speed control and braking of induction motors-Double cage induction motor – Synchronous induction motor -Single-phase induction motors.

v) (a) TEXT BOOKS

1) Say M G, *The Performance and Design of AC Machines*, CBS Publishers, New Delhi, 3rd edition, 2002.
2) Bimbhra P S, *Electric Machines*, Khanna Publishers, 2nd edition, 2017.

3) D. P. Kothari, I. J. Nagrath, *Electric Machines*, Tata McGraw Hill, 5th edition, 2019.
4) Langsdorf M. N., *Theory of Alternating Current Machinery*, Tata McGraw Hill, 2nd revised edition, 2001.
5) Deshpande M. V., *Electrical Machines*, Prentice Hall India, New Delhi, Eastern Economy Edition, 2011.

(b) REFERENCES

1) Fitzgerald A. E., C. Kingsley and S. Umans, *Electric Machinery*, 6th edition, McGraw Hill, 2003.
2) Charles I. Hubert, *Electric Machines*, Pearson, New Delhi, 2nd edition, 2007.
3) J B Gupta, *Performance of Electrical Machines*, S K Kataria & Sons, 14th edition, 2013.
4) Ashfaq Husain, Haroon Ashfaq, *Electric Machines*, Dhanpat Rai and Co., 3rd edition, 2016.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Alternators** - basic principle, constructional features, Classification. Armature windings – types- single layer, double layer, full pitched and short pitched windings, Terminology, pitch factor and distribution factor – numerical problems. Effect of pitch factor on harmonics – advantages of short chorded winding, EMF Equation – numerical problems. Harmonics in generated EMF – suppression of harmonics. **Performance of an alternator** – Causes for voltage drop in alternators – armature resistance, armature leakage reactance – armature reaction, synchronous reactance, and synchronous impedance– phasor diagram of a loaded alternator.	**12**
II	Power Flow Equations of a cylindrical rotor type alternator, Rating of Alternators. **Voltage regulation** – Direct Loading, EMF, MMF and ZPF methods – numerical problems. **Theory of salient pole machine** – Blondel's two reaction theory – direct axis and quadrature axis synchronous reactances – Analysis of phasor diagram under lagging power factor- Determination of X_d and X_q by slip test. Power Developed in a salient pole alternator- numerical problems.	**14**
III	**Parallel operation of alternators** – necessity of parallel operation of alternators, methods of synchronization – dark lamp method and bright lamp method, synchroscope - Synchronizing current, power and torque-Numerical Problems. **Synchronous motor** – construction and principle of synchronous motor, methods of starting-Torque and power relationship, phasor diagram, losses and efficiency calculations of cylindrical rotor type motor; P-δ curve of a synchronous machine. Effects of excitation on armature current and power factor - V and Inverted V Curves, Synchronous Condensers.	**10**

IV	**Induction Machines** – Three phase Induction Motors - constructional features - slip ring and cage types. Basic Principle - Concept of Rotating Magnetic Field - Phasor diagram, power & torque relations, equivalent circuit. Circle diagrams – tests on induction motors for determination of equivalent circuit. Cogging, crawling and noise production in cage motors – remedial measures. **Starting and braking** of induction motors. **Speed control** - From stator side - V/f control or frequency control, Changing the number of stator poles, controlling supply voltage, adding rheostat in the stator circuit; From rotor side - Adding external resistance, Cascade control.	**12**
V	**Double cage induction motor** – principle, torque-slip curves. Synchronous induction motor – principle of operation. **Induction generator** – principle of operation, grid connected and self-excited operation, comparison of induction and synchronous machines. **Single-phase induction motor** – double field revolving theory, equivalent circuit, torque-slip curve, types of single-phase induction motors – split phase, capacitor start, capacitor start and run types - Applications.	**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
EE1U30I	INTRODUCTION TO CONTROL ENGINEERING	PCC	3	1	0	4	2022

i) **PRE-REQUISITE:** MA0U10B: Vector Calculus, Differential Equations and Transforms.

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

iii) **COURSE OUTCOMES**

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

CO1	Develop the transfer function model of LTI systems.	Apply
CO2	Develop the state space model of LTI systems.	Apply
CO3	Describe the role of various control blocks and components in feedback systems.	Understand
CO4	Apply the time domain techniques in LTI systems.	Apply
CO5	Apply the frequency domain techniques in LTI systems.	Apply

iv) SYLLABUS

Open loop and closed loop control systems, Transfer function of LTI systems - Mechanical and Electromechanical systems – Force voltage and force current analogy - block diagram representation - signal flow graph.

Introduction to state space and state model concepts, Control system components, Controllers and Compensators, Time domain analysis of control systems, Impulse and Step responses of first and second order systems.

Steady state error analysis and error constants, Concept of Stability Analysis, Root Locus Analysis.

Frequency domain analysis - correlation between time domain and frequency domain responses, Polar plot, Concepts of gain margin and phase margin - stability analysis.

Bode Plot, Effect of Transportation lag and non-minimum phase systems, Design of compensators using bode plot, Nyquist criterion.

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

1) Kuo 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.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Basics of Control Systems**: Open loop and closed loop control systems - Examples of automatic control systems. Review of Laplace transforms. **Transfer function of LTI systems**: Transfer function approach to feed-back control systems – Effect of feedback, Characteristic equation. Mechanical and Electromechanical systems – Force voltage and force current analogy - block diagram representation - block diagram reduction - signal flow graph - Mason's gain formula.	**12**
II	**Control system components**: Control applications of DC and AC servo motors, Synchro, Gyroscope and Stepper motor, Controllers and Compensators. **State space modeling**: Introduction to state space and state model concepts - state equation of linear continuous time systems, matrix representation - Examples of electrical circuits and DC servomotors, Conversion of state space model to transfer function.	**12**
III	**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. **Error analysis**: Steady state error analysis and error constants - Dynamic error coefficients. **Concept of Stability**: Time response for various pole locations - stability of feedback systems - Routh's stability criterion.	**11**
IV	**Root Locus Analysis**: Construction of Root locus - stability analysis - effect of addition of poles and zeros. **Frequency domain analysis:** Frequency domain specifications - correlation between time domain and frequency domain responses. **Polar plot**: Concepts of gain margin and phase margin - stability analysis.	**12**
V	**Bode Plot**: Construction - Concepts of gain margin and phase margin-stability analysis, Effect of Transportation lag and non-minimum phase systems, Design of compensators using bode plot. **Nyquist stability criterion**: Nyquist criterion: Nyquist plot - Stability criterion – Analysis.	**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
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:

CO1	Explain the operation of modern power semiconductor devices and its characteristics.	Understand
CO2	Analyze the working of controlled rectifiers.	Apply
CO3	Explain the working of AC voltage controllers, inverters and PWM techniques.	Understand
CO4	Identify different dc-dc converters based on their performance	Apply
CO5	Explain 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, Francis Labrique, 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.	**12**

	Voltage control in 1-phase inverters – Pulse width modulation – Single pulse width, Multiple pulse width and Sine-triangle PWM– Modulation Index - Frequency modulation ratio.	
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: EE1U20B 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:

CO1	Interpret the basics concepts of anatomy and physiology.	Understand
CO2	Explain different techniques for the measurement of various physiological parameters.	Understand
CO3	Illustrate modern imaging techniques for medical diagnosis	Understand
CO4	Summarize the various therapeutic equipments used in biomedical field	Understand
CO5	Outline the patient safety measures and recent advancements in the medical field.	Understand

iv) SYLLABUS

Introduction to biomedical instrumentation, Physiology and Anatomy of human body, Bioelectric potential, Bio potential Electrodes, Transducers for biomedical applications. Measurement of blood pressure, blood flow, cardiac output, Plethysmography, heart sounds. ECG, ECG and EMG block diagram, electrodes, waveforms and features, Measurements of respiratory parameters. Modern Imaging System, Therapeutic equipment, Test on blood cells. Physiological effects of electric current, 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. **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 – Oscillo metric method –Ultrasonic method - Measurement of blood flow and cardiac output - Plethysmography –Photoelectric and Impedance Plethysmography - Measurement of heart sounds –Phonocardiography. **Cardiac measurements:** Electro-cardiography – Electrodes and leads – Einthoven triangle- ECG read out devices - ECG machine – block diagram	9
III	**Measurements from the nervous system:** EEG waveforms and features - 10-20 electrode measurement - EEG Block diagram. **Muscle response:** Electromyography- Block diagram of EMG recorders – Nerve conduction velocity measurement. **Measurements of respiratory parameters:** Spirometer – Pneumography, Finger-tip oximeter.	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), Retinal Imaging - Imaging application in Biometric systems. **Therapeutic equipment:** Cardiac Pacemakers - Defibrillators - Hemodialysis machines - Artificial kidney – Lithotripsy - Shortwave and Microwave 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, Nano robots, Robotic surgery, Orthopedic prosthesis fixation.	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	3	0	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:

CO1	Describe the environmental aspects of renewable energy resources.	Understand
CO2	Explain the operation of various renewable energy systems.	Understand
CO3	Design solar PV systems.	Apply
CO4	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 of	**9**

	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
EE1U31Z	ELECTRICAL DRAWING WITH CAD	PEC	2	1	0	3	2022

i) PRE-REQUISITE: ES0U10D: Basics of Electrical Engineering.

ii) COURSE OVERVIEW:
The course content should be taught and implemented with the aim to develop different types of skills so that students are able to draw/simulate electrical and electronics circuit using software

iii) COURSE OUTCOMES

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

CO1	Explain various symbols and notations in electrical and electronics engineering drawings.	Understand
CO2	Interpret drawings, draw inferences and workout other technical details.	Understand
CO3	Demonstrate various electrical and electronics circuits according to standard practices using CAD software.	Understand
CO4	Develop a wiring diagram for the house.	Apply
CO5	Construct Single line diagram for a substation.	Apply

iv) SYLLABUS

Computer Aided Electrical Drawing - Procedure to be adopted for computer aided drawings. Draw and identify symbols and wiring diagrams of electrical engineering.

Computer Aided Electronics Drawing - Symbols and notations of electronic components

Combination of Electrical Circuits - Getting started, ending, commonly used blocks,

Creating and Masking Sub-systems, Series and parallel circuits.

Prepare a wiring diagram for the house.

Draw Single line diagram for a substation.

v) (a) TEXT BOOKS

1) Sham Tickoo *AutoCAD 2013 for Engineers and Designers*, Dream tech press, New Delhi, Latest edition
2) George Omura, Sybex, *Mastering AutoCAD 2013 and AutoCAD LT 2013*, New Delhi, Latest edition
3) C. R. Dargan *Electrical Engineering Drawing (With Estimating and Installation Designs)*, New Asian Publishers (A Division of Computech Publication Ltd.), New Delhi
4) N. D. Bhatt, *Engineering Drawing: Plane and Solid Geometr*y, Charotar, Publishing House Pvt. Ltd., 53rd edition.

5) B. R. Sharma, *Electrical Engineering Drawing*, Satya Prakashan New Delhi.

(b) REFERENCES

List of Open-Source Software/learning website:

1) https://www.falstad.com/circuit/
2) https://www.autodesk.com/education/edu-software/overview?sorting=featured&page=1
3) https://www.ti.com/tool/TINA-TI
4) https://www.ni.com/en-in/support/downloads/software-products/download.multisim.html#312060
5) https://www.proficad.com/
6) https://www.kicad.org/
7) Documentations from https://docs.kicad.org/
8) Manual from https://www.proficad.com/help/

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Computer Aided Electrical Drawing** Procedure to be adopted for computer aided drawings, Draw and identify symbols and wiring diagram of electrical engineering. Symbols of practical units, symbols of decimal multiples and submultiples of units. Symbol of supplies-single phase, three phase three wire, three phase four wire, D.C. supply. Symbol of switches, distribution boards, fan, light fixtures, bell, buzzer, fuse, lighting arrestor - Symbol of all types of motor starters, electrical instruments, CT/PT, Measuring instruments.	**9**
II	**Computer Aided Electronics Drawing** Symbols and notations of electronic components - Resistor, Inductor, transformer and Capacitor Semiconductor device Diodes, Zener diode, Transistors PNP/ NPN, photo diode, varactor, FET, MOSFET, IGBT, UJT etc. Half-wave, full-wave and bridge rectifier, Power amplifier and voltage amplifier and different types of oscillators circuits.	**9**
III	**Combination of Electrical Circuits** Getting started, ending, commonly used blocks, Creating a model, Assigning Variables, Observing Variables during Simulation, Storing/Saving Data, Creating and Masking Sub-systems, Series and parallel R-L circuit, Series and parallel R-C circuit, Series and parallel R-L-C circuit, Resonance in AC Circuit.	**9**
IV	**Prepare wiring diagram for house** Light, fan and power circuit, Godown/corridor wiring (With & without looping), Staircase wiring, Inverter wiring.	**9**
V	**Substation and Earthing System** Draw single line diagram of substation and diagram of earthing System, 33KV/11KV substation with all protective devices, Substation: - Single bus bar arrangement, Earthing- Plate, Pipe as per I.S.S./B.I.S.	**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
EE1U31Y	ILLUMINATION ENGINEERING	PEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

Goal of this course is to impart basic concepts of lighting design, measurement, and technology and their application in the analysis and design of indoor, exterior, architectural lighting systems.

iii) COURSE OUTCOMES

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

CO1	Explain the fundamental concepts of natural and artificial lighting schemes	Understand
CO2	Apply the laws of illumination and concept of polar curves for the calculation of illuminance at a point.	Apply
CO3	Design efficient indoor lighting systems.	Apply
CO4	Design efficient outdoor lighting systems.	Apply
CO5	Explain the various control methods for lighting and demonstrate various features of aesthetic lighting.	Understand

iv) SYLLABUS

Introduction of Light, Types of illumination, Lighting systems, Lighting Schemes, Measurement of Light, Laws of illumination

Design of Interior Lighting, Special features for Interior lighting in recreational buildings, hospitals, retails shops

Outdoor Lighting Design Standards, Flood Lighting, Street Lighting and Area Lighting

Special Features of Aesthetic Lighting: Monument and statue lighting, Sports lighting, Hospital lighting, Auditorium lighting

Practical application of lighting design software in Indoor and Outdoor Lighting Design

v) (a) TEXT BOOKS

1) D.C. Pritchard, Lighting, 6th edition, Routledge, 2014
2) Jack L. Lindsey, Applied Illumination Engineering, 1997.
3) Craig DiLouie, “Advanced Lighting Controls: Energy Savings, Productivity, Technology and Applications”, CRC Press, 2005
4) M K Giridharan, Electrical Systems Design, I K International Publishing House Pvt. Ltd, 2015

(b) REFERENCES

1) John Matthews Introduction to the Design and Analysis of Building Electrical Systems, Springer, 1993.

2) M.A. Cayless, Lamps and Lighting, Routledge, 1996.
3) Craig DiLouie, Advanced Lighting Controls: Energy Savings, Productivity, Technology and Applications, CRC Press, 2005.
4) Lighting Engineering Applied calculations R. H. Simons and A. R. Bean, Routledge; 1st edition, 2020.
5) C L Wadhwa, Generation, Distribution and Utilization of Electrical Energy, New Age International Publishers; Third edition, June 2017.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction of Lighting fundamentals: Concept of light, radiant energy & visible spectrum. Day lighting techniques. Qualities of good lighting, Factors affecting the lighting. Types of Lamps & its constructional features- Incandescent lamps, Fluorescent lamps, LPSV and HPSV lamps, mercury vapour lamps, metal halide lamps- Introduction to LED Lighting-soft light, hard light, ambient light, shadow, glare, reflection, Colour rendering and stroboscopic effect. Methods of artificial lighting, Lighting systems-direct, indirect, semi direct, semi indirect, Lighting scheme, General and localized, Different types of Luminaires.	**9**
II	Measurement of Light: luminous flux, Luminous intensity, Lumen, Candle power, Illumination, M.H.C.P, M.S.C.P, Lamp efficiency, Brightness or luminance. Concept of polar curve. Laws of illumination- Inverse square law and Lambert's Cosine law, Illumination at horizontal and vertical plane from point source. Calculation of luminance and illumination in case of linear source, round source and flat source. Measuring apparatus- Goniophotometer, Integrating sphere, lux meter.	**9**
III	Design of Interior Lighting: Definitions of maintenance factor, Uniformity ratio, Direct ratio, Coefficients of utilization and factors affecting it, Illumination required for various work planes, Types of fixtures and relative terms used for interior illumination such as DLOR and ULOR, Selection of lamp and luminance, Selection of utilization factor, reflection factor and maintenance factor, Determination of Lamp Lumen output taking into account voltage and temperature variations, Calculation of wattage of each lamp and no of lamps needed, Layout of lamp luminaire, Calculation of space to mounting height ratio, Indian standard recommendation and standard practices for illumination levels in various areas, Special feature for entrance, staircase, Corridor lighting and industrial building.	**9**
IV	Design of Outdoor Lighting: Design of Outdoor Lighting: Street Lighting - Types of street and their level of illumination required, Terms related to street lighting, Types of fixtures used and their suitable application, Various arrangements in street lighting, Requirements of good street lighting, Selection of lamp and luminaire, Calculation of illumination level available on road. Flood Lighting: Terms related to flood lighting, Types of fixtures and their suitable applications, Selection of lamp and projector, recommended method for	**9**

	aiming of lamp, Calculation of their wattage and number and their arrangement, Calculation of space to mounting height ratio.	
V	Special Features of Aesthetic Lighting: Monument and statue lighting, Sports lighting, Hospital lighting, Auditorium lighting. General Aspects of emergency lighting. Lighting controllers – dimmers, motion and occupancy sensors, photo sensors and timers. Lighting system design using software (eg: DIALux and Relux).	**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: ES0U10E 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:

CO1	Interpret the fundamental concepts in object-oriented approach and programming in JAVA.	Understand
CO2	Apply the principles of inheritance and interfaces in the software design process.	Apply
CO3	Explain the I/O streams that develop Applet in JAVA.	Understand
CO4	Illustrate the advanced features of JAVA such as Multithreading and Error Management.	Understand
CO5	Explain 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
EE1U31F	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:

CO1	Compare the characteristics of conductor, semiconductor and solar energy materials.	Understand
CO2	Classify different insulating materials and explain polarization in dielectrics.	Understand
CO3	Explain the mechanisms of breakdown in solids, liquids and gases.	Understand
CO4	Classify the different magnetic and superconducting materials.	Understand
CO5	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) Kshitij RB Singh, Vanya Nayak and Ravindra Pratap Singh**.,** *Introduction to bionanomaterials: an overview,* 2021.
4) *Nanomaterials: Science and Applications,* Edited By Deborah M. Kane, Adam Micolich, Peter Roger

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.	**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 – Photoelectron 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
EE1U31X	FUNDAMENTALS OF SOFT COMPUTING	PEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil

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 non-traditional metaheuristic optimization techniques and data clustering algorithms.

iii) COURSE OUTCOMES

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

CO1	Explain the basics of Fuzzy Logic, Artificial Neural Networks and Genetic algorithm.	Understand
CO2	Apply fuzzy logic techniques to control a system.	Apply
CO3	Explain the different Artificial Neural Network architectures and the different learning methods for training of ANNs.	Understand
CO4	Infer the optimal solution of a given problem using genetic algorithm techniques.	Understand
CO5	Explain the Non-traditional Metaheuristic Optimization Techniques and data clustering algorithms.	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, Data Clustering Algorithms.

Genetic Algorithm – basic concepts, operators, steps.

Hybrid Systems - Adaptive Neuro-fuzzy Inference System (ANF1S), Genetic algorithm based back propagation networks, fuzzy back propagation networks.
Introduction to Non-traditional Metaheuristic Optimization Techniques.

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, Fuzzy relations - Cardinality of Fuzzy relations, Operations on Fuzzy relations, Properties of Fuzzy relations. **Fuzzy logic controller**: Block diagram - Fuzzification, rule base, inference engine and defuzzification - simple fuzzy logic controllers with example.	**9**
II	**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. **Neural network architecture and learning**: Single layer, multilayer, recurrent network architectures. Knowledge representation - Learning process - Supervised and unsupervised learning. **Learning algorithms**: Error correction learning - Hebbian learning – Boltzmann learning - competitive learning.	**8**
III	Linear Separability, Pattern Classification: Perceptrons.	**9**

	Back propagation network and its architecture, Derivation of the back-propagation algorithm – Case study. Radial basis function networks. Classification and Regression Trees – Data Clustering Algorithms – K-Means, Fuzzy C-Means, Subtractive Clustering.	
IV	**Genetic Algorithm**: Introduction - basic concepts of Genetic Algorithm - encoding, fitness function, reproduction, cross over, mutation operator, bit-wise operators, generational cycle. **Introduction to Metaheuristic Optimization Techniques**: Random Optimization, Simulated Annealing, Tabu Search, Ant Colony Optimization, Particle Swarm Optimization, Harmony Search, Memetic Algorithms, Evolutionary Algorithms.	**12**
V	**Hybrid Systems**: Adaptive Neuro-fuzzy Inference System (ANF1S), Genetic algorithm based back propagation networks, fuzzy back propagation networks, examples. Case studies – Applications in Control Systems, Renewable energy systems etc.	**7**
	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
HS0U30B	MANAGEMENT FOR ENGINEERS	HSC	3	0	0	3	2020

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW: This course aims to enable the student learn the basic concepts and functions of management and its role in the performance of an organization and to understand various decision-making approaches available for managers to achieve excellence.

iii) COURSE OUTCOMES

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

CO1	Explain the characteristics of management in the contemporary context	Understand
CO2	Summarize the functions of management	Understand
CO3	Infer the decision-making process and productivity analysis	Apply
CO4	Demonstrate project management technique and develop a project schedule	Apply
CO5	Explain the functional areas of management and the concept of entrepreneurship	Understand

iv) SYLLABUS

Introduction to management theory- Characteristic of Management, System approaches to Management, Task and Responsibilities of a professional Manager.

Management and organization-Management Process, Planning types, Principles of Organization, Organization Structures.

Productivity and decision making- Concept of productivity and its measurement; Decision making process; Decision trees; Models of decision making.

Project management- Network construction, CPM and PERT Networks, Scheduling computations, PERT time estimates, Probability of completion of project.

Functional areas of management- Operations management, Human resources management, Marketing management, Financial management, Entrepreneurship, Business plans, Corporate social responsibility, Patents and Intellectual property rights.

v) (a) TEXT BOOKS

1. H. Koontz, and H. Weihrich, Essentials of Management: An International Perspective. 10th ed., McGraw-Hill, 2015.
2. P. Kotler, K. L. Keller, A. Koshy, and M. Jha, Marketing Management: A South Asian Perspective. 15th ed., Pearson, 2016.
3. R. D. Hisrich, and M. P. Peters, Entrepreneurship: Strategy, Developing, and Managing a New Enterprise, 11th ed., McGraw-Hill Education, 2020.
4. M. Y. Khan, and P. K. Jain, Financial Management, Tata-McGraw Hill, 2020.

(b) Reference Books

1. R. B. Chase, Ravi Shankar and F. R. Jacobs, Operations and Supply Chain Management, 15th ed. McGraw Hill Education (India), 2018.
2. P C Tripathi and P N Reddy, Principles of management, TMH, 5th edition, 2012.
3. K. Ashwathappa, 'Human Resources and Personnel Management', TMH, 7th edition, 2011.
4. D. J. Sumanth, Productivity Engineering and Management, McGraw-Hill Education, 2019.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to management theory, Management Defined, Characteristic of Management, Management as an art-profession, System approaches to Management, Task and Responsibilities of a professional Manager, Levels of Manager and Skill required.	**8**
II	Management Process, Planning types, Mission, Goals, Strategy, Programmes, Procedures, Organizing, Principles of Organization, Delegation, Span of Control, Organization Structures, Directing, Leadership, Motivation, Controlling.	**8**
III	Concept of productivity and its measurement; Competitiveness; Decision making process; decision making under certainty, risk and uncertainty; Decision trees; Models of decision making.	**9**
IV	Project Management, Network construction, Arrow diagram, Redundancy. CPM and PERT Networks, Scheduling computations, PERT time estimates, Probability of completion of project, Introduction to crashing.	**10**
V	Introduction to functional areas of management, Operations management, Human resources management, Marketing management, financial management, Entrepreneurship, Business plans, Corporate social responsibility, Patents and Intellectual property rights.	**10**
	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
NC0U30A	DISASTER MANAGEMENT	MNC	2	0	0	--	2020

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

The goal of this course is to expose the students to the fundamental concepts of hazards and disaster management. The course details the various phases of disaster risk management and the measures to reduce disaster risks.

iii) COURSE OUTCOMES

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

CO1	Explain the fundamental concepts and terminology related to disaster management cycle	Understand
CO2	Explain hazard and vulnerability types and disaster risk assessment	Understand
CO3	Describe the process of risk assessment and appropriate methodologies to assess risk	Understand
CO4	Explain the core elements and phases of disaster risk management and measures to reduce disaster risks across sector and community	Apply
CO5	Discuss the factors that determine the nature of disaster response and the various disaster response actions	Understand
CO6	Explain the legislations and best practices for disaster management and risk reduction at national and international level	Understand

iv) SYLLABUS

Introduction- Systems of Earth, Key concepts and terminology in disaster risk reduction and management

Hazard types, Vulnerability types and their assessment, Disaster risk assessment

Disaster risk management- Phases of disaster risk management, Measures for disaster risk reduction- prevention, mitigation, preparedness, Disaster response, Relief

Participatory stakeholder engagement, Disaster communication, Capacity building

Common disaster types in India, Legislations in India on Disaster Management, National Disaster Management Policy, Institutional arrangements for disaster management in India, The Sendai Framework for Disaster risk reduction.

v) (a) TEXT BOOKS

1) Coppola, D.P., *Introduction to International Disaster Management*, Elsevier Science (B/H), London, 2020.
2) Srivastava, H.N., Gupta, G.D., *Management of Natural Disasters in developing countries*, Daya Publishers, Delhi, 2007.
3) Subramanian, R., *Disaster Management*, Vikas Publishing House, 2018.
4) Sulphey, M.M., Disaster *Management*, PHI Learning, 2016.

(b) REFERENCES

1) NDMA, *National Policy on Disaster Management*, Ministry of Home Affairs, Government of India, 2009.
2) National Disaster Management Division, *Disaster Management in India - A Status Report*, Ministry of Home Affairs, Government of India, New Delhi, 2004.
3) *National Disaster Management Plan*, NDMA, Ministry of Home Affairs, Government of India, 2019.
4) *Disaster Management Training Manual*, UNDP, 2016.
5) United Nations Office for Disaster Risk Reduction, *Sendai Framework for Disaster Risk Reduction 2015-2030*, 2015.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction about various systems of earth, Lithosphere- composition, rocks, soils; Atmosphere- layers, ozone layer, greenhouse effect. Weather, cyclones, atmospheric circulations, Indian monsoon; Hydrosphere- oceans, inland water bodies; Biosphere. Definition and meaning of key terms in Disaster risk reduction and Management – disaster, hazard, exposure, vulnerability, risk, risk assessment, risk mapping, capacity, resilience, disaster risk reduction, disaster risk management, early warning systems, disaster preparedness, disaster prevention, disaster mitigation, disaster response, damage assessment, crisis counselling, needs assessment.	**6**
II	Various hazard types, hazard mapping; Different types of vulnerability types and their assessment- Physical, social, economic and environmental vulnerability. Core elements of disaster risk assessment. Components of a comprehensive disaster preparedness strategy approaches, procedures. Different disaster response actions.	**6**
III	Introduction to disaster risk management, core elements of disaster risk management. Phases of disaster risk management, Measures for disaster risk reduction. Measures for disaster prevention, mitigation, and preparedness. Disaster response - objectives, requirements. Disaster response planning; types of responses. Disaster relief, International relief organizations.	**7**
IV	Participatory stakeholder engagement, Importance of disaster communication, Disaster communication- methods, barriers, Crisis counselling. Introduction to capacity building, Concept- Structural measures, Non-structural measures. Introduction to Capacity assessment, Capacity assessment- Strengthening, Capacity for reducing risk.	**5**
V	Introduction - common disaster types in India. Common disaster legislations in India on disaster management. National disaster management policy, Institutional arrangements for disaster management in India. The Sendai Framework for Disaster risk reduction and targets- priorities for action, guiding principles.	**6**
	Total hours	**30**

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
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:

CO1	Develop the characteristics of SCR and design triggering circuits for SCR based circuits	Apply
CO2	Develop single-phase AC voltage controllers.	Apply
CO3	Develop suitable gate drives for MOSFET/IGBT.	Apply
CO4	Experiment with various inverter topologies.	Apply
CO5	Apply modern simulation tools to model dc-dc converters, rectifiers and inverters.	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 Synchronized 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	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

(a) Attendance	:	15 marks
(b) Continuous Assessment	:	30 marks
(c) Continuous Assessment Examination	:	30 marks
Total	**:**	**75 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- **One test of 30 marks**
- Duration – **2 ½ hours**

viii) END SEMESTER EXAMINATION PATTERN

(a)	Preliminary work	:	15 marks
(b)	Implementing the work/Conducting the experiment	:	20 marks
(c)	Performance, result and inference (usage of equipment and troubleshooting):	:	15 marks
(d)	Viva voce	:	20 marks
(e)	Record	:	5 Marks
	Total	**:**	**75 marks**

ix) 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
EE1U38E	ELECTRICAL MACHINES LAB	PCC	0	0	3	2	2022

i) PRE-REQUISITE: EE1U20D DC Machines and Transformers

ii) COURSE OVERVIEW:

Objective of the course is to impart practical knowledge to the students by exposing them to hands-on experience of testing AC and DC machines and to validate the results. The course also intends to prepare the students to analyse the performance of a given machine by adopting suitable tests.

iii) COURSE OUTCOMES

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

CO1	Apply suitable tests on the given DC motor/generator to obtain its performance characteristics.	Apply
CO2	Apply OC and SC tests on the given transformer to obtain the equivalent circuit.	Apply
CO3	Apply suitable tests on the given Induction Motor to obtain its performance characteristics.	Apply
CO4	Develop the equivalent circuit of the given single phase or three phase induction motor by conducting no load and blocked rotor tests.	Apply
CO5	Apply direct loading, EMF, and MMF methods to calculate the regulation of the given three phase alternators.	Apply
CO6	Develop V and inverted V curves of a three-phase alternator or synchronous induction motor by conducting suitable experiments.	Apply

iv) SYLLABUS

- Familiarisation of meters, instruments and safety measures adopted in the laboratory; Study of starters of three phase Induction Motors
- Load Test on a DC Series Motor
- Load Test on a DC Shunt Motor
- OCC of a DC Shunt Generator
- Load Characteristics of a DC Shunt Generator
- OC and SC Tests on a single phase transformer
- OC and SC Tests on a three phase transformer
- Load Test on a single phase transformer
- Load Test on a three phase slip ring Induction Motor
- No Load and Blocked Rotor tests on a three phase squirrel cage Induction Motor
- Load Test on a single phase capacitor start Induction Motor
- Regulation of a three phase Alternator by direct loading

- Regulation of a three phase Alternator by EMF and MMF methods
- Reactive power control in grid connected Alternators
- V and Inverted V curves of a Synchronous Induction Motor

v) REFERENCES

1) Bimbra P S, *Electric Machines*, Khanna Publishers, 2nd edition, 2017.

2) D. P. Kothari, I. J. Nagrath, *Electric Machines*, Tata McGraw Hill, 5th edition.

3) Say M G, *The Performance and Design of AC Machines*, CBS Publishers, New Delhi, 3rd edition, 2002.

4) Langsdorf M. N., *Theory of Alternating Current Machinery*, Tata McGraw Hill, 2nd revised edition, 2001.

vi) COURSE PLAN

Experiment No.	List of exercises/experiments	No. of hours
I	a. Familiarization of meters and instruments used in Electrical Machines Lab b. Study of safety measures to be taken while performing experiments in the lab c. Study of starters of three phase Induction Motors	**3**
II	**Load Test on a DC Series Motor** a. Plot the performance characteristics b. Plot the electrical and mechanical characteristics	**3**
III	**Load Test on a DC Shunt Motor** a. Plot the performance characteristics b. Plot the electrical and mechanical characteristics	**3**
IV	**OCC of a DC Shunt Generator** a. Plot the OCC at rated speed b. Plot the OCC at a speed other than the rated c. Determine critical resistance and critical speed d. Determine the additional resistance required to just excite the machine	**3**
V	**Load Characteristics of a DC Shunt Generator** Plot the internal and external characteristics	**3**
VI	**OC and SC Tests on a single-phase transformer** a. Predetermination of efficiency b. Predetermination of regulation c. Obtain the equivalent circuit	**3**
VII	**OC and SC Tests on a three-phase transformer** a. Predetermination of efficiency b. Predetermination of regulation c. Obtain the equivalent circuit	**3**
VIII	**Load Test on a single-phase transformer** Calculate the regulation and efficiency at different loads	**3**
IX	**Load test on a three-phase slip ring Induction Motor** a. Start the motor using autotransformer or rotor resistance starter and perform load test b. Plot the performance characteristics	**3**
X	**No load and block rotor test on a three-phase squirrel cage Induction Motor**	**3**

	a. Predetermination of performance parameters from circle diagram b. Deduction of equivalent circuit	
XI	**Load Test on a single-phase capacitor start Induction Motor** a. Perform load test on the motor b. Plot the performance characteristics of the motor	**3**
XII	**Regulation of a three phase Alternator by direct loading** a. Determine the regulation of three phase alternator b. Plot the regulation curve	**3**
XIII	**Regulation of a three phase Alternator by emf and mmf methods** Predetermine the regulation of alternator by emf and mmf methods at 0.8pf lag, upf and 0.8pf lead.	**3**
XIV	**Reactive power control in grid connected Alternators** a. Synchronize the alternator by bright lamp method b. Control the reactive power and plot the V and inverted V curves for generator operation	**3**
XV	**V and inverted V curves of a synchronous Induction Motor** Plot the V and inverted V curves of the Synchronous Induction Motor at no load and full load.	**3**
	Total Hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

(a)	Attendance	:	15 marks
(b)	Continuous Assessment	:	30 marks
(c)	Continuous Assessment Examination	:	30 marks
	Total	**:**	**75 marks**

viii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- **One test of 30 marks**
- Duration – **2 ½ hours**

ix) END SEMESTER EXAMINATION PATTERN

(a)	Preliminary work	:	15 marks
(b)	Implementing the work/Conducting the experiment	:	20 marks
(c)	Performance, result and inference (usage of equipment and troubleshooting):	:	15 marks
(d)	Viva voce	:	20 marks
(e)	Record	:	5 Marks
	Total	**:**	**75 marks**

B.TECH MINORS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE0M30I	RASPBERRY PI-PYTHON INTERFACE FOR ELECTRICAL ENGINEERING	VAC	4	0	0	4	2022

i) PRE-REQUISITE: - EE0M20E Hardware Interfacing using Arduino - C Platform

ii) COURSE OVERVIEW:

The Goal of this course is to expose the students to learn how the Raspberry Pi platform works in terms of the physical board and libraries and the IDE (Integrated Development Environment). The course will cover programming the Raspberry Pi using Python code and accessing the pins on the board via the software to control external devices.

iii) COURSE OUTCOMES

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

CO1	Explain the composition of Pi Processor, its architecture, Raspberry Pi Vs Arduino and Raspberry Pi IoT	Understand
CO2	Develop skills for writing Python programs for Raspberry Pi	Apply
CO3	Illustrate the communication of devices with Raspberry Pi	Understand
CO4	Summarize the networking in Raspberry Pi	Understand
CO5	Explain the interfacing of devices with Raspberry Pi	Understand

iv) SYLLABUS

Introduction to Raspberry Pi and Linux, Raspberry Pi vs Arduino, Linux operating system Basics, Linux file system, Linux Graphic user interface.
Basics of Python Programming- Python on Raspberry Pi, Basic debugging requirements: controllability and observability using UART communication.
Communication of devices with Raspberry Pi-General purpose IO pins, Tkinter library. Networking socket interface- sockets, sending data, exemptions, server code, network libraries, web services, public APIs. Interfacing with Raspberry Pi - camera module, pi camera library, capturing images

v) (a) TEXT BOOKS

1) Tim Cox, Raspberry Pi Cookbook for Python Programmers, Packt Publishing Limited, second edition, September 2016.
2) Alex Bradbury, Ben Everard, Learning Python with Raspberry Pi, John Wiley & Sons, 2014.
3) Simon Monk, Programming the Raspberry Pi, McGraw-Hill Education, second edition 2015

(b) REFERENCES

1) Herb Norbom, *Raspberry Pi Python Projects*, Create space Independent Publishers, first edition, 2017.
2) Colin Dow, Internet of Things Programming Projects: Build modern IoT solutions with the Raspberry Pi 3 and Python, Packt Publishing Limited, 2018.
3) Joe Grant, Raspberry Pi: A Comprehensive Beginner's Guide to Setup, Programming (Concepts and techniques) and Developing Cool Raspberry Pi Projects, Independently Published, 2019.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Raspberry Pi and Linux - Pi Processor, Raspberry Pi Vs Arduino, Raspberry Pi IoT and Raspberry Pi set up, Raspberry Pi configuration, Linux operating system Basics, Linux file system, Linux Graphic user interface.	**8**
II	Basics of Python Programming-Introduction, Python on Raspberry Pi, Python Expressions, strings, functions, function arguments, lists, list methods, control flow	**14**
III	Communication of devices with Raspberry Pi-General purpose IO pins, protocol pins, GPIO Access, Graphic user interface, Tkinter library, interaction, Network programs, secure shell, SSH cline/server, Internet protocols, IP addresses, domain names	**14**
IV	Networking socket interface-Introduction, sockets, sending data, exemptions, server code, live server, internet control, Python client demo, Python server demo, network libraries, web services, public APIs	**14**
V	Interfacing with Raspberry Pi-Introduction, camera module, pi camera library, capturing images, PWM on RPI, servo control	**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
EE0M30J	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 Buildings*, 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	**12**

	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.	
	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
EE0M30K	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 familiarized 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:

CO1	Explain the basics of solar energy conversion systems.	Understand
CO2	Explain the principle behind solar thermal systems and its applications.	Understand
CO3	Apply the design aspects of solar photovoltaic systems in sizing its components.	Apply
CO4	Describe the concepts involved in wind energy systems.	Understand
CO5	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
EE0M30L	HYBRID AND ELECTRIC VEHICLES	VAC	4	0	0	4	2022

i) PREREQUISITE: Nil

ii) COURSE OVERVIEW: The main goal of this course is to expose the students to the fundamental concepts and trends in electric and hybrid vehicles and it also discusses how to choose proper energy storage devices for vehicle applications. It gives an insight into the electric machines used and its control for application of electric vehicles. It also intends to deliver various charging systems and various communication protocols.

iii) COURSE OUTCOMES

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

CO1	Explain the basic concepts of Conventional, Electric and Hybrid Electric Vehicles.	Understand
CO2	Compare various configurations of Electric and Hybrid Electric drive trains based on application	Understand
CO3	Explain the propulsion unit for Electric and Hybrid vehicles.	Understand
CO4	Choose various energy storage devices based on their performance requirements for EV application and explain EV charging systems.	Understand
CO5	Select drive systems and various communication protocols for 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 vehicles, 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, 3rd Edition, 2003.

2) Ehsani M., Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2005.
3) Gianfran C O 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, 2nd Edition 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, 2nd Edition, John Wiley & Sons Ltd,2017.
4) Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013.

(c) ONLINE RESOURCES

1) NPTEL courses/Materials (IITG, IITM, IITD) – Electric and Hybrid vehicles
   https://nptel.ac.in/courses/108/103/108103009/ (IIT Guwahati)
   https://nptel.ac.in/courses/108/102/108102121/ (IIT Delhi)
   https://nptel.ac.in/courses/108/106/108106170/ (IIT Madras)
2) FOC Control - video lecture by Texas Instruments
   https://training.ti.com/kr/field-oriented-control-permanent-magnet-motors
3) Sensored and sensorless FOC control of PMSM motors – Application notes (TI, MATLAB)
   https://www.ti.com/lit/an/sprabz0/sprabz0.pdf?ts=1620018267996&ref_url=https%253A%252F%252Fwww.google.com%252F
   https://in.mathworks.com/help/physmod/sps/ref/pmsmfieldorientedcontrol.html
4) Electric Vehicle Conductive AC Charging System
   https://dhi.nic.in/writereaddata/UploadFile/REPORT%20OF%20COMMITTEE636469551875975520.pdf

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Hybrid Electric Vehicles**: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. **Conventional Vehicles**: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.	**12**

II	**Hybrid Electric Drive-trains**: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. **Electric Drive-trains:** Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.	**12**
III	**Electric Propulsion unit:** Introduction to electric components used in hybrid and electric vehicles **DC Drives**: Review of Separately excited DC Motor control – Speed and torque equations - Independent control of orthogonal flux and torque - Closed loop control of speed and torque (block diagram only) **PMSM Drives**: PMSM motor basics – Independent control of orthogonal flux and torque (concept only)- Field Oriented Control (FOC) – Sensored and sensorless control (block diagram only)	**12**
IV	**Energy Storage**: Introduction to energy storage requirements in Hybrid and Electric Vehicles- Battery based energy storage systems, Battery Management System, Types of battery- Fuel Cell based energy storage systems- Supercapacitors -Hybridization of different energy storage devices **Overview of Electric Vehicle Battery Chargers** - On-board chargers, Electric Vehicle Supply Equipment (EVSE) - Grid to EVSE to On-board chargers to battery pack power flow block schematic diagrams. **Types of charging stations** - AC Level 1 & 2, DC - Level 3 –V2G concept-Types of Connectors - CHAdeMO, CCS Type1 and 2, GB/T - PIN diagrams and differences	**12**
V	**Sizing the drive system:** Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics **Vehicle Communication protocols**: Need and requirements - Functions of Control Pilot (CP) and Proximity Pilot (PP) pins, Communication Protocols - CAN, LIN, FLEXRAY (Basics only)- Power line communication (PLC) in EV	**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 HONOURS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1H30I	NON- CONVENTIONAL ENERGY SOURCES	VAC	4	0	0	4	2022

i) PREREQUISITE: Students who have taken EE0M30J MINOR are not eligible to take this course.

ii) COURSE OVERVIEW: The goal of this course is to expose the students to learn the concepts of solar thermal and solar electric systems. It illustrates the operating principles of wind, and ocean energy conversion systems and the features of biomass and small hydro energy resources. The course describes the concepts of fuel cell and hydrogen energy technologies.

iii) COURSE OUTCOMES

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

CO1	Summarize the different energy resources and their scope.	Understand
CO2	Explain the concepts of solar thermal and solar electric systems.	Understand
CO3	Explain the concepts of ocean thermal energy conversion systems, tidal power plants and wind energy conversion technologies.	Understand
CO4	Outline the features of biomass energy, small hydro energy, fuel cell and hydrogen energy.	Understand
CO5	Illustrate the concepts of different energy storage methods.	Understand

iv) SYLLABUS

Classification of Energy Resources-Current world energy scenario and Indian energy scenario.Principle of Conversion of Solar Radiation into Heat, Solar Thermal Electric Power Generation, Solar PV Systems. Ocean Thermal Energy Conversion, Tidal power plants. Wind Energy Conversion Systems wind speed measurement-Classification of WECS- Types of rotors. Biomass conversion technologies - Biogas production from waste biomass.

Small Hydro Power - Basic concepts and types of turbines- selection considerations.

Energy storage –necessity and different methods. Batteries- Types –Specifications. Testing and Performance of Batteries.

v) (a) TEXT BOOKS

1) G. D. Rai, “Non-Conventional Energy Sources”, Khanna Publishers, 2010.
2) Rao S. and B. B. Parulekar, “Energy Technology”, Khanna Publishers, 1999.

(b) REFERENCES

1) G.N. Tiwari, “Solar Energy-Fundamentals, Design, Modelling and Applications”, Narosa Publishers, 2002.
2) Earnest J. and T. Wizelius, “Wind Power Plants and Project Development”, PHI Learning, 2011.
3) Sab S. L., “Renewable and Novel Energy Sources”, MI. Publications, 1995.
4) Sawhney G. S., “Non-Conventional Energy Resources”, PHI Learning, 2012.
5) Tiwari G. N., “Solar Energy- Fundamentals, Design, Modelling and Applications”, CRC Press, 2002.
6) A.A.M. Saigh (Ed), “Solar Energy Engineering”, Academic Press, 1977
7) Abbasi S. A. and N. Abbasi, “Renewable Energy Sources and Their Environmental Impact”, Prentice Hall of India, 2001.
8) Boyle G. (ed.), “Renewable Energy - Power for Sustainable Future”, Oxford University Press, 1996
9) Earnest J. and T. Wizelius, “Wind Power Plants and Project Development”, PHI Learning, 2011.
10) F. Kreith and J.F. Kreider: “Principles of Solar Engineering”, McGraw Hill, 1978.
11) Khan B.H, “Non-Conventional Energy resources”, Tata McGraw Hill, 2009.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Classification of Energy Resources- Conventional Energy Resources - Availability and their limitations- Comparison. Impact of conventional energy resources on the environment –Global warming, KYOTO Protocol. Current world energy scenario and Indian energy scenario. Non-Conventional Energy Resources – Classification, Advantages, Limitations.	**12**
II	SOLAR THERMAL SYSTEMS- Principle of Conversion of Solar Radiation into Heat – Solar thermal collectors. – Flat plate collectors. Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector). Solar Thermal Power Plants. SOLAR ELECTRIC SYSTEMS - Solar Thermal Electric Power Generation – Solar Photovoltaic – Solar Cell fundamentals - characteristics, classification, construction. Solar PV Systems – stand-alone and grid connected- PV Panel Design.	**12**
III	ENERGY FROM OCEAN - Ocean Thermal Energy Conversion (OTEC)- Principle of operation– Types- Open, Closed and Hybrid- Advantages & Limitations of OTEC. Tidal Energy – Principle of Tidal Power- Components of Tidal Power Plant (TPP)- Classification-single basin - double basin types –Limitations.	**12**

	WIND ENERGY – Introduction - Basic principles of Wind Energy Conversion Systems (WECS) wind speed measurement-Classification of WECS - types of rotors. Advantages and Disadvantages of WECS - site selection criteria.	
IV	BIOMASS ENERGY – Introduction - Biomass fuels - Biomass conversion technologies –Factors affecting biogas generation-types of biogas plants – KVIC and Janata model. SMALL HYDRO POWER- Classification as micro, mini and small hydro projects - Basic concepts and types of turbines- selection considerations. Fuel Cell-principle of operation –classification-applications. Hydrogen energy - hydrogen production - hydrogen storage and utilization.	**12**
V	ENERGY STORAGE: Need of energy storage; Different modes of energy storage, Flywheel storage, Pumped Hydroelectric energy storage, Compressed Air Energy Storage. Supercapacitors. Batteries- Types – Primary and Secondary Cells. Nickel Cadmium, Nickel Metal Hydride, Lead Acid, Lithium ion and Specifications. Testing and Performance of Batteries.	**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
EE1H30J	ELEMENTS OF SOLAR ENERGY CONVERSION	VAC	4	0	0	4	2022

i) PRE-REQUISITE: ES0U10D Basics of Electrical and Electronics Engineering

ii) COURSE OVERVIEW:

This course aims to impart the knowledge in solar energy conversion systems, DC-DC converters, Inverters and storage systems. The students will be familiarized with different solar cell technologies and power conditioning systems used for energy conversion. 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:

CO1	Explain the basics of solar cell technologies for energy conversion systems.	Understand
CO2	Describe the concepts involved in tracking maximum power from solar photovoltaic systems	Understand
CO3	Classify various converter topologies used in conversion of solar energy to electrical energy	Understand
CO4	Apply the design aspects of solar photovoltaic systems in sizing its components.	Apply
CO5	Analyse the importance of storage systems in solar photovoltaic systems	Understand

iv) SYLLABUS

Solar Cell technologies –Crystalline Cells: Mono- crystalline and poly – crystalline cells, Metallurgical Grade Si, Electronic Grade Si; Solar PV Systems - Solar cell characteristics and their measurement, PV Module, PV array, Partial shading of a solar cell and a module; Solar Converters - Switched mode regulators, Analysis of Buck Regulators, Boost regulators, Buck and boost regulators, Cuk regulators; Solar Inverters - Centralized Inverters, String Inverters, Multi-string Inverters, Module Integrated Inverter/Micro-inverters, Inverter Topology, Model of Inverter; Storage Systems – Electrochemical storage systems, Secondary batteries, Lead-Acid Batteries, Lithium-Ion Batteries, Flow batteries.

v) (a) TEXT BOOKS

6) Godfrey Boyle, *Renewable Energy: Power for a sustainable future*, Oxford University Press, 2012.
7) Rai. G.D, *Non-conventional Energy Sources*, Khanna publishers, 2011.

8) A.A.M. Saigh (Ed): *Solar Energy Engineering*, Academic Press, 1977.
9) G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers,2002.

(b) REFERENCES

6) C. S. Solanki, *Solar Photovoltaics: Fundamentals Technologies and Applications*, Prentice-Hall of India Pvt. Limited, 3rd edition, 2015.
7) Rai. G.D, *Solar Energy Utilization*, Khanna Publishers, 1995.
8) Rashid M.H., *Power Electronics Circuits, Devices and Applications*, 4th edition, Pearson Education, 2017.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Solar Cell technologies** –Crystalline Cells: Mono- crystalline and poly – crystalline cells, Metallurgical Grade Si, Electronic Grade Si, wafer production, Mono – crystalline Si Ingots, Poly – crystalline Si Ingots, Si – wafers, Si – sheets, Solar grade Silicon, Si usage in solar PV, Commercial Si solar cells, process flow of commercial Si cell technology, process in solar cell technologies, Sawing and surface texturing, diffusion process, thin film layers, Metal contact	**12**
II	**Solar PV Systems** - Solar cell characteristics and their measurement, PV Module, PV array, Partial shading of a solar cell and a module, the diode, Power conditioning unit, maximum power point tracker, Implementation of Perturb and Observe Method, Incremental Conductance Method, Battery charger/discharge controller.	**12**
III	**Solar Converters** - Switched mode regulators, Analysis of Buck Regulators, Boost regulators, Buck and boost regulators, Cuk regulators, Condition for continuous inductor current and capacitor voltage, Comparison of regulators, Multi output boost converters, Advantages, Applications.	**12**
IV	**Solar Inverters** - Centralized Inverters, String Inverters, Multi-string Inverters, Module Integrated Inverter/Micro-inverters, Inverter Topology, Model of Inverter, Sizing Inverters for a Solar PV System. Types of PV Systems: Grid-Connected Solar PV System, Stand-Alone Solar PV System.	**12**
V	**Storage Systems** – Electrochemical storage systems, Secondary batteries, Lead-Acid Batteries, Lithium-Ion Batteries, Flow batteries, Other Batteries in Development, Internal configuration of battery storage systems, External connection of EES systems, Aggregating EES systems and distributed generation (Virtual Power Plant), “Battery SCADA” aggregation of many dispersed batteries.	**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
EE1H30K	SOLAR PHOTOVOLTAICS FUNDAMENTALS	VAC	4	0	0	4	2022

i) PRE-REQUISITE: ES0U10D Basics of Electrical and Electronics Engineering,

ii) COURSE OVERVIEW:

This course aims to impart the knowledge of photovoltaic systems, various technologies of solar PV cells, details about manufacture, sizing, operating techniques and design considerations. The students will be familiarized with the major aspects of solar energy conversion systems. This course also aims at providing the fundamental information in solar energy conversion systems.

iii) COURSE OUTCOMES

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

CO1	Explain the basics of solar energy conversion systems.	Understand
CO2	Explain the principle behind the design of solar cells.	Understand
CO3	Design and sizing of components for solar photovoltaic systems	Apply
CO4	Illustrate the various maximum power point tracking methods.	Understand

iv) SYLLABUS

Solar Energy - Solar radiation – Solar Radiation on an Inclined/Tilted Surface. Manufacture of Solar Cells-Technologies. Flat plate arrays, Support structures, Module interconnection and cabling, Lightning protection, Solar photovoltaic systems - Characteristics - Types of solar cells - PV Module - Block diagram of SPV system – MPPT – Design of SPV - Modelling of SPV.

v) (a) TEXT BOOKS

1) F. C. Treble, “Generating electricity from Sun”, Pergamon Press.
2) A. K. Mukherjee, Nivedita Thakur, “Photovoltaic systems: Analysis and design”, PHI, 2011.
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) OTHER REFERENCES

1) C. S. Solanki, *Solar Photovoltaics: Fundamentals Technologies and Applications*, Prentice-Hall of India Pvt. Limited, 3rd edition, 2015.
2) Rai. G.D, *Solar Energy Utilization*, Khanna Publishers, 1995.

3) Rashid M.H., *Power Electronics Circuits, Devices and Applications*, 4th edition, Pearson Education, 2017.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Solar Energy** - Sun and Earth, Solar Spectrum, Solar Geometry, Solar radiation on horizontal and inclined planes, Instruments for measurement of solar radiation, Solar cell, Equivalent circuit, V-I characteristics, Performance improvement.	**12**
II	**Solar Cells** -Manufacture of Solar Cells-Technologies, Design of Solar cells, Photovoltaic modules, Design requirements, Encapsulation systems, Manufacture, Power rating, Hotspot effect, Design qualifications.	**12**
III	**Protection and Measurements** - Flat plate arrays, Support structures, Module interconnection and cabling, Lightning protection, Performance measurement using natural sun light and simulator, Determination of temperature coefficients, Internal series resistance, Curve correction factor.	**12**
IV	**Photovoltaic Systems** – Photovoltaic systems, Types, General design considerations, System sizing, Battery sizing, Inverter sizing, Design examples, Balance of PV systems.	**12**
V	**Maximum Power Point Trackers** – Maximum power point trackers, Perturb and observe, Incremental conductance method, Hill climbing method, Hybrid and complex methods, Data based and other approximate methods, Instrument design, Other MPP techniques, Grid interactive PV system.	**12**
	Total hours	**60**

viii) 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

SEMESTER VI

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1U30A	POWER SYSTEMS I	PCC	3	1	0	4	2020

i) PRE-REQUISITE: ES0U10D Basics of Electrical & Electronics Engineering, PH0U10A Engineering Physics A.

ii) COURSE OVERVIEW:

The goal of this course is to expose the students to the fundamental concepts of generation, transmission and distribution of electric power. The course also intends to deliver the basic concepts of power system protection including the different types of relays and circuit breakers.

iii) COURSE OUTCOMES

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

CO1	Explain the different forms of power generation schemes, the importance of power system protection and different types of Circuit Breakers and relays.	Understand
CO2	Solve problems based on the economics of power generation and power factor improvement.	Apply
CO2	Solve for the inductance, capacitance, ABCD parameters and volume of conductor material required for the various types of power transmission schemes.	Apply
CO4	Solve for the various parameters related to overhead transmission lines and cables.	Apply
CO5	Solve loading problems related to various power distribution systems and compare AC and HVDC transmission schemes.	Apply

iv) SYLLABUS

Introduction - Generation of Electric Power - Overview of conventional generation schemes, Economics of Generation – Terminology - Power Factor Improvement using capacitors.
Power Transmission - Transmission Line Parameters: Resistance, inductance and capacitance of single phase, two wire and three phase lines, Modelling of Transmission Lines.
Introduction of Overhead transmission and underground transmission – Volume of conductor material required - Mechanical Characteristics of transmission lines – Insulators, Cables – Corona.
HVDC Transmission – Comparison, Types of DC Links - Power distribution systems – DC and AC distribution - Types.
Basics of power system protection – Circuit Breakers - Protective Relays – Principle and types.

v) (a) TEXT BOOKS

1) B. R. Gupta, *Power System Analysis and Design*, Wheeler Publishers, 7th revised edition, 2005.
2) J. B. Gupta, *A course in Electrical Power*, Kataria and Sons, 2013 edition.

3) C. L. Wadhwa, *Electrical Power System*, New Age International Publishers, 1st edition, 2016.
4) Grainer J.G., Stevenson W.D., *Power System Analysis*, Tata McGraw Hill, 1st edition, 2017.
5) Badri Ram, D. N. Vishwakarma, *Power System Protection and Switchgear*, Tata McGraw Hill, 2nd edition, 1994.

(b) REFERENCES

1) A. Chakrabarti, M. L. Soni, P. V. Gupta, U. S. Bhatnagar, A *text book on Power System Engineering*, Dhanpat Rai and Co., 2016 edition.
2) I. J. Nagarath & D. P. Kothari, *Modern Power System Analysis*, Tata McGraw Hill, 4th edition, 2011.
3) K. R. Padiyar, *FACTS Controllers in Power Transmission and Distribution*, New Age International, New Delhi, 2nd edition, 2016.
4) William D. Stevenson Jr, *Elements of Power System Analysis*, Tata McGraw Hill, 4th edition, 1982.
5) Sunil S. Rao, *Switchgear and Protection*, Khanna Publishers, 2nd edition, 2012.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction:** Typical layout of Power system Network. **Generation of Electric Power:** Overview of conventional generation schemes-Hydro, Thermal and Nuclear; Nonconventional Sources-Solar and Wind. Economics of Generation: Terminology-Load factor, diversity factor, Load curve; Numerical Problems. Causes of low lagging power factor, Importance of power factor improvement, Power Factor Improvement using capacitors.	**12**
II	**Power Transmission:** Transmission Line Parameters: Resistance, inductance and capacitance of 1-Φ, 2 wire lines-composite conductors. Inductance and capacitance of 3-Φ lines. Symmetrical and unsymmetrical spacing-transposition-double circuit lines-bundled conductors - Numerical Problems. Modelling of Transmission Lines: Classification of lines - short lines - voltage regulation and efficiency-medium lines - nominal T and Π configurations - ABCD constants - Ferranti effect.	**14**
III	**Introduction of Overhead transmission and underground transmission:** Conductors - types of conductors - copper, aluminium and ACSR conductors - Volume of conductor required for various systems of transmission. Mechanical Characteristics of transmission lines – Calculation of sag and tension-supports at equal and unequal heights - effect of wind and ice. Insulators - Different types - Voltage distribution, grading and string efficiency of suspension insulators. Corona – disruptive critical voltage - visual critical voltage -power loss due to corona - Factors affecting corona. Underground Cables - types of cables - insulation resistance - voltage stress - grading of cables.	**12**

IV	**HVDC Transmission:** Comparison between AC & DC Transmission, Power flow equations and control, Types of DC links. **Power distribution systems:** Radial and Ring Main Systems - DC and AC distribution: Types of distributors - bus bar arrangement - Concentrated and Uniform loading - Methods of solving distribution problems.	**10**
V	**Power System Protection:** Nature, causes and consequences of faults - Fault statistics - Need for protection - Essential qualities of protection - Types of protection – Primary and back up protection. **Circuit breakers:** principle of operation - formation of arc - Arc quenching theory - Restriking Voltage - Recovery Voltage, RRRV; Interruption of Capacitive currents and current chopping. Types of Circuit Breakers: Air blast CB – Oil CB – SF6 CB – Vacuum CB –CB ratings. **Protective Relays:** Zones of Protection, Essential Qualities -Classification of Relays - Electro mechanical, Static Relays, Microprocessor Based Relays; Buchholz relay for transformer protection.	**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
EE1U30J	ENGINEERING ELECTROMAGNETICS	PCC	3	1	0	4	2022

i) **PRE-REQUISITE:** ES0U10D Basics of Electrical and Electronics Engineering, PH0U10A Engineering Physics A, MA0U20A Partial Differential Equations and Complex Analysis.

ii) **COURSE OVERVIEW**:

The purpose of the course is to familiarize the students with the fundamental concepts of electrostatics, magnetostatics and electromagnetic fields. It enables the students to apply this knowledge in the determination of electric and magnetic fields and to summarize Maxwell's equations for different applications. It also introduces students to the concepts of electromagnetic wave propagation, transmission lines.

i) **COURSE OUTCOMES**

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

CO1	Apply vector analysis and co-ordinate systems to solve static electric and magnetic field problems.	Apply
CO2	Apply Gauss's Law, Coulomb's law and Poisson's equation to evaluate fields and potentials for different charge distributions and capacitors.	Apply
CO3	Solve magnetic fields due to various current distributions by applying Biot-Savart's law and Ampere's Circuital law.	Apply
CO4	Summarize Maxwell Equations for time varying fields by modifying Faraday's law and Ampere's Circuital law.	Understand
CO5	Identify the characteristics of wave propagation in different media and solve for simple electromagnetic problems using ANSYS Maxwell software.	Apply

ii) **SYLLABUS**

Introduction to Co-ordinate Systems; Del operations; Divergence Theorem; Stokes' Theorem.

Coulomb's Law; Electric field intensity; Flux Density; Gauss's law; Potential-Potential Gradient; Poisson's and Laplace's equations; Capacitance and Inductance.

Biot-Savart's Law; Magnetic Field intensity; Magnetic Flux Density; Ampere's circuital law; Force between current carrying conductors; Magnetic potential.

Conductors and dielectrics; Continuity equation; Boundary conditions; Maxwell's Equations; Polarization.

Electromagnetic Wave Equations, Uniform Plane Waves, Poynting Theorem, Transmission Lines.

iii) (a) TEXT BOOKS

1) Matthew N.O. Sadiku, *Principles of Electromagnetics*, Oxford university Press, 2015.
2) Bakshi A.V. and Bakshi U.A., *Electromagnetic Theory*, Technical Publications, 2017.
3) John Kraus and Daniel Fleisch, *Electromagnetics with Applications*, McGraw-Hill Education, 2017.

(b) REFERENCES

1) William, H. Hayt. and John A. Buck, *Engineering Electromagnetics*, McGraw-Hill Education, 2017.
2) William, H. Hayt and John A. Buck, *Problems and Solutions in Electromagnetics,* McGraw- Hill Education, 2017.
3) Joseph A. Edminister, *Electromagnetics, Schaum's Outline Series*, McGraw-Hill Education, 2013.

iv) COURSE PLAN

Module	Contents	No. of hrs
I	**Introduction to Co-ordinate Systems:** Introduction to vector calculus and different co-ordinate systems- Rectangular, Cylindrical and Spherical Co-ordinate Systems; Co-ordinate transformation. Gradient of a Scalar field, Divergence of a Vector field and Curl of a Vector field- their physical interpretation, Laplacian of a scalar; Divergence Theorem, Stokes' Theorem.	12
II	**Electrostatics:** Coulomb's Law, Electric field intensity; Electric Flux and Flux Density; Gauss's law and its application to determine the field due to an infinite line charge, infinite sheet charge. Electric Potential-Potential Gradient, Conservative property of electric field, Equipotential surfaces; Electric Dipole; numerical problems. Capacitance and Inductance of a co-axial cable and two-wire transmission line; Poisson's and Laplace's equations.	12
III	**Magnetostatics:** Biot-Savart's Law, Magnetic Field intensity due to finite and infinite current carrying wires; Magnetic field intensity on the axis of circular and rectangular current carrying loop; Magnetic flux Density. Ampere's circuital Law and its application to find the magnetic field due to an infinite current carrying wire; force between current carrying conductors; numerical problems on magnetostatics. Scalar and Vector magnetic potential.	12
IV	**Electric and magnetic fields in materials:** Boundary conditions for electric fields and magnetic fields. Conduction current and displacement	12

	current; Equation of continuity; Dielectric polarization; Electrostatic energy and energy density. Maxwell's Equations in Differential and Integral form for time-varying fields. **Electromagnetic Waves:** Wave Equations from Maxwell's Equations; Wave equations in Phasor form.	
V	**Uniform Plane Waves** -Propagation of Uniform Plane waves in free space, loss-less and lossy dielectric medium, good conductors; properties in different medium-attenuation constant, phase constant, propagation constant, intrinsic impedance, phase velocity and group velocity; Skin effect and skin depth; numerical problems; Poynting Theorem; Basic concepts of Transmission Lines. **Familiarization of Ansys Maxwell software** – solution of simple electric and magnetic fields using ANSYS Maxwell software.	**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
EE1U30K	INTRODUCTION TO SIGNALS AND SYSTEMS	PCC	3	1	0	4	2022

i) **PRE-REQUISITE:** MA0U10A: Linear Algebra and Calculus, MA0U10B: Vector Calculus, Differential Equations and Transforms, MA0U20A: Partial Differential Equations and Complex Analysis.

ii) **COURSE OVERVIEW**: This course aims to impart knowledge about the representation and properties of signals and systems and its applications in engineering and technology.

iii) COURSE OUTCOMES

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

CO1	Apply the basic operations on signals and systems.	Apply
CO2	Apply Fourier Series and Fourier Transform concepts for continuous time signals.	Apply
CO3	Make use of Laplace Transforms for continuous time systems.	Apply
CO4	Make use of Z-Transforms for discrete time systems.	Apply
CO5	Apply Fourier Series and Fourier Transform concepts for discrete time signals.	Apply

iv) SYLLABUS

Basics of signals- operation on signals; Classification of systems; Representation of LTI Systems. Fourier analysis of continuous time signals; Fourier transform- properties; Frequency response of LTI Systems. Laplace Transform analysis of systems- Time and Frequency responses.

Sampling- signal reconstruction, Z Transform- Region of convergence- properties;

Solution of LTI Systems using Z transform method. Fourier representation of discrete time systems- discrete time Fourier series- discrete time Fourier transform.

v) (a) TEXT BOOKS

1) Haykin S. & Veen B.V., "*Signals & Systems*", John Wiley Publications, 2nd edition, 2007.
2) Oppenheim A.V, Willsky A.S. & Nawab S.H., "*Signals and Systems*", Pearson Publications, 2nd edition, 2015.
3) I J Nagrarth, "*Signals and Systems*", McGraw Hill Education, 2009.
4) P.Ramesh Babu, R. Anandanadarajan, "*Signals and Systems*", SCITECH Publications Pvt. Ltd, 2008.
5) Dr. D. Ganesh Rao, Satish Tunga," *Signals and Systems*", Cengage India Private Limited, 2017.

(b) REFERENCES

1) Bracewell R.N., "*Fourier Transform & Its Applications*", McGraw Hill Education, 1999.

2) Farooq Husain, "*Signals and Systems*", Umesh Publications, 2017.
3) Papoulis A., "*Fourier Integral & Its Applications*", McGraw-Hill Book Company, 1962.
4) Taylor F.J., Principles of Signals & Systems, McGraw Hill

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Signals and Systems: Classification of signals: Elementary Signals - Basic operations on continuous time and discrete time signals. Concept of system: Classification of systems - Properties of systems - Impulse response. Representation of LTI systems: Differential equation representations of LTI systems. Basics of Non-linear systems - types and properties.	**12**
II	Fourier Analysis: Fourier analysis of continuous time signals: Fourier Series- Harmonic analysis of common signals. Fourier transform: Existence- Properties of Continuous time Fourier transform- Concept of Frequency response.	**12**
III	Laplace transform analysis of systems - relation between the transfer function and differential equation –causality and stability - inverse system - determining the time domain and frequency response from poles and zeros.	**12**
IV	Sampled data systems - Sampling process-sampling theorem signal re construction- Zero order and First order hold circuits- Z Transform - Region of convergence - Properties of the Z transform – Inverse ZT-methods	**12**
V	Difference equation representations of LTI systems - Z-transfer function - Analysis of difference equation of LTI systems - Basic idea on Stability and causality conditions. Fourier representation of discrete time signals – Discrete Fourier series– properties - Frequency response of simple DT systems	**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
EE1U32Z	ELECTRICAL MACHINE DESIGN	PEC	2	1	0	3	2022

i) PREREQUISITE: EE1U20D DC Machines and Transformers, EE1U30D Synchronous and Induction Machines.

ii) COURSE OVERVIEW:

The main goal of this course is to expose the students to the design of static and rotating electrical machines. It introduces students to cognitive learning and develops problem solving skills. It gives an insight into the fundamental concepts of computer aided design of electrical machines.

iii) COURSE OUTCOMES

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

CO1	Explain the basic principles of electrical machine design and computer aided design.	Understand
CO2	Develop the temperature rise characteristics of an electrical machine during heating and cooling.	Apply
CO3	Make use of the given specific data to determine the gap contraction factors and air gap mmf of electrical machines.	Apply
CO4	Design the main dimensions of single phase and three phase transformers using the given specific data.	Apply
CO5	Design the main dimensions of rotating electrical machines using the given specific data.	Apply

iv) SYLLABUS

Principles of electrical machine design - General design considerations - specifications of machines, Magnetic circuit calculations.
Design of transformers - output equation of single phase and three phase transformers – optimum designs.
Design of DC Machines - output equation – calculation of main dimensions – Armature Design - Design of field system – pole design, design of shunt field winding.
Design of synchronous generators - output equation - main dimensions of salient pole alternators - design of main dimensions of turbo alternators.
Design of three phase induction motors – output equation - main dimensions - choice of specific loadings.
Introduction to computer aided design.

v) (a) TEXT BOOKS

1) Sawhney A.K., A Course in Electrical Machine Design, Dhanpat Rai & Co. (P) Limited, New Delhi, 2016.

2) William T. Ryan, Design of Electrical Machinery, Creative Media Partners, LLC, 4th Edition, 2015.

3) Upadhay K.G., Design of Electrical Machines, New Age International, 2011.

4) Agarwal R.K., Principles of Electrical Machine Design, S. K. Kataria & Sons, 5th Edition 2014.

5) Say M.G., The Performance and Design of AC Machines, CBS Publishers, New Delhi, 3rd Edition, 2002.

6) Albert E Clayton & Hancock N.N., Performance and Design of DC Machines, Oxford and IBH Publishing CO& PVT Ltd, New Delhi, 3rd Edition,1971.

(b) REFERENCES

1) Rajani V., Nagarajan V.S., Electrical Machine Design, Pearson Publications, 3rd Edition, 2018.
2) Thomas A. Lipo, Introduction to AC machine design, Wiley-IEEE Press, 2017.
3) Deshpande M.V., Design and Testing of Electrical Machines, PHI Learning Pvt. Ltd., 2010.
4) Juha Pyrhonen, Valeria Hrabovcova, Tapani Jokinen, Design of Rotating Electrical Machines, John Wiley and Sons Inc., 2nd Edition 2013.
5) Ramamoorthy M, "Computer Aided Design of Electrical Equipment", East-West Press, 2nd Edition, January 2008.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Principles of electrical machine design** - General design considerations - specifications of machines – limitations in design –materials for electrical machines – conducting materials, magnetic materials and insulating materials - types of ventilation - temperature rise-time curve – numerical problems – ratings of electrical machines – temperature rise with short time ratings. **Magnetic circuit calculations** – Reluctance of air gap in machines – effect of slots and ventilating ducts – gap contraction factors – calculation of air gap mmf – effect of saliency – numerical problems.	**10**
II	**Design of transformers** - output equation of single phase and three phase transformers – emf/turn – optimum designs- design for minimum cost, minimum losses - variation of output and losses with linear dimensions - core design – design of windings, window dimensions and yoke – overall dimensions – numerical problems – Design of transformer tank with cooling tubes – numerical problems.	**8**
III	**Design of Rotating Electrical Machines** – Main Dimensions, Total Loadings, Specific Loadings. **Design of DC Machines** - output equation – choice of specific loadings - choice of speed and no of poles - calculation of main dimensions – design of length of air gap - numerical problems – Armature Design – Choice of armature winding – number of armature coils – slot dimensions – guiding factors for the choice of number of armature slots and design of winding – numerical problems – Design of field system – pole design,	**10**

	design of shunt field winding – numerical problems. Fundamental design aspects of interpoles, compensating winding, commutator and brushes.	
IV	**Design of synchronous generators** - output equation - main dimensions of salient pole alternators – numerical problems - choice of specific loadings and Short Circuit Ratio (SCR) - Stator Design – number of armature slots, stator winding turns/phase and conductor cross section - numerical problems - choice of length of air gap – design of main dimensions of turbo alternators - numerical problems - cooling of alternators.	**9**
V	**Design of three phase induction motors** – output equation - main dimensions - numerical problems - choice of specific loadings - stator design – stator winding turns/phase, conductor cross section, number of slots, area of slots – numerical problems – choice of length of air gap. Rotor Design – design of squirrel cage induction motor - number of rotor slots – design of rotor bars and end rings - design of slip ring rotor winding - number of rotor slots – number of turns/phase and conductor cross section - numerical problems. **Introduction to computer aided design** - Analysis and synthesis methods - hybrid techniques - Introduction to Finite element method, Advantages.	**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
EE1U32Y	ADVANCED CONTROL SYSTEMS	PEC	2	1	0	3	2022

i) PRE-REQUISITE: EE1U30I Introduction to Control Engineering

ii) COURSE OVERVIEW: This course introduces advanced concepts in control theory to the students to enable them to design a controller or a compensator required for a control system. The course also presents the concept of state feedback controllers and their design. Apart from these, non-linear systems and its analysis using different methods are also discussed in the course. It thus helps the students to get an overview of the advanced concepts and enables them to apply these advanced control principles in various areas of industry.

iii) COURSE OUTCOMES

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

CO1	Develop the state variable representation of physical systems	Apply
CO2	Apply state variable approach in linear and nonlinear systems	Apply
CO3	Design compensators and controllers for a given system	Apply
CO4	Explain the characteristics of nonlinear systems	Understand
CO5	Apply describing function approach and phase plane approach in nonlinear systems	Apply
CO6	Apply Lyapunov method in physical systems.	Apply

iv) SYLLABUS

State Space Representation of Systems - Canonical forms - Similarity transformations to diagonal canonical form.

State Space Analysis: State transition matrix- Computation of state transition matrix using Laplace transform and Cayley Hamilton method.

Solution of time response of autonomous systems and forced systems, State Feedback Controller, State observers for LTI systems.

PID Controller, Ziegler-Nichols method, Design of Compensator using Root locus, Design of PID controller using Root locus and frequency domain techniques.

Nonlinear Systems: Types and characteristics of nonlinear systems.

Describing function method: Determination of describing function of nonlinearities, Application of describing function for stability analysis of autonomous system with single nonlinearity.

Phase Plane and Lyapunov Stability Analysis: Singular points, Definition of stability, Construction of phase trajectories using Isocline method, Lyapunov stability analysis.

v) (a) TEXT BOOKS

1) Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age Publishers, 2007
2) Ogata K., Modern Control Engineering, 5/e, Prentice Hall of India, 2010.
3) Gopal M, Modern Control System Theory, 2/e, New Age Publishers, 1984.
4) Kuo B.C, Analysis and Synthesis of Sampled Data Systems, Prentice Hall Publications, 2012.

(b) REFERENCES

1) Khalil H. K, Nonlinear Systems, 3/e, Prentice Hall, 2002
2) Gibson J.E. Nonlinear Automatic Control, McGraw Hill, 1963.
3) Gopal M., Control Systems Principles and Design, 4/e, Tata McGraw Hill, 2012.
4) Slotine J. E and Weiping Li, Applied Nonlinear Control, Prentice-Hall, 1991,
5) Thomas Kailath, Linear Systems, Prentice-Hall, 1980.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**State Space Representation of Systems:** Phase variable forms of state space representation - controllable and observable companion forms, Diagonal & Jordan canonical forms of state space representation - Similarity transformations to diagonal canonical form. **State Space Analysis:** State transition matrix - Properties of state transition matrix - Computation of state transition matrix using Laplace transform - Cayley Hamilton method. Solution of time invariant systems: Solution of time response of autonomous systems and forced systems.	**10**
II	**State Feedback Controller Design:** Controllability & observability: Kalman's, Gilbert's test - Duality property. State feedback controller design: State feed-back design via pole placement technique. State observers for LTI systems - Full order and reduced order observers - Design of full order observer design.	**7**
III	**PID Controller** – transfer function, tuning of PID controllers using Ziegler-Nichols method. **Design of Controllers and Compensators**: Compensator design using Root locus, Design of PID controller using Root locus technique, Design of PID controller in frequency domain.	**10**
IV	**Nonlinear Systems:** Types of nonlinear systems - characteristics of nonlinear systems - peculiar features like Jump resonance, Limit cycles and Frequency entrainment. Describing function Method: Analysis through harmonic linearisation. Determination of describing function of nonlinearities, Application of describing function for stability analysis of autonomous systems with single nonlinearity (relay, dead zone and saturation only).	**8**
V	**Phase Plane and Lyapunov Stability Analysis** Phase plots: Concepts - Singular points - Classification of singular points. Construction of phase trajectories using Isocline method for linear and nonlinear systems, Definition of stability - asymptotic stability and instability. Lyapunov stability analysis: Lyapunov function - Lyapunov methods to stability of nonlinear systems. Lyapunov methods to LTI continuous time systems.	**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
EE1U32X	FUNDAMENTALS OF MACHINE LEARNING	PEC	3	0	0	3	2022

i) PRE-REQUISITE: EE1U30K Introduction to Signals and Systems

ii) COURSE OVERVIEW: The main goal of this course is to equip the students with a machine learning mindset for successful practical implementations, in particular: understand, analyze and design an approach to work with a data science or electrical engineering problem.

iii) COURSE OUTCOMES

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

CO1	Identify relevant real-world problems as instances of canonical machine learning problems.	Understand
CO2	Design and implement effective strategies for data pre-processing.	Understand
CO3	Explain and utilize concepts of machine learning for electrical engineering	Understand
CO4	Make connections between different fields of machine learning.	Understand
CO5	General level of competency in critical questioning and analysis.	Apply

iv) SYLLABUS

Introduction-applications, probability theory - random-variables, distributions, mean, variance, marginalisation, independence, condition and Bayes rule, Algorithm - Naïve bayes, nearest neighbour estimators, simple classifier, perceptron, k-means, Density Estimation.

Optimization - Convex sets, convex functions, Convex minimization, constrained optimization, stochastic optimization, non-convex minimization.

Kernels and Function spaces – Basics, examples, Kernels - Feature maps, Linear models - Support vector classification-regularised risk minimization view point, specialised algorithms for training SVMs.

Extensions-v-trick, squared hinge loss, ramp loss. Support vector regression - general loss function and v-trick. Margins and probability.

Classification - Multiclass, multilabel, ordinal regression and ranking. Large margin classifiers - margin, penalised margin, non-convex losses, Applications, Optimizations - column generation, bundle methods, over relaxation in the dual. CRF and structured large margin models - loss functions, dual connections, optimization.

v) (a) TEXT BOOKS

1) Christopher Bishop, Pattern Recognition and Machine Learning, First Edition, Springer publications, 2006.
2) Alex Smola and S.V.N. Vishwanathan, Introduction to machine learning, Cambridge University Press, 2008.

(b) REFERENCE BOOKS

1) Kevin P. Murphy. Probabilistic Machine Learning: An introduction. MIT Press, 2022.
2) Bernhard Scholkopf and Alexander J. Smola. Learning with Kernels: Support Vector Machines, Regularization, Optimization, and Beyond. MIT Press, Cambridge, MA, USA, 2001.
3) Shai Shalev-Shwartz and Shai Ben-David. Understanding Machine Learning: From Theory to Algorithms. Cambridge University Press, New York, NY, USA, 2014.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction** - applications, probability theory - random-variables, distributions, mean-variance, marginalisation, independence, condition and Bayes rule, Algorithm-Naïve bayes, nearest neighbour estimators, simple classifier, perceptron, k-means. Density Estimation-limit theorem, parzen windows, estimation and sampling.	**9**
II	**Optimization** - Convex sets, convex functions, sub gradients, convex functions with Lipschitz continuous gradient, Fenchel duality, Bregan divergence, Convex minimization, constrained optimization, stochastic optimization, non-convex minimization.	**9**
III	**Kernels and Function spaces** - Basics-examples, Kernels - Feature maps, Kernel trick, examples, Algorithm-kernel perceptron, trivial classifier, kernel principal component analysis, reproducing kernel Hilbert spaces-hilbert spaces, theoretical properties, regularisation, Banach spaces-norms and convex sets.	**10**
IV	**Linear models**-Support vector classification-regularised risk minimization viewpoint, exponential family interpretation, specialised algorithms for training SVMs. Extensions-v trick, squared hinge loss, ramp loss. Support vector regression-general loss function and v-trick. Margins and probability.	**8**
V	**Classification**: Multiclass, multilabel, ordinal regression and ranking. Large margin classifiers - margin, penalized margin, non-convex losses, Applications, Optimizations - column generation, bundle methods, over relaxation in the dual. CRF and structured large margin models - loss functions, dual connections, optimization.	**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
EE1U32W	DIGITAL SIGNAL PROCESSING	PEC	2	1	0	3	2022

i) PRE-REQUISITE: EE1U30K Introduction to Signals and Systems

ii) COURSE OVERVIEW: This course introduces the discrete Fourier transform (DFT) and its computation using direct method and fast Fourier transform (FFT). Techniques for designing infinite impulse response (IIR) and finite impulse response (FIR) filters from given specifications are also introduced. Various structures for realization of IIR and FIR filters are discussed. Detailed analysis of finite word-length effects in fixed point DSP systems is included. Architecture of a digital signal processor is also discussed.

iii) COURSE OUTCOMES

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

CO1	Construct Discrete Fourier transform and Fast Fourier transform.	Apply
CO2	Examine the various structures for realization of IIR and FIR discrete-time systems.	Analyse
CO3	Develop IIR (Butterworth and Chebyshev) digital filters using impulse invariant and bilinear transformation methods.	Apply
CO4	Develop FIR filters using frequency sampling method and window function method.	Apply
CO5	Compare fixed point and floating-point arithmetic used in digital signal processors and discuss the finite word length effects.	Understand
CO6	Explain the architecture of digital signal processors and the applications of DSP.	Understand

iv) SYLLABUS

Discrete-Fourier Transform- Frequency domain sampling - Discrete Fourier transform (DFT) - Fast Fourier transform (FFT) -radix -2 decimation-in-time FFT (DITFFT) algorithm, Radix-2 decimation-in-frequency FFT (DIFFFT) algorithm. Realization of IIR and FIR Systems- IIR Filter Design -frequency transformation in analog domain - design of LP, HP, BP, BS IIR digital filters using impulse invariance and bilinear transformation. FIR Filter Design and Representation of Numbers - IEEE 754 32-bit single precision floating point representation. Finite Word Length Effects and Digital Signal Processors- Digital signal processor architecture based on Harvard architecture (block diagram) – applications of DSP.

v) (a) TEXT BOOKS

1) John G. Proakis & Dimitris G.Manolakis, “Digital Signal Processing Principles, Algorithms & Applications”, Pearson.

2) P. Ramesh Babu, “Digital Signal Processing”, Scitech Publications (India) Pvt Ltd, 2nd edition, 2003

(b) REFERENCES

1) Emmanuel Ifeachor & Barrie W Jervis, “Digital Signal Processing”, Pearson, 13th edition, 2013.
2) Li Tan, “Digital Signal Processing, Fundamentals & Applications”, Academic Press, Ist edition, 2008.
3) D. Ganesh Rao & Vineeta P Gejji, “Digital Signal Processing, A Simplified Approach”, Sanguine Technical Publishers, 2nd edition, 2008.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Discrete-Fourier Transform**-Review of signals and systems - Frequency domain sampling - Discrete Fourier transform (DFT) – inverse DFT (IDFT) - properties of DFT – linearity, periodicity, symmetry, time reversal, circular time shift, circular frequency shift, circular convolution, complex conjugate property – Filtering of long data sequences – over-lap save method, over-lap add method – Fast Fourier transform (FFT) – advantages over direct computation of DFT - radix -2 decimation-in-time FFT (DITFFT) algorithm, Radix-2 decimation-in-frequency FFT (DIFFFT) algorithm.	**10**
II	**Realization of IIR and FIR Systems**-Introduction to FIR and IIR systems - Realization of IIR systems – direct form 1, direct form 2, cascade form, parallel form, lattice structure for all-pole system, lattice-ladder structure – conversion of lattice to direct form and vice- versa - signal flow graphs and transposed structures – Realization of FIR systems – direct form, cascade form, lattice structure, linear phase realization.	**8**
III	**IIR Filter Design** -Conversion of analog transfer function to digital transfer function – impulse invarient transformation and bilinear transformation – warping effect. Design of IIR filters – low-pass, high-pass, band-pass, band-stop filters – Butterworth and Chebyshev filter – frequency transformation in analog domain - design of LP, HP, BP, BS IIR digital filters using impulse invariance and bilinear transformation.	**9**
IV	**FIR Filter Design And Representation Of Numbers**-Impulse response of ideal low pass filter – linear phase FIR filter – frequency response of linear phase FIR filter – Design of FIR filter using window functions (LP, HP, BP, BS filters) – Rectangular, Bartlett, Hanning, Hamming and Blackmann only – FIR filter design based on frequency sampling approach (LP, HP, BP, BS filters).Representation of numbers – fixed point representation – sign-magnitude, one’s complement, two’s	**9**

	complement – floating point representation – IEEE 754 32-bit single precision floating point representation.	
V	**Finite Word Length Effects and Digital Signal Processors**-Finite word length effects in digital Filters – input quantization – quantisation noise power – steady-state output noise power – coefficient quantisation – overflow – techniques to prevent overflow - product quantization error – rounding and truncation – round-off noise power – signal scaling. Digital signal processor architecture based on Harvard architecture (block diagram) – Harvard architecture, pipelining, dedicated hardware multiplier/accumulator, special instructions dedicated to DSP, replication, on-chip memory cache, extended parallelism- comparison of fixed-point and floating-point processor – applications of DSP.	**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
EE1U32V	ELECTRIC DRIVES	PEC	3	0	0	3	2020

i) **PRE-REQUISITE:** EE1U30G: Power Electronics, EE1U20D: DC Machines and Transformers. EE1U30D: Synchronous and Induction Machines

ii) **COURSE OVERVIEW**: The goal of this course is to expose the students to the basic concepts of Electric Drives. It also includes the speed control methods of DC and AC drives. The course also provides an insight on the basic concepts of space vectors.

iii) **COURSE OUTCOMES**

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

CO1	Illustrate the transient and steady state aspects of electric drives.	Understand
CO2	Apply the appropriate configuration of controlled rectifiers for the speed control of DC motors.	Apply
CO3	Identify the different quadrant operation of chopper-fed DC motor drive.	Apply
CO4	Illustrate the various speed control techniques of induction motors.	Understand
CO5	Compare different speed control methods of synchronous motor drives.	Understand

iv) **SYLLABUS**

Block diagram of electric drives- fundamental torque equations, types of loads – classification of load torque, four quadrant operation of drives, Equivalent values of drive parameters - steady state stability.

Rectifier control of DC drives- separately excited DC motor drives using single-phase and three phase controlled rectifiers - dual converter control of DC motor - circulating current mode.

Chopper control of DC drives - two quadrant and four quadrant chopper drives - motoring and regenerative braking -closed loop speed control for separately excited dc motor.

Three phase induction motor drives: Stator voltage control - Stator frequency control – v/f control - static rotor resistance speed control– static slip power recovery scheme.

Concept of space vector – Clarke and Park transformation – field orientation principle – Introduction to direct vector control of induction motor drives-Synchronous motor drives self-controlled mode – load commutated CSI fed synchronous motor.

v) **(a) TEXT BOOKS**

1) G. K. Dubey, “Fundamentals of Electric Drives”, Naroda publishers, 2nd Edition, 2001

2) Bimal K. Bose, "Power Electronics and Motor Drives", Academic press, An Imprint of Elsevier, 2006.

(b) REFERENCES

1) Vedam Subrahmanyam, "Electric Drives Concepts and Applications", MC Graw Hill Education, 2nd Edition, 2011, New Delhi.
2) Dr. P. S. Bimbhra, "Power Electronics", Khanna publishers, 5th Edition, 2012.
3) Ned Mohan, Tore M Undeland, William P Robbins, "Power electronics converters applications and design", John Wiley and Sons Inc.,3rd Edition, 2009.
4) Muhammad H. Rashid, "Power Electronics, Devices, Circuits and Applications", Pearson, 3rd Edition, 2014
5) R Krishnan, "Electric Motor Drives: Modeling, Analysis, and Control", Prentice Hall, 2001.

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 torque equations, types of loads – classification of load torque, four quadrant operation of drives, Equivalent values of drive parameters- effect of gearing - steady state stability.	**9**
II	Rectifier control of DC drives- separately excited DC motor drives using controlled rectifiers- single-phase fully controlled rectifier fed drives (discontinuous and continuous mode of operation), critical speed - single-phase semi converter fed drives (continuous mode of operation) - three-phase semi converter and fully controlled converter fed drives (continuous mode of operation) - dual converter control of DC motor - circulating current mode.	**9**
III	Chopper control of DC drives - two quadrant and four quadrant chopper drives - motoring and regenerative braking - chopper fed DC series motor drive - closed loop speed control for separately excited dc motor.	**9**
IV	Three phase induction motor drives: Stator voltage control - Stator frequency control – v/f control - below and above base speed – Voltage Source Inverter (VSI) fed v/f control using sine-triangle PWM - static rotor resistance speed control employing chopper – static slip power recovery speed control scheme for speed control below synchronous speed.	**9**

V	Concept of space vector – Clarke and Park transformation – field orientation principle – Introduction to direct vector control of induction motor drives – decoupling of flux and torque components - space vector diagram and block diagram Synchronous motor drives – v/f control – open loop control – self-controlled mode – load commutated CSI fed synchronous motor.	**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
EE1U32U	SENSORS AND SENSING TECHNIQUES	PEC	3	0	0	3	2022

i) PRE-REQUISITE: EE1U20B Measurements and Instrumentation

ii) COURSE OVERVIEW:

The goal of this course is to make students understand the underlying principles and performance characteristics of important sensors. This course introduces the concept of smart sensors. The students will learn how to design the interfacing circuits for these sensors and will get acquainted with the process of developing and evaluating measurement systems for industrial and scientific applications.

iii) COURSE OUTCOMES

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

CO1	Explain the different types of mechanical and acoustic sensors.	Understand
CO2	Illustrate different magnetic and electric field sensors.	Understand
CO3	Demonstrate the working of light sensitive and thermal sensors.	Understand
CO4	Explain the principle and interfacing of smart sensors.	Understand
CO5	Summarize the applications of smart sensors in different fields and recent development.	Understand

iv) SYLLABUS

Sensors: Types and characteristics. Mechanical and acoustic sensors

Magnetic and Electric field sensors: Sensors based on variable magnetic coupling, Hall effect devices, integrated Hall devices, flux gate sensors, solid-state read and write heads, electrostatic sensors and applications.

Light-sensitive sensors: photovoltaic diodes, photoconductors, photodiodes, phototransistors, positron sensitive photo detectors, charge coupled devices, fibre optic sensor technologies and applications. Thermal sensors: Platinum resistors, thermistors, silicon transistor thermometers, integrated temperature transducers

Smart Sensors: Definition, Integrated smart sensors, sensing elements, design of Interface electronics, parasitic effects, sensor linearization, Microcontrollers and digital signal processors for smart sensors, selection criteria, Timer Standards for smart sensor interface, Sensor system and applications.

v) (a) TEXT BOOKS

1) Pallas-Areny Ramon, John G. Webster, *Sensors and signal conditioning,* Wiley, 2001.
2) Gerord C.M. Meijer, *Smart Sensor Systems*, John Wiley and Sons, 2008.
3) D. Patranabis, *Sensors and Transducers*, 2nd edition, Prentice Hall India, 2004.

4) Johnson, Curtis D, *Process control instrumentation technology*, 8th edition, India, Pearson/Prentice Hall, 2006.

(b) REFERENCES

1) Barney G.C.V, *Intelligent Instrumentation,* Prentice Hall of India Pvt. Ltd., 2nd edition, 1988.
2) De Silva, Clarence W, *Sensors and actuators: Engineering system instrumentation,* CRC Press, 2nd edition, 2015.
3) Pavel Ripka, Alois Tipek, *Modern sensors handbook*, John Wiley & Sons, 2nd edition, 2013.
4) Khazan, Alexander D, *Transducers and their elements: design and application*, Prentice Hall, 1994.
5) Fraden Jacob, *Handbook of modern sensors: physics, designs, and applications*, Springer Science & Business Media, 2004.
6) Slawomir Tumanski , *Handbook of magnetic measurements*, CRC Press, 2016.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Sensors**: Types and characteristics. **Mechanical and acoustic sensors**: metallic, thin-film and semiconductor strain gauges, silicon pressure sensors, accelerometers, displacement transducers, piezo junction devices, piezoelectric field-effect transducers, surface acoustic wave devices, ultrasonic based sensors, flow sensors.	**9**
II	**Magnetic and Electric field sensors**: Sensors based on variable magnetic coupling, search coil, magneto resistors, Hall-effect devices, integrated Hall devices, flux-gate sensors, solid-state read and write heads, electrostatic sensors and applications.	**9**
III	**Light-sensitive sensors**: photovoltaic diodes, photoconductors, photodiodes, phototransistors, positron-sensitive photo detectors, opto-isolators, photodiode arrays, charge-coupled devices, fiber-optic sensor technologies and applications. **Thermal sensors**: Platinum resistors, Thermistors, silicon transistor thermometers, integrated temperature transducers, Thermocouples	**9**
IV	**Smart Sensors**: Definition, integrated smart sensors, sensing elements, design of Interface electronics, parasitic effects, sensor linearization, Dynamic range, Universal Sensor Interface, front end circuits, DAQ, Design, Digital conversion, Microcontrollers and digital signal processors for smart sensors, selection criteria, Timer, Analog Comparator, ADC and DAC modules - Standards for smart sensor interface.	**10**
V	**Sensor systems and applications**: Integrated sensors, actuators, micro systems, sensor buses, multiple-sensor systems, sensor networks and automotive, consumer, power, medical measurement systems.	**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
EE1U32T	EMBEDDED SYSTEMS	PEC	3	0	0	3	2022

i) PRE-REQUISITE: EE1U20F Microcontroller and Applications, EE1U20A Digital Electronics

ii) COURSE OVERVIEW:

This course aims to design an embedded electronic circuit and implement the same.

iii) COURSE OUTCOMES

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

CO 1	Explain the characteristics and the design process of an embedded system	Understand
CO 2	Explain the various communication standards, types of memory and different interrupt sources of an embedded system	Understand
CO 3	Infer the ARM processor architecture and its assembly language programming	Understand
CO 4	Interpret the architectural support for high level language and system development of an ARM processor	Understand
CO 5	Explain the basics of a Real Time Operating System	Understand

iv) SYLLABUS

Characteristics of Embedded Computing Applications, Challenges in Embedded Computing System, Characteristics and quality attributes of an embedded system, Performance in Embedded Computing, Embedded System design process, Embedded Product Development Life Cycle

Communication standards – Serial Communication standards: UART, SPI, CAN I2C, Parallel Communication Standards: ISA, PCI, Different types of memory and Interrupt sources

ARM Processor Architecture, ARM assembly language programming, Organization and Implementation of ARM, ARM architectural support for high level languages and system development, Thumb Instruction set, Basics of Real time Operating system.

v) (a) TEXT BOOKS

1) Raj kamal, *Embedded Systems Architecture, Programming and Design,* TMH, 2003
2) K.V. Shibu, *Introduction to Embedded Systems*, 2e, McGraw Hill Education India, 2016.
3) Wayne Wolf, *Computers as Components: Principles of Embedded Computing System Design*, Morgan Kaufman Publishers - Elsevier 3ed, 2008
4) Steve Furber, *ARM system-on-chip architecture*, Addison Wesley, Second Edition, 2000.

(b) REFERENCES

1) David E. Simon, *An Embedded Software Primer*, Pearson Education Asia, First Indian Reprint 2000.
2) Steve Heath, *Embedded Systems Design*, Newnes – Elsevier 2ed, 2002
3) Andrew N. Sloss, Dominic Symes, Chris Wright, *ARM System Developer's Guide Designing and Optimizing System Software,* Morgan Kaufmann Publishers 2004
4) Frank Vahid and Tony Givargis, *Embedded Systems Design – A Unified Hardware/ Software Introduction*, John Wiley, 2002.
5) Tammy Noergaard, *Embedded Systems Architecture, A Comprehensive Guide for Engineers and Programmers*, Newnes – Elsevier 2nd edition, 2012
6) Iyer , *Embedded Real time Systems*, 1e, McGraw Hill Education New Delhi, 2003
7) Lyla B. Das, *Embedded Systems: An Integrated Approach*, 1st edition, Cengage Learning India Pvt Ltd, 2012

vi) COURSE PLAN

Module	Contents	No. of hours
I	Characteristics of Embedded Computing Applications, Challenges in Embedded Computing System, Characteristics and quality attributes of an embedded system, Performance in Embedded Computing. **The Embedded System Design Process**: Requirements, Specification, Architecture Design, Designing Hardware and Software Components, System Integration. **Formalisms for System Design**: Structural Description, Behavioral Description, An embedded system design example. **Embedded product development cycle (EDLC):** Different phases of EDLC, EDLC models	**8**
II	**Communication**: Serial Communication Standards and Devices - UART, HDLC and SPI. Serial Bus Protocols -I2C Bus, CAN Bus and USB Bus. Parallel communication standards ISA, PCI and PCI-X Bus. **Memory**: ROM-Flash, EEPROM, RAM-SRAM, DRAM, Cache memory, memory mapping and addresses, memory management unit– DMA. **I/O Device**: Interrupt sources, recognizing an interrupt, ISR, Device drivers for handling ISR, Shared data problem, Interrupt latency.	**8**
III	**ARM Processor Architecture**: The Acorn RISC Machine, Architectural inheritance, The ARM programmer's model, ARM development tools. **ARM Assembly Language Programming**: Data processing instructions, Data transfer instructions, Control flow instructions.	**10**
IV	**Architectural Support for High-Level Languages**: Abstraction in software design, Data types, Floating-point data types, The ARM floating-point architecture, Expressions, Conditional statements, Loops, Functions and procedures, Use of memory, Run-time environment. **The Thumb Instruction Set:** The Thumb bit in the CPSR, The Thumb programmer's model, Thumb implementation, Thumb applications.	**10**

V	**Operating system basics**: Kernel, types of operating systems. **Real time operating systems**: Tasks, process, threads, multiprocessing and multi-tasking, task scheduling, types, threads and process scheduling, task communication, task synchronization, device drivers, choosing an RTOS.	**9**
	Total hours	**45**

ix) CONTINUOUS ASSESSMENT EVALUATION PATTERN

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

x) 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
EE0U33Z	INTRODUCTION TO FLIGHT DYNAMICS AND CONTROL	OEC	3	0	0	3	2022

i) PRE-REQUISITE: MAT201 - Complex Analysis and Transforms

ii) COURSE OVERVIEW: The main goal of this course is to present the fundamentals of aerodynamics of flight and its motion. This course discusses the various control surfaces and systems in an aircraft. It gives an insight into the performance measures, dynamics, static and dynamic stability of aircrafts.

iii) COURSE OUTCOMES

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

CO1	Develop state space and transfer function models of an LTI system.	Apply
CO2	Apply time domain techniques to analyse the stability of a linear system	Apply
CO3	Explain the basic concepts of flight, aircraft aerodynamics and flight mechanics.	Understand
CO4	Explain the various control surfaces and performance measures in flight control systems	Understand
CO5	Solve for various performance measures in aircraft	Understand
CO6	Describe the concepts of static and dynamic stability, various modes and control of aircraft.	Understand

iv) SYLLABUS

Introduction to open loop and closed loop control systems - Transfer function - Time domain analysis - Introduction to state space - controllability & observability.

Concept of stability - Routh Hurwitz stability criterion - Root locus - Stability analysis using Root Locus

Introduction to Aerodynamics - Aerodynamic flows. Airfoil nomenclature - Wing geometry - Aerodynamic forces and moments - aerodynamic coefficients - Control surfaces - Wind tunnels. Drag Polar - Equation of motion of aircraft - Rate of climb - range and endurance - gliding flight - landing performance - V-n diagram.

Static and dynamic stability - Longitudinal and lateral dynamics – Autopilots - Displacement autopilots - Stability augmentation system.

v) (a) TEXT BOOKS

1. John D Anderson Jr., *Introduction to Flight*, McGraw Hill International, 6th edition, 2017
2. Katsuhiko Ogata, *Modern Control Engineering*, Prentice Hall of India, New Delhi, 5th edition, 2010.
3. Robert C Nelson, *Flight Stability and Automatic Contro*l, McGraw-Hill Education, 2nd edition, 1996

(b) REFERENCES

1. Bernard Etkin, *Dynamics of flight Stability and Control*, John Wiley and Sons Inc. 7th edition, 2011.
2. Nagarath I. J. and Gopal M, *Control System Engineering*, New Age International, 6th edition, 2017.
3. Nise N. S., *Control Systems Engineering*, Wiley Eastern, 6th edition, 2010.
4. Richard S.Shevell, *Fundamentals of Flight* Pearson Education Inc., 2nd edition , 2004.
5. R.F Stengel, *Flight dynamics*, Princeton University Press, Princeton, N.J., USA, 2004.
6. John D Anderson *Aircraft Performance & Design*. McGraw-Hill Education, 1999
7. A C Kermode, *Flight Without Formulae*, Pearson Education Inc., 5th edition, 2004.
8. Thomas R. Yechout, *Introduction to Aircraft Flight Mechanics: Performance, Static Stability, Dynamic Stability, Feedback Control and State-Space Foundations*, AIAA Education Series, 2014.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to control system: Open loop and closed loop control systems - Transfer function of LTI systems – characteristic equation – Type and order of system. Time domain analysis of control systems: Standard test signals – Transient and steady state responses – first and second order systems – time domain specifications – step responses of first and second order systems. Introduction to state space: state equation of linear continuous time systems – Eigen values and Eigen vectors of system matrix – concept of controllability & observability – relationship between state equations and transfer function.	**8**
II	**Concept of stability:** Bounded Input Bounded Output stability – stability of feedback system – location of poles and stability – Routh Hurwitz stability criterion. **Root locus:** General rules for constructing Root loci – stability from root loci – effect of addition of poles and zeros. **Introduction to Aerodynamics:** standard atmosphere – definition of altitudes–density, pressure and temperature altitudes. Aerodynamic flows – inviscid and viscous flows – incompressible and compressible flows – Mach number – laminar and turbulent flows – Reynolds number.	**10**
III	**Airfoils**: Airfoil nomenclature – symmetric and cambered airfoils –generation of lift. Wing geometry –aspect ratio – chord line – angle of attack. Aerodynamic forces and moments– aerodynamic coefficients – lift, drag and moment coefficients– lift curve, drag curve – stalling of airfoil. Control surfaces: elevator – aileron – rudder – dihedral angle and its effects – flaps and slots – spoilers. Flow similarity – Wind tunnels – open and close wind tunnels.	**9**
IV	**Aircraft Performance**: Drag Polar – Equation of motion of aircraft for level, un–accelerated flight. Thrust and power required for level, un–accelerated flight– thrust and power available – condition for maximum velocity.	**9**

	Rate of climb– gliding flight– time to climb – range and endurance – takeoff performance – landing performance – Turning flight – wing loading – load factor – V-n diagram.	
V	**Aircraft Stability and Control**: Static and dynamic stability – conditions for longitudinal static stability. Longitudinal and lateral dynamics (linear state space model) – Longitudinal dynamic modes - short period, phugoid. Lateral and directional dynamic stability – Spiral divergence and dutch roll (concepts only -mathematical derivations not needed) **Autopilots**: Control surface actuator – Displacement autopilots – pitch displacement autopilot – attitude hold and velocity hold control systems – block diagrams – Stability augmentation system.	**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
EE0U33Y	INTRODUCTION TO POWER PROCESSING	OEC	3	0	0	3	2022

i) PRE-REQUISITE: MA0U10B Vector Calculus, Differential Equation and Transforms, ES0U10D Basics of Electrical and Electronics Engineering.

ii) COURSE OVERVIEW: The goal of this course to enhance the problem-solving skills by using various techniques to solve different types of AC and DC circuits. Time Domain analysis will help students to understand the transient and the steady-state response of R, L, C circuits. The course also aims to introduce two port network modelling and network functions.

iii) COURSE OUTCOMES

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

CO1	Explain the power semiconductor devices and wide bandgap devices.	Understand
CO2	Explain the operation of AC-DC rectifiers, DC-DC converters, DC-AC inverters, AC voltage controllers, and the impact of Total Harmonic Distortion.	Understand
CO3	Explain the working of electric motor drives, including 4-quadrant DC motor control and v/f control of induction motors, along with industrial applications.	Understand
CO4	Illustrate the power electronics applications in renewable energy systems, including solar PV, wind energy, energy storage, grid integration, microgrids, and smart grids.	Understand
CO5	Explain power supplies and power electronics in electric vehicles, powertrain, charging technologies and energy storage solutions.	Understand

iv) SYLLABUS

Power semiconductor devices – Diode, SCR, MOSFET, IGBT – operation and characteristics, wide bandgap devices (SiC, GaN), applications in renewable energy and transportation.

Single-phase fully controlled rectifier (R, RL load), DC-DC converters – Buck, Boost, Buck-Boost, single-phase full bridge inverter – square-wave operation, sinusoidal PWM, THD, introduction to AC voltage controllers.

Electric drives – block diagram, 4-quadrant DC motor, v/f control of induction motor, industrial applications – heating, lighting, robotics, traction, aerospace.

Solar PV systems – off-grid, on-grid, MPPT, wind energy systems, energy storage – lithium-ion batteries, hydrogen fuel cells, grid integration, microgrids.

Linear and switched-mode power supplies (SMPS), EV classifications – HEV, PHEV, BEV, powertrain schematic, EV charging – fast/wireless, energy storage – lithium-ion batteries, hydrogen fuel cells, future trends.

v) a) TEXTBOOKS

1) Ned Mohan, Tore M. Undeland, William P. Robbins, *Power Electronics: Converters, Applications, and Design*, Wiley, 3rd Edition, 2002.
2) Muhammad H. Rashid, *Power Electronics: Circuits, Devices & Applications*, Pearson, 4th Edition, 2013.
3) P.S. Bimbhra, *Power Electronics*, Khanna Publishers, 6th Edition, 2018.
4) Gopal K. Dubey, *Fundamentals of Electrical Drives*, Narosa Publishing, 2nd Edition, 2010.
5) Andrzej M. Trzynadlowski, *Introduction to Modern Power Electronics*, 3rd Edition, Wiley, 2015.
6) Iqbal Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003.

b) REFERENCES

1) Robert W. Erickson, Dragan Maksimovic, *Fundamentals of Power Electronics*, Springer, 2nd Edition, 2001.
2) M.D. Singh, K.B. Khanchandani, *Power Electronics*, McGraw Hill, 2nd Edition, 2007.
3) Bimal K. Bose, *Modern Power Electronics and AC Drives*, Pearson, 1st Edition, 2001.
4) R. Krishnan, *Electric Motor Drives: Modeling, Analysis, and Control*, Pearson, 1st Edition, 2001.
5) Chetan Singh Solanki, *Solar Photovoltaics: Fundamentals, Technologies, and Applications*, PHI Learning, 3rd Edition, 2021.
6) James Larminie, John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2nd Edition, 2012.
7) Ali Emadi, *Advanced Electric Drive Vehicles*, CRC Press, 1st Edition, 2014.
8) D.P. Kothari, K.C. Singal, Rakesh Ranjan, *Renewable Energy Sources and Emerging Technologies*, PHI Learning, 2nd Edition, 2011.
9) Jahangir Hossain, Hemanshu Roy Pota, *Renewable Energy Integration*, Academic Press, 1st Edition, 2014.
10) Daniel M. Mitchell, *DC-DC Switching Regulator Analysis*, McGraw Hill, 1st Edition, 1988.
11) Abbasi S. A. and N. Abbasi, *Renewable Energy Sources and their Environmental Impact*, Prentice Hall of India, 2001.
12) Sawhney G. S., *Non-Conventional Energy Resources*, PHI Learning, 2012.
13) *Non-conventional energy sources*, NPTEL lecture by Prof. Prathap Haridoss, IIT Chennai.
14) Abad, Gonzalo, *Power electronics and electric drives for traction applications*. USA: Wiley, 2017.

c) Additional Online Learning Resources

NPTEL Courses (IITs, IISc):

- *Introduction to Power Electronics* (IIT Delhi)
- *Fundamentals of Electric Drives* (IIT Madras)
- *Energy Storage & Renewable Energy Systems* (IIT Delhi)

MIT OpenCourseWare:

- *Power Electronics (ocw.mit.edu/courses/electrical-engineering-and-computer-science)*

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Fundamentals of Power Processing** Introduction to power processing – Elements of power electronics – Power semiconductor devices – Uncontrolled, semicontrolled, and fully controlled switches – Diode, SCR, MOSFETs, IGBTs: Principle of operation – Advantages of wide bandgap devices: SiC, GaN – Applications of power electronics in modern systems.	9
II	**Power Conversion Circuits** AC-DC conversion: Single-phase fully controlled SCR-based bridge rectifier with R and RL load (continuous mode only) – Principle of operation and waveforms – DC-DC Converters (Non-isolated): Buck, Boost, Buck-Boost converter – Circuit operation, voltage gain, and waveforms in continuous conduction mode – DC-AC conversion: Single-phase half and full bridge inverter with R load – Square-wave operation – Types of PWM: Single pulse, multiple pulse, sinusoidal PWM – Total harmonic distortion (THD) – AC-AC conversion: Single-phase AC voltage controller with R load – Waveforms.	9
III	**Electric Drives & Industrial Applications** Electric motor drives: Introduction – Block diagram of an electric drive – 4-quadrant operation of a separately excited DC motor – Circuit diagram and waveforms – Induction motor drives: Principle of operation – v/f control – Power electronics applications in industrial systems: Heating, lighting, robotics, automation – Power electronics in aerospace and railway traction systems.	9
IV	**Power Processing in Renewable Energy Systems** Solar photovoltaic (PV) systems: Principle of operation – Off-grid and on-grid solar systems – Block diagram – Maximum power point tracking (MPPT) – Wind energy conversion systems (WECS): Working principle – Grid integration – Energy storage technologies: Lithium-ion batteries, lead-acid batteries, supercapacitors, hydrogen fuel cells – Microgrids and smart grids: Concept and applications.	9

V	**Power Processing in Power Supplies & Electric Vehicles** Power supplies: Principle of operation – Linear power supply, switched-mode power supply (SMPS) – Power supply requirements: Isolation, protection, regulation – Electric vehicles (EVs): Introduction to HEV, PHEV, BEV – Block schematic of power train – Energy storage in EVs: Li-ion batteries, hydrogen fuel cells – Charging technologies: Fast charging, wireless charging – Future trends in power electronics: AI, IoT, wide bandgap devices	**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
EE0U33X	SPORTS ENGINEERING	OEC	3	0	0	3	2022

i) **PRE-REQUISITE:** ES0U10A Engineering Mechanics, Basics of Mathematics

ii) **COURSE OVERVIEW**: The goal of this course is to expose the students to the fundamental concepts of Sports Engineering and understanding of the scientific and engineering aspects that is covered in the field, which is related to science and all the Core engineering streams. The course aims to give an overview of the application of Engineering in different domains of Sports, such as Mechanics, Sports gear and equipment, construction, athletic performance, broadcasting, management and so on. The course also attempts to give a basic awareness of the safety and ethics essential in Sports Engineering.

iii) **COURSE OUTCOMES**

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

CO1	Illustrate the various application and research domains in the area of sports.	Understand
CO2	Explain the biomechanics and mechanical principles in movements and performance measurement of athletes and sports gear.	Understand
CO3	Compare the indoor and outdoor sports facilities as per the regulatory standards.	Understand
CO4	Explain the advancement and technological innovations used in sports and the application of Assistive Technology for Differently Abled.	Understand
CO5	Outline the various engineering designs for specific sports applications.	Understand

iv) **SYLLABUS**

Introduction to sports technology and engineering, Different Domains and Research areas in Sports Engineering.

Sports Biomechanics, Aerodynamics. Design & Production of Sports Equipment.

Sports Infrastructure, Sports Lighting and Acoustics.

Sports Analytics, Sports Broadcasting. Mechanics of Sports Engineering Products, Wearable Technology, Disability Sports.

Regulating Standards, Safety Requirements, Sports Engineering and Ethics, Sports Engineering and Sustainability.

v) **(a) TEXT BOOKS**

1) Steve Haake - Editor, *The Engineering of Sports*, Taylor & Francis, 2006.

2) Franz Konstantin Fuss, Aleksandar Subic, Martin Strangwood, Rabindra Mehta, *Routledge Handbook of Sports Technology and Engineering*, Routledge- Taylor & Francis group, 2014.
3) Fuss F. K., Subic A., Ujihashi S. – Editors, *The Impact of Technology on Sports II*, Taylor & Francis 2008.
4) Eckehard Fozzy Moritz, Steve Haake, *The Engineering of Sports 6*, Vol 3, Developments for Innovation, Springer 2006.
5) Colin White, *Projectile Dynamics in Sport: Principles and Applications*, Routledge, 2010.

(b) REFERENCES

1) Helge N., *Sports Aerodynamics* (Springer Science & Business Media, 2009.
2) Jenkins M., Editor, *Materials in Sports Equipment*, *Volume I,* Elsevier, 2003.
3) Aleksandar Subic, Editor *Materials in Sports Equipment, Volume II*, Elsevier, 2007.
4) Eric C. et al., Editor *Sports Facility Operations Management- A Global Perspective*, 2nd edition, Routledge, 2015.
5) Dr. Indulekha R., Sports Career- Unknown Jobs in Sports Industry, Research Support -SMRI, Liwing, 2019.
6) LG04 Lighting Guide 04: Sports Lighting - LG4, CIBSE, Oct 2006.
7) Sports Lighting, http://www.thornlighting.com/download/Handbook5-11.pdf.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to sports technology and engineering – Sports Engineering activities around the world. Sports Scientists and Sport Engineers, Different domains of sports engineering. New Trends used in Sports Technology in different sports. Research areas in Sports Engineering	**8**
II	Sports Biomechanics - Biomechanics of daily and common activities, Mechanical principles in movements, Performance Measurement, Aerodynamics and Hydrodynamics. Sports Balls. Sports implements, Design & Production of Sports Equipment. Apparels & Protection Equipment	**9**
III	Sports Infrastructure- Design of Indoor & Outdoor sports Facilities, Air Ventilation, Day Lighting, Sports Lighting, Emergency Provisions, Sports Acoustics, Sports surfaces and Facilities, Playground and Recreational Facilities, Facility life cycle costing, Maintenance Policy. Case Studies on Technological innovations used in various sports stadiums	**10**
IV	Sports Broadcasting - Technology Advancements and Innovations, Sports Analytics- Statistical Analysis, Use of Data Science, Data Visualization, Instrumentation Technology – Smart Devices and	**10**

	technologies for athletes, sports equipment, Exertion games. Technology Enabled Coaching and Sport Education. Sports for Differently Abled - Assistive Technology, Activity-Specific Prosthetics for Sports.	
V	Sports rules and regulations, Safety in Sports, Sports Engineering and Ethics, Sports Engineering and Sustainability – Design and manufacturing techniques in Sports products. Sports Management. Career Opportunities in Sports Engineering	**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
EE0U33W	ELECTRICAL DRIVES AND CONTROL FOR AUTOMATION	OEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

This course is intended to provide the basic concepts of different types of electrical machines and their performance. The course also introduces to the different methods of starting D.C motors and induction motors and the introduction to the controllers for automation

iii) COURSE OUTCOMES

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

CO1	Choose a drive for a particular application based on power rating.	Understand
CO2	Explain the working of DC motors drives.	Understand
CO3	Explain the working of Induction motors drives.	Understand
CO4	Explain variable speed synchronous and permanent motor drives.	Understand
CO5	Discuss the controllers used for automation.	Understand

iii) SYLLABUS

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

DC Motors - principle of operation-emf equation-types of excitations.

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.

Three phase induction motors - principle of operation, Induction Motor Drives, 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.

Permanent Magnet and variable reluctance motor drives – Sinusoidal PMAC drives-Brushless DC motor drives.

Stepper motors, Principles of Automation.

iv) (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.
3) Kothari D. P. and I. J. Nagrath, Electrical Machines, Tata McGraw Hill, 2004.
4) Nagrath .I.J. & Kothari .D.P, Electrical Machines, Tata McGraw-Hill, 1998.

(b) REFERENCES

1) M D.Singh, K. B. Khanchandani, Power Electronics, Tata McGraw-Hill, 1998.
2) Dewan S.B., G. R. Slemon, A. Strauvhen, "Power semiconductor drives", John Wiley and sons, 1987.
3) Dr. P. S. Bimbra "Power electronics", Khanna publishers. 3. Dubey G. K. "Power semiconductor control drives" Prentice Hall, Englewood Cliffs, New Jersey, 1989.
4) N. K. De, P. K. Sen "Electric drives" Prentice Hall of India, 2002.
5) Ned Mohan, Tore M. Undeland, William P Robbins, "Power electronics converters applications and design", John Wiley and Sons, 2003.
6) Pillai S. K. "A first course on electric drives", Wiley Eastern Ltd, New Delhi, 3rd edition, 2000.
7) Vedam Subrahmanyam, "Electric Drives", Mc Graw Hill Education, New Delhi, 2013.
8) R. Krishnan, "Electric Motor Drives Modeling, Analysis and Control", Prentice Hall of India, 2007.

v) 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.	**8**
II	**DC Motors** - principle of operation - emf equation - types of excitations. Separately excited, shunt and series excited **DC motor drives** - constant torque and constant power operation, separately excited dc motor drives using controlled rectifiers - Single phase fully controlled converter drives, Chopper controlled DC drives – classification.	**10**
III	**Three phase induction motors** - slip ring and squirrel cage types, principles of operation – rotating magnetic field - torque slip characteristics. **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 - Rotor chopper speed control – slip power recovery control scheme.	**10**
IV	**Synchronous motors** – Working principle **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. **Permanent Magnet and variable reluctance motor drives –** different types – Sinusoidal PMAC drives - Brushless DC motor drives - control requirements, converter circuits, modes of operation.	**8**
V	**Stepper motors** - Principle of operation, Linear stepper motor, comparison, Torque-speed characteristics, control of stepper motors.	**9**

	Controllers for automation - Servo control, Digital controllers, Advanced control systems, Digital signal processors, motor controllers, Axis controllers, Machine tool controllers, Programmable Logic Controllers.	
	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
EE0U33V	RENEWABLE ENERGY SYSTEMS	OEC	3	0	0	3	2020

i) **PRE-REQUISITE: Students who have taken EE0M30B MINOR are not eligible to take this course**.

ii) **COURSE OVERVIEW**: The goal of this course is to expose the students to learn the concepts of solar thermal and solar electric systems. It illustrates the operating principles of wind, and ocean energy conversion systems and the features of biomass and small hydro energy resources. The course describes the concepts of fuel cell and hydrogen energy technologies.

iii) **COURSE OUTCOMES**

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

CO1	Illustrate the use of various renewable energy-based power generation scheme.	Understand
CO2	Explain the concepts of solar thermal and solar electric systems.	Understand
CO3	Illustrate the operating principles of wind, and ocean energy conversion systems.	Understand
CO4	Outline the features of biomass and small hydro energy resources.	Understand
CO5	Explain the concepts of fuel cell and hydrogen energy technologies.	Understand

iv) **SYLLABUS**

Introduction, Classification of Energy Resources- Conventional Energy Resources and Non-Conventional Energy Resources.

Principle of Conversion of Solar Radiation into Heat – Solar thermal collectors. – Flat plate collectors. Solar concentrators Solar Thermal Electric Power Generation, Solar Photovoltaic – Solar Cell fundamentals

Solar PV Systems – stand-alone and grid connected- Applications. Ocean Thermal Energy Conversion, Open Cycle (Claude cycle), Closed Cycle

Site-selection criteria- Biofouling - Wind Energy Conversion Systems wind speed measurement-Classification of WECS- types of rotors. wind power equation -Betz limit.

Electrical Power Output and Capacity Factor of WECS -Environmental impacts. Small Hydro Power - Classification as micro, mini and small hydro projects. Basic concepts and types of turbines- selection considerations.

Fuel Cell-principle of operation- Hydrogen energy - hydrogen production, electrolysis - thermo chemical methods - hydrogen storage and utilization.

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) Rao S. and B. B. Parulekar, "Energy Technology", Khanna Publishers, 1999.

(b) REFERENCES

1) G.N. Tiwari, "Solar Energy-Fundamentals, Design, Modelling and Applications", Narosa Publishers, 2002.
2) Earnest J. and T. Wizelius, "Wind Power Plants and Project Development", PHI Learning, 2011.
3) Sab S. L., "Renewable and Novel Energy Sources", MI. Publications, 1995.
4) Sawhney G. S., "Non-Conventional Energy Resources", PHI Learning, 2012.
5) Tiwari G. N., "Solar Energy- Fundamentals, Design, Modelling and Applications", CRC Press, 2002.
6) A.A.M. Saigh (Ed), "Solar Energy Engineering", Academic Press, 1977
7) Abbasi S. A. and N. Abbasi, "Renewable Energy Sources and Their Environmental Impact", Prentice Hall of India, 2001.
8) Boyle G. (ed.), "Renewable Energy - Power for Sustainable Future", Oxford University Press, 1996
9) Earnest J. and T. Wizelius, "Wind Power Plants and Project Development", PHI Learning, 2011.
10) F. Kreith and J.F. Kreider: "Principles of Solar Engineering", McGraw Hill, 1978.
11) Khan B.H, "Non-Conventional Energy resources", Tata McGraw Hill, 2009.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction, Classification of Energy Resources- Conventional Energy Resources - Availability and their limitations- Non-Conventional Energy Resources – Classification, Advantages, Limitations; Comparison. SOLAR THERMAL SYSTEMS- Principle of Conversion of Solar Radiation into Heat – Solar thermal collectors. – Flat plate collectors. Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector). SOLAR ELECTRIC SYSTEMS - Solar Thermal Electric Power Generation – Solar Photovoltaic – Solar Cell fundamentals - characteristics, classification, construction. Solar PV Systems – stand-alone and grid connected - Applications.	11

II	ENERGY FROM OCEAN - Ocean Thermal Energy Conversion (OTEC)- Principle of OTEC system - Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle. Site-selection criteria- Biofouling - Advantages & Limitations of OTEC. TIDAL ENERGY – Principle of Tidal Power- Components of Tidal Power Plant (TPP)- Classification-single basin - double basin types – Limitations - Environmental impacts.	**10**
III	WIND ENERGY – Introduction - Basic principles of Wind Energy Conversion Systems (WECS) wind speed measurement-Classification of WECS - types of rotors. wind power equation - Betz limit. Electrical Power Output and Capacity Factor of WECS- Advantages and Disadvantages of WECS -site selection criteria.	**9**
IV	BIOMASS ENERGY – Introduction - Biomass fuels - Biomass conversion technologies - Urban waste to Energy Conversion- Biomass Gasification - Biomass to Ethanol Production- Biogas production from waste biomass - factors affecting biogas generation- types of biogas plants – KVIC and Janata model - Biomass program in India.	**8**
V	SMALL HYDRO POWER- Classification as micro, mini and small hydro projects - Basic concepts and types of turbines- selection considerations. EMERGING TECHNOLOGIES: Fuel Cell-principle of operation – classification- conversion efficiency and losses - applications. Hydrogen energy - hydrogen production - electrolysis - thermo chemical methods - hydrogen storage and utilization.	**7**
	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 signal
EE1U30L	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:

CO1	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	EE1U20B	Measurements and Instrumentation
2	EE1U20C	Analog Electronics
3	EE1U20F	Digital Electronics
4	EE1U20A	Circuits and Networks
5	EE1U20D	DC Machines and Transformers
6	EE1U20E	Microcontroller and Applications
7	EE1U30D	Synchronous and Induction Machines
8	EE1U30E	Linear Control Systems
9	EE1U30G	Power Electronics

iv) MARK DISTRIBUTION

Total Marks	ESE	ESE Duration
50	50	1 hour

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1U38F	CONTROL SYSTEMS LAB	PCC	0	0	3	2	2022

i) PRE-REQUISITE:EE1U30I: Introduction to Control Engineering

ii) COURSE OVERVIEW:

Objective of the course is to impart practical experience to students to develop mathematical models for electrical systems. The course deals with the time and frequency analysis of the systems and implementation of compensators for systems based on system performance. The course is also designed to familiarize the students with different simulation tools used in control engineering.

iii) COURSE OUTCOMES

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

CO 1	Develop the mathematical model of a given physical system by conducting appropriate experiments.	Apply
CO 2	Apply time domain and frequency domain techniques in second order systems.	Apply
CO 3	Experiment with P/PI/PID controllers in process control systems.	Apply
CO 4	Develop compensators for given specifications.	Apply
CO 5	Simulate various control system models and compensators using MATLAB/SIMULINK tools.	Apply

iv) SYLLABUS

- Modeling of Transfer function of Synchro, AC Servomotor and DC Servomotor – 3 sessions
- Time and frequency responses of second order systems – 2 sessions
- Frequency response characteristics of Lag networks and Lead networks – 3 sessions
- Study of P, PI and PID controllers - 1 session
- Study of performance characteristics of a typical Level control system - 1 session
- Experiments on MATLAB Software – 4 sessions

v) REFERENCES

1) Ogata K., *Modern Control Engineering*, Pearson Prentice Hall, 2006.
2) Gopal M., *Control Systems*, Tata McGraw-Hill, 3rd edition, 2006.
3) Franklin G. F., Powell J. D. and Naeini A. E., *Feedback Control of Dynamic Systems*, Pearson Education Asia, 7th edition., 2014.
4) Goodwin G. C., Graebe S. F. and Salgado M. E., *Control System Design*, Prentice Hall India, 2003.
5) D'Azzo J. J., Houpis C. H., Sheldon S. N., *Linear Control System Analysis & Design with MATLAB*, 5/e, Marcel Dekker, 2003.

vi) COURSE PLAN

Expt. No.	List of exercises/experiments	No. of hours
I	**Step response of a second order system.** Objective: Design a second order system (eg: RLC network) to analyze the following: A. The effect of damping factor (ξ: 0, <1,=1,>1) on the unit step response using simulation study (M-File and SIMULINK). B. Verification of the delay time, rise time, peak overshoot and settling time with the theoretical values. C. Performance analysis of hardware setup and comparison with the simulation results.	**3**
II	**Performance Analysis using Root-Locus Method.** Objective: Plot the root locus of the given transfer function to analyze the following using simulation: A. Verification of the critical gain, wo with the theoretical values B. The effect of controller gain K on the stability C. The sensitivity analysis by giving small perturbations in given poles and zeros D. The effect of the addition of poles and zeros on the given system.	**3**
III	**Stability Analysis by Frequency Response Methods.** Objective: Plot the i) Bode plot and ii) Nyquist plot of the given transfer functions to analyze the following using simulation: A. Determination of Gain Margin and Phase Margin B. Verification of GM and PM with the theoretical values C. The effect of controller gain K on the stability, D. The effect of the addition of poles and zeros on the given system (especially the poles at origin).	**3**
IV	**Realization of lead compensator.** Objective: Design, set up and analyze the gain and phase plots of a lead compensator by hardware experimentation using i) passive elements and ii) active components.	**3**
V	**Realization of lag compensator.** Objective: Design, set up and analyze the gain and phase plots of a lag compensator by hardware experimentation using i) passive elements and ii) active components.	**6**
VI	**Design of compensator in frequency domain and time domain.** Objective: Design a compensator for the given system to satisfy the given specifications A. Time domain specifications using MATLAB B. Frequency domain specifications using MATLAB	**3**
VII	**State space model for analysis and design** Objective: Study and analysis of state variable model of a given system (eg. DC Motor speed control/ Servo motor/etc) and design a controller by pole-placement technique using MATLAB based tool boxes. A. Determine the open loop stability, controllability and observability	**6**

	B. Analyze the effect of system parameters on eigen values and system performance. C. Design a controller by pole-placement technique.	
VIII	**PID Controller Design** Objective: Design and analysis of a PID controller for a given system (eg. DC Motor speed control/ Servo motor/etc) using SIMULINK/ MATLAB based tool boxes A. Design of PID controller to meet the given specifications B. Study the effect of tuning of PID controller on the above system.	**3**
IX	**Transfer Function of DCServo/DC Motor** Objective: Obtain the transfer function of the DC Servo/DC motor by experiment.	**3**
X	**Synchro Transmitter and Receiver.** Objective: Plot and study the different performance characteristics of Synchro transmitter- receiver units in Direct mode and Differential mode.	**3**
XI	**Transfer function of A.C. Servo motor.** Objective: Obtain the open loop transfer function of AC Servo motor by experiment.	**3**
XII	**Performance of a typical process control system** Objective: Study of performance characteristics and response analysis of a typical temperature/ Flow/ Level control system.	**3**
XIII	Realisation of Logic Gates using PLC controller **Project on PLC controller**	**3**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

(a)	Attendance	:	15 marks
(b)	Continuous Assessment	:	30 marks
(c)	Continuous Assessment Examination	:	30 marks
	Total	**:**	**75 marks**

viii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- **One test of 30 marks**
- Duration – **2 ½ hours**

ix) END SEMESTER EXAMINATION PATTERN

(a)	Preliminary work	:	15 marks
(b)	Implementing the work/Conducting the experiment	:	20 marks
(c)	Performance, result and inference (usage of equipment and troubleshooting):	:	15 marks
(d)	Viva voce	:	20 marks
(e)	Record	:	5 Marks
	Total	**:**	**75 marks**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1U39A	MINI PROJECT	PWS	0	0	3	2	2022

i) PRE-REQUISITE: Nil.

ii) COURSE OVERVIEW: A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The objective of Mini Project Work is to enable the student to take up investigative study in the broad field of Electrical and Electronics Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department to a group of three/four students, under the guidance of a supervisor. This is expected to provide a good initiation for the student(s) in R&D work.

The assignment to normally include:

♦ Survey and study of published literature on the assigned topic;

♦ Preparing an Action Plan for conducting the investigation, including team work;

♦ Working out a preliminary Approach to the Problem relating to the assigned topic;

♦ Block level design documentation

♦ Conducting preliminary Analysis/ Modelling/ Simulation/ Experiment/ Design/ Feasibility;

♦ Preparing a Written Report on the Study conducted for presentation to the Department.

iii) COURSE OUTCOMES

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

CO1	Extend knowledge in solving the real-life engineering problems.	Understand
CO2	Develop a work plan and liaison with the team in completing as per schedule.	Apply
CO3	Inspect the prototype / process. (Demonstration and testing)	Analyse
CO4	Construct effective reports, make effective presentations.	Apply
CO5	Develop professional ethics and communicate effectively.	Apply

iv) GUIDELINES

1. Detailed Analysis /Modelling /Simulation /Problem Solving / for implementation as needed.
2. Final development of product/process, testing, results, inferences, conclusions and future directions.
3. Preparing a paper for Conference presentation/Publication in Journals, based on the quality/quantity of work as judged by the evaluation committee.

4. Preparing a report in the standard format for being evaluated by the dept. evaluation committee.
5. Preparing presentations for assessments at various stages.

v) ASSESSMENT PATTERN

Only Continuous Internal Evaluation (CIE), minimum required to pass is 50 marks.

Project Supervisor	:	30
Interim evaluation by the evaluation committee (2 times in the semester by the evaluation committee)	:	20
Quality of the report evaluated by the above committee	:	20
Final evaluation by a three-member committee	:	30
Total marks	**:**	**100**

The interim evaluation committee comprises HoD or a senior faculty member, Project coordinator and Project supervisor.

The final evaluation committee comprises Project coordinator, expert from Industry/research Institute and a senior faculty from a sister department.

vi) EVALUATION BY GUIDE

The guide/supervisor must monitor the progress being carried out by the project groups on a regular basis. Incase it is found that progress is unsatisfactory, it should be reported to the Department Evaluation Committee for necessary action. The presence of each student in the group and their involvement in all stages of execution of the project shall be ensured by the guide.

Project evaluation by the guide: 30 marks

This mark shall be awarded to the students in his/her group by considering the following aspects.

i) **Project Scheduling and Distribution of work among team members: 5 marks**
Detailed and extensive scheduling with timelines provided for each phase of project. Work breakdown structure well defined.

ii) **Literature Survey: 4 marks**
Outstanding investigation in all aspects

iii) **Student's diary/Daily log: 7 marks**
The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily/weekly activity diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches and drawings related to the observations made by the students. The daily/weekly activity diary shall be signed after every day/week by the guide.

iv) **Individual Contribution: 9 marks**
The contribution of each student at various stages.

v) **Completion of the project: 5 marks**

The students should demonstrate the project to their respective guide. The guide shall verify the results and see that the objectives are met.

B.TECH MINORS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE0M30M	CLOUD COMPUTING FOR INTERNET OF THINGS	VAC	4	0	0	4	2022

i) PRE-REQUISITE: EL2U30B-Microprocessors and Embedded Systems.

ii) COURSE OVERVIEW: The goal of this course is to introduce students to the concepts of cloud computing, cloud services and IoT. This course will enable students to explore the various sensors and protocols relating to IoT and make use of the cloud services in various IoT applications.

iii) COURSE OUTCOMES

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

CO1	Explain the fundamental concepts of cloud computing	Understand
CO2	Describe the different cloud services and deployment models.	Understand
CO3	Explain the basic concepts of IoT	Understand
CO4	Classify the different sensor technologies and communication standards for IoT applications.	Understand
CO5	Make use of cloud-based development platforms for various applications	Apply

iv) SYLLABUS

Overview of cloud computing: Definition, characteristics, architecture and infrastructure. Cloud management.
Cloud service Models: SaaS, PaaS, IaaS, FaaS, XaaS, Cloud deployment models. Cloud service providers.
IoT: Definition, characteristics, physical design, protocols, logic design.
Sensor technologies for IoT, data acquisition using embedded devices, data logging to cloud services-protocols and programming.
Cloud based IoT application development: development platforms, building, designing and deploying IoT application.

v) (a) TEXT BOOKS

1) Simone Cirani, Internet of things: Architecture, protocols and standards, Wiley, 2019.
2) Charles Bell, MicroPython for the Internet of Things: A Beginner's Guide to programming with Python on Microcontrollers, Apress, 2017.
3) B.K Thripathy, J Anuradha, Internet of things (IoT) - technologies, applications, challenges and solutions, CRC press, 2018.
4) Marinescu, D. C., "Cloud computing: theory and practice.", Morgan Kaufmann, 2017.
5) Buyya, R., Broberg, J., & Goscinski, A. M., "Cloud computing: Principles and paradigms" John Wiley & Sons, 2011.

(b) REFERENCES

1) Thomas, E., Zaigham M., Ricardo P., Cloud Computing Concepts, Technology & Architecture, Prentice Hall, 2013.

2) Buyya, R., Vecchiola, C., & Selvi, S. T. Mastering cloud computing: foundations and applications programming, Morgan Kaufmann, 2017.
3) Alasdair Gilchrist, Industry 4.0 The Industrial Internet of Things, Apress, 2016.
4) David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, First Edition, Cis CO Press, 2017.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Overview of Cloud Computing**: Definition and characteristics of cloud computing, Cloud Computing architecture, Cloud computing infrastructure, Virtualization, and hypervisors, Data center and server architecture, Cloud management in cloud computing, storage systems in cloud, networking in the cloud.	**10**
II	**Cloud service models**: Software as a service (SaaS), Platform as a service (PaaS), Infrastructure as a service (IaaS), Anything/Everything as a service (XaaS), Function as a Service (FaaS): Advantages and Disadvantages. Deployment models: Public, Private, Hybrid, Community clouds. Cloud service providers: AWS, Microsoft Azure, Google Cloud.	12
III	**Introduction to IoT**: Definition and Characteristics of IoT, Physical Design of IoT: Things in IoT, IoT Protocols, Logical Design of IoT: IoT Functional Blocks, IoT Communication Models, IoT Communication APIs, IoT Enabling Technologies. Design challenges – power consumption and security issues.	**10**
IV	**Sensor technologies for IoT-** Wireless sensor network and its integration with the cloud. Voltage, Current, Speed, Temperature and humidity sensors and data acquisition using embedded devices- block diagram. Data logging to cloud services- protocols and programming. IoT Device and Sensor Connectivity, Communication protocols for IoT devices (e.g., MQTT, CoAP). Wireless technologies for IoT (e.g., Wi-Fi, Bluetooth, Zigbee).	**14**
V	**Cloud-based IoT Application Development** Cloud Application Development Platforms. Introduction to cloud-based development platforms (e.g., AWS IoT Core, Azure IoT Hub). Setting up an IoT application environment in the cloud. Building and Deploying IoT Applications. Designing IoT applications with cloud integration. Deploying and testing IoT applications in the cloud.	**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
EE0M30N	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.	**13**

	Practical Exercise – Design of electrical system of residential building using MS Excel	
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
EE0M30P	SMART GRID AND ENERGY STORAGE SYSTEMS	VAC	4	0	0	4	2022

i) PRE-REQUISITE: Nil.

ii) COURSE OVERVIEW: The course aims to provide students with a conceptual introduction to smart grids, its architecture, components and communication technologies. It also aims to expose the students to the fundamental concepts of energy storage systems used in different applications.

iii) COURSE OUTCOMES:

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

CO1	Summarize the need, benefits and functions of Smart Grid and its various components.	Understand
CO2	Explain the various Smart Grid Technologies.	Understand
CO3	Identify the functions of mobile electrical storage systems and explain the need for hybrid energy storage.	Apply
CO4	Interpret the role of energy storage in power systems.	Understand
CO5	Summarize energy storage technology applications for smart grids.	Understand

iv) SYLLABUS

Evolution of Electric Grid-Conventional Grid vs Smart Grid - Benefits, Challenges and Key Application Areas of Smart Grid. Smart Grid Reference Architecture-Introduction to Smart Meters, Real Time Pricing Smart Substations, Substation Automation, Smart Appliances, Smart Sensors, Home & Building Automation.

Communication Networks for Smart Grid: Interoperability and connectivity - Home Area Network (HAN), Neighbourhood-Area Networks (NANs), Sensor and Actuator Networks (SANETs)- Communication Protocols.

Cloud computing in Smart Grid: Private, public and Hybrid cloud. Cloud architecture of smart grid. Communication Networks for Smart Grid, Communication Protocols. Cloud architecture of smart grid.

Introduction to Energy storage in power systems: Need and role of energy storage systems in power system- Scope of energy storage, needs and opportunities in energy storage, comparison of storages and applications, Importance of energy storage systems in electric vehicles, Current electric vehicle market.

Energy Storage Technologies: Role of Energy Storage Systems-Applications - Overview of energy storage technologies - Thermal, Mechanical, Chemical, Electrochemical, Electrical - Comparison of Various Storage Technologies-Criteria for Selection of Storage.

Mobile Storage Systems: Electric Vehicle, G2V, V2G. Basic concepts of Hybrid Energy storage systems.

v) (a) TEXT BOOKS

1) Stuart Borlase "Smart Grid Infrastructure Technology and Solutions", CRC Press; 2nd edition.
2) James Momoh, "Smart Grid: Fundamentals of Design and Analysis", Wiley, 2012.
3) S. Chowdhury, "Microgrids and Active Distribution Networks." Institution of Engineering and Technology, 2009.
4) Janaka Ekanayake, Kythira Liyanage, Jianzhong Wu, Akihiko Yokohama, Nick Jenkins- "Smart Grids Technology and Applications", Wiley, 2012.
5) Osaka T., Datta M., "Energy Storage Systems in Electronics-New Trends in Electrochemical Technology", CRC Press 2000.
6) A Ralph Zito, Energy storage: A new approach, Wiley, 2010.
7) Frank S. Barnes and Jonah G. Levine, Large Energy Storage Systems Handbook (Mechanical and Aerospace Engineering Series), CRC press, 2011.

(b) REFERENCES

1) Barker, Preston, Price, Rudy F., "Cybersecurity for the Electric Smart Grid: Elements and Considerations", Nova Science Publishers Inc, 2012.
2) Eric D. Knapp, Raj Samani, "Applied Cyber Security and the Smart Grid: Implementing Security Controls into the Modern Power Infrastructure", Syngress; 1st edition.
3) Richard J. Campbell, "The Smart Grid and Cybersecurity: Regulatory Policy and Issues", Congressional Research Service, 2011.
4) Dariusz Kloza, Vagelis Papakonstantinou, Sanjay Goel, Yuan Hong, "Smart grid security", Springer.
5) Roger C. Dugan, "Electrical Power Systems Quality", McGraw-Hill Publication, 3/e.
6) G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 2/e.
7) Broussely M. and Pistoia G., "Industrial Applications of Batteries from Cars to Aerospace and Energy Storage", Elsevier, 2007.
8) Nazri G. A. and Pistoia G., "Lithium Batteries – Science and Technology", Kluwer Academic Publishers, 2004.
9) Larminie J., Dicks A. and Wiley-Blackwell, "Fuel Cell Systems Explained", 2nd Edition, Wiley Publications, 2013.
10) Pistoia, Gianfranco, and Boryann Liaw, "Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost", Springer International Publishing AG, 2018.
11) Robert A. Huggins, "Energy Storage", Springer Science & Business Media, 2010.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Smart Grid**: Evolution of Electric Grid- Conventional Grid vs Smart Grid -Need and Definitions of Smart Grid- Benefits, Challenges and Key Application Areas of Smart Grid. **Smart Grid Components:** Smart Grid Reference Architecture- Introduction to Smart Meters, Real Time Pricing- Intelligent Electronic Devices (IED) and their application for monitoring & protection, Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU).	**12**
II	**Smart Grid Technologies:** Smart Substations, Substation Automation, Feeder automation, Fault detection, Isolation, and Service Restoration (FDISR), Geographic Information System (GIS), Outage Management System (OMS). Smart Appliances, Automatic Meter Reading (AMR), Advanced Metering Infrastructure (AMI) Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation.	**13**
III	**Communication Networks for Smart Grid:** Interoperability and connectivity - Home Area Network (HAN), Neighborhood-Area Networks (NANs), Sensor and Actuator Networks (SANETs). **Communication Protocols in Smart grid**, Introduction to IEC 61850 standard and benefits, IEC Generic Object-Oriented Substation Event - GOOSE, Substation model. **Cloud computing in Smart Grid:** Private, public and Hybrid cloud. Cloud architecture of smart grid**.**	**12**
IV	**Introduction to Energy storage in power systems:** Need and role of energy storage systems in power system- Scope of energy storage, needs and opportunities in energy storage, comparison of storages and applications, Energy storage in the power and transportation sectors. Importance of energy storage systems in electric vehicles, Current electric vehicle market. **Need and role of energy storage systems in power systems** - General considerations, Energy and power balance in a storage unit, Econometric model of storage system.	**12**
V	**Energy Storage Technologies**: Role of Energy Storage Systems- Applications - Overview of energy storage technologies - Thermal, Mechanical, Chemical, Electrochemical, Electrical - Comparison of Various Storage Technologies-Criteria for Selection of Storage. **Mobile Storage Systems**: Electric Vehicle, G2V, V2G. Basic concepts of Hybrid Energy storage systems.	**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
EE0M30Q	INTRODUCTION TO AUTOMOTIVE ELECTRICAL & ELECTRONIC SYSTEMS	PCC	4	0	0	4	2022

i) PREREQUISITE: ES0UI0D-Basics of Electrical & Electronics Engineering

ii) COURSE OVERVIEW: The aim of this subject is to offer the students a general understanding of various automotive electronic systems used in automobiles.

iii) COURSE OUTCOMES

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

CO1	Explain constructional details and working of various batteries used in automotive vehicles	Understand
CO2	Illustrate the construction and working of starter motor and alternator	Understand
CO3	Explain the construction and working of battery ignition system and also working of electronic fuel injection system	Understand
CO4	Explain the different types of components that make up the lighting systems.	Understand
CO5	Summarize the working of various sensors used in automobiles	Understand

iv) SYLLABUS

Principle of lead acid battery & constructional details-Capacity Rating, Battery charging methods, Battery tests. Developments in storage. Charging system: Working and constructional details of Alternators Starting system: Requirement of starter motor -Starter drive mechanisms. Battery coil and Magneto ignition system, Centrifugal and Vacuum advance mechanisms, Spark plugs, constructional details and types. Electronically assisted ignition system; Non-contact triggering devices - Electronic fuel injection system overview. Lighting, Instrumentation types -Sensors and applications in Automobile, Actuators. Introduction to internet of things (IOT) and its automotive applications.

v) (a) TEXT BOOKS

1) Kohli.P.L. “Automotive Electrical Equipment”, Tata McGraw-Hill Co Ltd,1st Edition,2009
2) Tom Denton, “Automobile Electrical and Electronic Systems”, Elsevier Butterworth-Heinemann, 3rdEdition,2004.

(b) REFERENCES

1) Al Santini“Automotive Electricity and Electronics, Cengage Learning”,AUTOMOBILE ENGINEERING, 2013
2) Robert Bosch, “Automotive Handbook”, Bently Publishers,1st Edition,2004
3) William B. Ribbens, Norman P. Mansour, “Understanding automotive electronics”, Newnes, 6th Edition,2003
4) Jim Horner, “Automotive Electrical HandBook”, Penguin, 1986
5) Barry Hollembeak, Automotive Electricity & Electronics, Cengage Learning,5th Edition 2010

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Batteries:** Principle of lead acid battery & constructional details, Effect of temperature on electrolyte, Capacity Rating, Battery charging methods, Battery tests. Developments in storage: Nickel metal hydride battery, Lithium-ion battery, Fuel cells, Ultra capacitors.	12
II	**Charging system:** Working and constructional details of Alternators (single and three phase), Rectification, voltage regulation, current regulation, **Starting system:** Requirement of starter motor; Starter Motor types, construction and characteristics, Starter drive mechanisms, Starting circuit, Starter Switches.	12
III	**Battery coil and Magneto ignition system**: Centrifugal and Vacuum advance mechanisms, Spark plugs, constructional details and types. Electronically assisted ignition system; Non-contact triggering devices - Fully electronic ignition System, Capacitive Discharge Ignition, Distributorless ignition. **Electronic fuel injection system overview;** D jetronic, K jetronic and L jetronic fuel injection; Injections schemes–Single point, Multi point, Sequential, Direct injection, Common rail direct injection, Gasoline direct injection, Supercritical injection.	12
IV	**Lighting:** Types of headlights, headlight reflectors, headlight lenses, indicator lamp details, lighting circuit, projector headlights; Horn and wiper mechanisms. **Instrumentation:** Speedometer, Fuel Level Indicator, Oil Pressure and Coolant Temperature Indicators, Display devices – LED, LCD, VFD, Onboard diagnostics (OBD), OBD – II	12
V	**Sensors and applications in Automobile**: Pressure sensors, Temperature sensors, Position sensors, Lambda sensor, Air flow sensor, Wheel speed sensor, Knock sensor, Optical sensors. **Actuators:** Solenoids, Stepper motors, Relays, Piezoelectric. Introduction to internet of things (IOT) and its automotive applications.	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 HONOURS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EE1H30L	ANALYSIS OF ELECTRIC MACHINES	VAC	3	1	0	4	2020

i) PREREQUISITE: Nil

ii) COURSE OVERVIEW: The main goal of this course is to expose the students to the fundamental concepts and trends in electric and hybrid vehicles. It gives an insight into the drive system, battery management system and energy sources used in electric vehicles. It also intends to deliver various communication protocols.

iii) COURSE OUTCOMES

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

CO1	Develop the basic two pole model representation of electrical machines	Apply
CO2	Develop the linear transformation equations of rotating electrical machines incorporating the concept of power invariance.	Apply
CO3	Apply linear transformation for the steady state and transient 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- reactance and time constants-Primitive machine model of synchronous machine - Balanced steady state analysis-power angle curves-Transient analysis.

Induction Machines- Primitive machine representation- Steady State Operation-Equivalent circuit. Double cage rotor representation- 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,4th Edition 1985.

3) Bernad Adkins, Ronald G Harley, General theory of AC machines. London, Springer Publications,2013.

(b) REFERENCES

1) Alexander S Langsdorf, Theory of Alternating Current Machinery, Tata McGraw Hill, 2nd revised Edition, 2001.
2) Charles Concordia, Synchronous Machines- Theory and Performance, John Wiley and Sons Incorporate, New York. 1988.
3) M. G. Say, Introduction to Unified Theory of Electrical Machine, Pitman Publishing,1978.

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.	**12**
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.	**12**
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.	**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
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:

CO1	Explain the operation of AC Voltage Controllers and PWM rectifiers.	Understand
CO2	Choose an appropriate power semiconductor device along with its driver circuits and protection for various applications.	Apply
CO3	Analyze the operation of controlled rectifier circuits.	Analyzing
CO4	Model inverter circuits with different modulation strategies.	Apply
CO5	Analyze the operation of different DC-DC converters.	Analyzing

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) P.S. Bimbhra, *Power Electronics,* 7th Revised Edition, 2022.
2) Ned Mohan, Tore M. Undeland, William P. Robbins, *Power Electronics: Converters, Applications, and Design*, Wiley India, 3rd edition, 2018.

(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	4	0	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) Weedy B. M., *Electric Power Systems*, John Wiley and Sons, New York, 1987.
5) Nagrath I. J., Kothari D. P., *Modern Power System Analysis*, Tata McGraw-Hill, 3rd edition, 2003.
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