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XXXIV Academic Council (AC) Minutes- Annexure-2.7

Dt: 26-10-2021

Department of Electrical & Electronics Engineering

Minutes of the XXVII BOS Meeting

The Department XXVII BOS meeting is held on 26th October 2021 from 1.30 PM onwards in online mode

The following members were present:

1. Dr. J Somlal-Professor & HoD, Department of EEE, KLEF- Chairman
2. Dr. K Siva Kumar, Associate Professor, IIT Hyderabad-External Member
3. Dr. P. Shankar, Assistant Professor, NIT AP-External Member
4. Mr. Sreeram Raavi, CEO-Eruvaka Technologies- External Member
5. Dr. M V V K Srinivasa Prasad, Assistant Professor & Associate Dean Curriculum Aspects TLP- KLEF-Invited Member from DAO
6. Dr. M Venkata Narayana, Professor, ECE Department, KLEF-Co-Opted Member
7. Dr. J V Shanmukha Kumar, Professor, Department of Chemistry, KLEF-Co-Opted Member
8. Dr. K V Divya, Professor, Department of English, KLEF- Co-Opted Member
9. Dr. N S M P Latha Devi, Associate Professor, Department of Physics, KLEF- Co-Opted Member
10. Mr. T Ratna Prasad, Assistant Professor, ME Department, KLEF -Co-Opted Member
11. Dr. K Subba Rao Professor, Department of EEE, KLEF -Internal Member
12. Dr. S V N L Lalitha, Professor, Department of EEE, KLEF -Internal Member
13. Dr. K Narasimha Raju, Professor, Department of EEE, KLEF -Internal Member
14. Dr. A Pandian, Professor, Department of EEE, KLEF - Internal Member
15. Dr. B Loveswara Rao, Professor, Department of EEE, KLEF - Internal Member
16. Dr. P Srinivas Varma, Associate Professor, Department of EEE, KLEF- Internal Member
17. Dr. M Kiran Kumar, Associate Professor, Department of EEE, KLEF- Internal Member
18. Dr. B Jyothi, Associate Professor, Department of EEE, KLEF- Internal Member
19. Mrs. K Sarada, Associate Professor, Department of EEE, KLEF- Internal Member
20. Mr. R Bhanu Prakash, Associate Professor, Department of EEE, KLEF- Internal Member
21. Mr. D Seshi Reddy, Associate Professor, Department of EEE, KLEF- Internal Member
22. Dr. G Raja Sekhar, Associate Professor, Department of EEE, KLEF-Internal Member
23. Mr. T Teja Sreenu, Assistant Professor, Department of EEE, KLEF Internal Member
24. Mr. D Kalyan, Assistant Professor, Department of EEE, KLEF- Internal Member
25. Mr. S Ravi Teja, Assistant Professor, Department of EEE, KLEF- Internal Member

Members Absent : NIL

J. Somlal
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Opening Remarks by Chair

1. Dr. J Somlal, Chairman BoS opened the meeting by welcoming and introducing the external members, to the internal and co-opted members of the board. He thanked them for accepting to become members of the Board of Studies.
2. The Chairman reported the faculty awards and recognitions, research activities and placement status of the department for the last academic year before the BoS members.
3. Chairman of BoS informed the members present, about the Department Academic Committee (DAC) meeting held on 25/09/2021 and highlighted the major resolutions of discussion as brought to the notice of the DAC by the stake holders. He then put forward the agenda items before the board for recommendations to the Academic Council.
   (Annexure I: Stakeholders Feedback)
   (Annexure-II DAC MoM dt. 25/09/2021)

AGENDA and RESOLUTIONS

AGENDA ITEM-1

Course Structure and Syllabi of proposed courses introduced for 2021-22 admitted batches for B. Tech EEE program as per the suggestions and feedback received from stakeholders and approved in DAC	It is resolved to approve the curriculum of the 2021-2022 admitted batch and the same is recommended to the academic council for approval

As per the feedback from academic peers, industry experts and alumni to improve practical knowledge and skills among the students few changes in B.Tech structures were put before the BoS members for review.

SL	Course Code	Course Title	Course Type	Remarks
1	21EE2101	Electrical Circuits	Core	New Course
2	21EE2203	Electrical Power Generation, Transmission and Distribution	Core	New Course
3	21EE2201	Analog Electronics	Core	New Course
4	21EE3103	Power System Analysis	Core	New Course
5	21EE3102	Measurements and Instrumentation	Core	New Course
6	21EE3202	Power System Protection and Control	Core	New Course
7	21IE2046E	Project Based Learning -1	Project	New Course
8	21IE2047	Project-based learning -2	Project	New Course
9	21TS6004	Skilling for Engineers-4	Project	New Course

The changes in the B.Tech EEE course structure are the inclusion of lab and tutorial components in relevant professional elective courses in all specializations.

BoS members reviewed the structure, outcomes and syllabus of courses which are modified. The following recommendations are made for the approval of structures and syllabi. Dr. K. Siva Kumar, Associate Professor, IIT Hyderabad and Dr. P. Shankar, Assistant Professor, NIT AP. enquired on how pre-requisite concepts for a few advanced topics in professional electives viz. AI tools, Networking etc. are taken care of. The department academic committee in reply justified the pre-requisite concepts completion through skilling courses.

The syllabus for the courses for which lab and tutorial components are included is put before the BoS.

- Dr. K Sivakumar, Associate Professor, IIT Hyderabad suggested changing the BTL level in the BEE course for application.

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- Sreeram Raavi, CEO-Eruvaka Technologies suggested modifying electrical power engineering into Electrical power generation, Transmission and Distribution by including renewable power generation and automated distribution and discarding power system control concepts
- Praveen Tamada, Asst. Manager, IOCL, suggested modifying Analog Electronic Circuit Design into to GATE syllabus-oriented course rather than a deep design course
- Chaitanya, a power engineer, at Texas Instruments recommended to Measurements and Instrumentation course for sufficient knowledge and exposure towards industrial instrumentation.
- Sravani Priya (id No: 170060028) requested CRT training is overlapping and it is difficult to manage, It is resolved to have credit-based CRT training.
- V. Tharun (Id No: 1800690028) requested to have a Yoga course online
- Rajasekhar Reddy N, Segment Manager- Weidmuller Germany, Project learning should be a blend of a software tool applied to core course concepts, it is resolved planned to include python programming based simulation applied to core courses in semester 3 and semester 4.

The contents of the skilling and technical proficiency courses are reviewed by the BoS members and verified relevance to project-based learning from current semester courses.

Annexure-II
The syllabus of new Courses is shown in point 3 of Annexure II

AGENDA ITEM-2

Proposed to revise the Syllabus for the Y21 batch courses based on the feedback received from stakeholders	It is resolved to approve the course revisions of B.Tech A.Y: 2021-2022 and the same is recommended for the academic council for approval

The following course revision in the syllabus is done

SL	Course Code	Course Title	Course Type	Percentage of Revision	Remarks
1	20EE4122	Grid Integration of Renewable Energy Resources	Elective	10%	synchronous and wind generators-based integration, stability and protection concepts for Grid Integration of Renewable Energy Sources
2	21EE4142	Communication Protocols & Testing of EV course	Elective	10%	Intricacies in power levels for Communication Protocols & Testing of EV course.

- Dr, Ch. Rami Reddy, Professor, Anurag University, recommended modifying Grid Integration of Renewable Energy Resources towards focussed PV inverter and wind power synchronization and associated challenges.
- B Pranav, AI Engineer- AI Kinetics, India recommended for inclusion of intricacies in power levels for the Communication Protocols & Testing of EV course.
- Dr. P. Sankar, Assistant Professor, NIT AP and M Ranga Prasad suggested to include vehicle to vehicle communication

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- Dr. K. Siva Kumar, Associate Professor, IIT Hyderabad suggested including synchronous and wind generators- based integration, all BoS members approved for removal of smart grid concepts and inclusion of stability and protection concepts for Grid Integration of Renewable Energy Sources course.

The changes in syllabi are shown in point 4 in Annexure II

AGENDA ITEM-3

Course Structure and Syllabi for 2021-22 admitted batches for M. Tech PS program as per the suggestions and feedback received from stakeholders and approved in DAC	It is resolved to approve the curriculum of 2021-2022 admitted batches for M. Tech PS and the same is recommended for the academic council for approval

Proposed following courses are introduced in M.Tech -Power Systems

SL	Course Code	Course Title	Course Type	Remarks
1	21EE51B1	Floating Solar and Off-Shore Wind Technologies	Elective	New Course
2	21EE52D3	Energy Management Systems	Elective	New Course

- As per the Contemporary requirements Floating Solar and Off Shore Wind Technologies and Energy Management Systems courses are introduced in M.Tech -Power Systems and

Annexure-III

Revisions done in the following courses

SL	Course Code	Course Title	Course Type	Percentage of Revision	Remarks
1	21EE5202	AI Techniques for Power Systems	core	25%	Neural networks are elaborated in CO-1 and CO2 and the Genetic algorithm is modified to CO4
2	21EE51S1	Reactive Power Compensation and Management	core	25%	CO3 is revised

- B Pranav, AI Engineer, AI Kinetics, India recommended for inclusion of **AI Techniques for Power Systems** in the M. Tech PS program with advanced load flow, interoperability, and programming techniques.
- On contemporary requirements of local/regional/ National/ Global needs **Reactive Power Compensation and Management** course is revised **Annexure-III**

AGENDA ITEM-4

Course Structure and Syllabi for 2021-22 admitted batches for M. Tech PED program as per the suggestions and feedback received from stakeholders and approved in DAC	It is resolved to approve the curriculum of 2021-2022 admitted batches for M. Tech PED and the the same is recommended for the academic council for approval

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Revisions done in the following courses

SL	Course Code	Course Title	Course Type	Percentage of Revision	Remarks
1	21EE5213	Electric Vehicle Technology	core	25%	power train elements, battery sizing, Chassis design and vehicle dynamics were added. basic converters and add bi-directional converters were removed
2	21EE5211	Switched Mode Power Supplies	core	25%	isolated converters are added
3	21EE51B1	Floating Solar and Off-Shore Wind Technologies	Elective	25%	case studies, practical constraints, and novel technologies are added

- Dr. Pranay, Anurag University suggested that **Electric Vehicle Technology** be included as a professional core course for the M. Tech-PED program which shall cover power train elements, battery sizing, Chassis design and vehicle dynamics.
- Dr. P. Sankar, Assistant Professor, NIT AP suggested for novel isolated converters in **Switched mode power supplies** to be included. Also, zero voltage switching techniques with inherent non-idealities of conductors are to be included.
- Dr. D. Ravi Teja recommends that the **Floating Solar and Off Shore Wind Technologies** course be modified in terms of case studies, practical constraints, and novel technologies.
- Dr K. Siva Kumar Associate Professor, IIT Hyderabad, suggested removing basic converters and adding bi-directional converters in charging technology for the EV course

Annexure IV

AGENDA ITEM-5

Value-added courses proposed for 2021-22 EVEN Semester	It is resolved to approve the curriculum of 2021-2022 admitted batches for M. Tech PS and the same is recommended for the academic council for approval

All the BoS members reviewed the syllabus of value-added courses proposed for the 2021-22 EVEN semester and approved the same. BEVT & Power train sizing; Li-ion Cell testing & BMS IoT and Data Science for Smart Grid; Advanced IoT & Machine Learning. HCIA- AI-1; HCIA- Routing & Switching AI Engineer-1; AI Engineer-2,Electric Vehicle Design ,Internet of Things from APSSDC Y20 admitted Batch Level-1
(Point 1 of Annexure V)

AGENDA ITEM-6

To recommend and approve Pre-PhD courses for Y21 admitted scholars	It is resolved to approve and recommend to the academic council for approval

- Following are the suggestions for Pre-PhD courses for scholars admitted in A.Y: 2021-2022
- Dr. B Jyothi recommended having **SMART GRID TECHNOLOGIES, SMAART METERS AND SMART CITIES.**
- Dr. P Srinivas Varma recommended the **FACTs** Devices course.

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- Dr. A Pandian recommended having **Charging stations for Electric Vehicles, Advanced Power Converters**
- Dr. T Vijay Muni suggested having **IOT for Industrial Automation**
- Dr. G Raja Sekhar recommended **Renewable Energy sources and Integration, Power Quality.**
- Dr. M Kiran Kumar suggested floating **Advanced Electric drives and Adaptive Control Systems.**
- Dr. SVNL Lalitha suggested adding **AI Techniques in Power Systems and digital protection of Power Systems.**
- Dr. J Somlal recommended **Realtime control of Power Systems.**
- Dr.K Narasimha Raju recommended including a **Battery Management System For Electric Vehicles**

BoS members appreciated the selection of courses covering all aspects of research.

AGENDA ITEM-7

Approval of Program Development Document for 2019-2020 admitted B.Tech and M. Tech Programs.	BOS members recommended for academic council approval

All the BOS members reviewed the program development document for 2019-2020 B.Tech and M. Tech structures highlighting Local/Regional/National/ Global needs and Mapping to courses are presented to all the BoS members which is reviewed for significance to introduction or revision of courses.

AGENDA ITEM-8

Approval of MOOC courses for A.Y:2019-2020	Bos members recommended MOOC courses to academic council approval

BoS members recommended COURSERA, SWAYAM, and various platforms for knowledge gain. They instructed us to identify the courses available on various platforms.
Annexure -

AGENDA ITEM-9

Proposal for introduction of new PG programs	BOS recommended to survey before going for implementation.

A proposal for introducing a new PG Program in Renewable Energy is put forward. The external BoS members appreciated and suggested reviewing on faculty expertise available and the laboratories to be set up.

The BOS chairman has proposed introducing Electrical and Computer Engineering as a UG program. The necessity, expertise and infrastructure available were discussed in length. All Bos members approved the proposal.

AGENDA ITEM-10

Review of Results obtained last semester and CO-PO attainment	It is resolved to approve CO-PO attainment of the previous semester and the same is recommended to Academic Council

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Annexure-I

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Stake Holders Feedback Summary for A.Y 2021-22

Feedback from different stake holders has been collected in respect of the curriculum offered for the academicyear 2021-22

Serial Number	Type of Stake holder	Number of feedbacks
1	Students	45
2	Parents	10
3	Alumni	15
4	Faculty	17
5	Academic peers	10
6	Industry persons	10
	Total	114

Serial Number	Recommendations	Action taken in BoS
Students Feedback		
1	Sravani requested CRT training and Academics are overlapping and hectic to manage	Credit based CRT training is included and forwarded to academic council for approval
2	VELDANDI THARUN students requested YOGA course in offline would be more effective	Due to Pandemic this is offered in online. Requests are considered and proposed for recommendation to BoS
Faculty Feedback		
3	Dr. K Narasimha Raju proposed conduction of FDPs and hands on training for modern tools such as IOT, Python programming and cloud computing	Planned to be included as part of SRP for effective delivery
4	Dr SVNL Lalitha suggested for availability of e-books for new courses in UG and PG	Planned to conduct review of available books and make recommend all the necessary books
Academic peers and		
5	For 2018 curriculum, syllabus of AnalogElectronic Circuits Design (AECD) Course is to be modified.	AECD course syllabus was modified as 3-0-2-0-3 Structure
6	Electrical Machines-I & Electrical Machines-IIwithout inclusion of Electrical Drives	It has been suggested to remove the electricdrives course and to add it in skilling.
7	It is suggested to float, Sensors & Instrumentation, Communication Protocols & Cyber Security as common courses for all specializations.	It is resolved in the BoS to offer Sensors & Instrumentation, Communication Protocols &Cyber Security as common courses for all specializations.

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8	Dr. K. Sivakumar, Professor, IITH-Change in the BTL level in BEEE courses to apply level.	Analyzed and identified the need of improvement and changedthe BTL level.
9	Dr. Chandrasekhar Perumalla, IIT Bubaneswar-To include tutorial components to improve real world problem solving skills in power train design and energy management	Identifed Power train design for EV and EMS & Green Building courses as suitable for incuding tutorial components and recommended for consideration by BoS
Industry Persons Feedback		
10	Lab or skilling for AI & IoT courses in specialization subjects provides a better understanding of the course and helps to achieve course outcomes	Identified suitable subjects and drafted structure, tentative experiments to recommend for BoS
11	Rajasekhar Reddy N, Segment Manager, Weidmuller Germany, Project Based learning should be blend of a software tool applied to core courses concepts	Planned to include python programming based simulation applied to core courses in semester 3 and semester 4 and the same is recommended for discussion in BoS
12	V Raja Phanideep recommended CAN application layer and lab component to be included for better outome of communication protocols and testing of electric vehicle course	Considered, anlyzed and modified part of syllabus and outcomes to include lab component
13	Mid-grad capstone project should come from the outcomes of lab components in core courses for semester 5 and from specialization courses for semester 6	A tentative list of projects/project statements is recommended for discussion in BoS
Parents Feedback		
14	VEMANA VENKATA SIVA REDDY suggested that the study should be more knowledgeable and not only marks-focused., also it should be equal for all	The curriculum is based on Choice Based Credit System (CBCS), which provides more flexible options with elective and audit courses to choose courses following the interest of students. Moreover, the courses in the curriculum are designed to achieve the goals of the program with enhancement in skill and knowledge of students, which ultimately built a community conscious towards environmental issues and think & act to attain the goals of sustainable development. communication abilities. Though the assessment part of students' performance is done through sessional and term-end examinations, the objectives and content of the syllabus are focused on building knowledge levels and improving skills to act for environmental causes.
15	K PULI RAJU recommended to conduct more bridge courses for Lateral entry students	Bos recommended floating bridge courses on coding courses and forwarded them for academic counselling approval.

3/11/21

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Alumni Feedback		
16	Madde Ranga Prasad, Senior Engineer , Tesla, United States - In EV specialization more focus is given on battery and Load management. Please also focus on other verticles like testing and communication.	Vehicle to Vehicle communication protocols to communication protocols and testing
17	Sandeep Polina, Senior Software Engineer, Robert Bosch, India- add smart grid technologies related to automation of electrical power systems.	Smart grid specialization covers the required concepts

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

DEPARTMENT ACADEMIC COMMITTEE (DAC) MEETING MINUTES

The Department of Electrical and Electronics Engineering, K L Deemed to be University, has scheduled Department Academic Committee (DAC) meeting on 24/09/2021 at 1:30 PM in the Head of the Department chambers.

Members of Department Academic Committee:

S.No	Name of the member	Designation	Member
1	Dr. J Somlal	Professor & HOD	**BOS Chairman**
2	Dr. K Narasimha Raju	Professor, Department of EEE	**BOS Secretary**
3	Dr. S V N L Lalitha	Professor, Department of EEE	Internal Member
4	Dr. P S Varma	Associate Professor, Department of EEE	Internal Member
5	Dr. A Pandian	Professor & PED Research Group Head, Department of EEE	Internal Member
6	Dr. B Loveswara Rao	Professor, Power Systems Research Group Head, Department of EEE	Internal Member
7	Dr. M Kiran Kumar	Associate Professor, Department of EEE	Internal Member
8	Dr. B Jyothi	Associate Professor, RPAC Chairman, Department of EEE	Internal Member
9	Dr. G G Raja Sekhar	Associate Professor, Department of EEE	Internal Member
10	Mrs. K Sarada	Associate Professor, Department of EEE	Internal Member
11	Mr. R B R Prakash	Associate Professor, Department of EEE	Internal Member
12	Mr. D Seshi Reddy	Associate Professor, Department of EEE	Internal Member
13	Mr. M Naga Chaitanya	Assistant Professor, Department of EEE	Internal Member
14	Mr. S Ravi Teja	Assistant Professor, Department of EEE	Internal Member
15	Mr. D. Kalyan	Assistant Professor, Department of EEE	Internal Member
16	Mr. T. Teja Sreenu	Assistant Professor, Department of EEE	Internal Member

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Reporting items:

a. Faculty awards and recognitions
b. Research activities in the department
c. Placement status

Agenda Points:

1. Discussion on Stake holder's feedback for the courses to be offered in A.Y. 2021-22 even semester.
2. Discussion on modifications proposed in courses and their syllabus to be offered in A.Y. 2021-22 even semester.
3. To identify and finalize the contents to be delivered in Skilling for Engineers-4 and Technical Proficiency & Training – 2 Courses to be offered for Y19 admitted batches.
4. Discussion and finalizing of Level – 3 certificate course to be offered for Y18, Y19 and level-1 certificate course for Y20 admitted batches for the A.Y. 2021-22 even semester.
5. Discussion on courses syllabus modifications of M.Tech. (PS & PED) to be offered for A.Y. 2021-22 admitted batch.
6. Discussion on introducing new programs.

Minutes of the Meeting:

1. HOD has presented the faculty awards, various research activities conducted during the odd semester of A.Y. 2021-22 and the current placement status.
2. Stake holder's feedback is discussed at length and the BOS chair suggested implementing new teaching pedagogies for effective course delivery.
3. All DAC members approved the modifications in syllabus for 19EE3221 AI and IoT for Green Energy Integration, 19EE3222 Grid Integration of Renewable Energy Sources, 19EE3241 AI and IoT for Electric Vehicle and 19EE3242 Communication Protocols and Testing of EV courses and forwarded to BOS for approval (as mentioned in Annexure I).
4. All DAC members approved the syllabus of skilling and technical proficiency courses (as mentioned in Annexure II) to be offered in the even semester for the A.Y. 2021-22 and forwarded to BOS for approval.

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5. All the DAC members approved the certificate courses (as mentioned in Annexure III) to be offered for Y18, Y19 and Y20 and forwarded to BOS for approval.
6. Course Structures for B.Tech Minor degrees to be offered by the department are discussed in length and a team is constituted for framing structure and syllabus of the courses
7. Introduction of new academic programs is discussed and proposal for two new programs viz. "B.Tech in Electrical and Computer Engineering" and "M.Tech in Renewable Energy" were accepted by all the DAC members. A team is constituted for working on modalities and procedures.

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HOD, EEE

Annexure-II

Course structure and Syllabus Revision for 2021—2022 B.Tech EEE program

1. Course structure for 2021-22 admitted BTech-EEE program

SNO	COURSE CODE	COURSE NAME	Category	L	T	P	S	Cr	Pre-requisites	New ...	Changes Proposed by	Focused on Employability/ ...preneurship	Justification
1	20UC1101	Integrated Professional English	HSS	0	0	4	0	2	Nil	Retained	No Change	Employability	Covers the soft, verbal, Quantative and reasoning skills Concepts which helps the students for attaining better employment
2	20UC1202	English Proficiency	HSS	0	0	4	0	2	Nil	Retained	No Change	Employability	Covers the soft, verbal and Quantative reasoning skills Concepts which helps the students for attaining better employment
3	21UC2103	Essential Skills for Employability	HSS	0	0	4	0	2	Nil	Retained	No Change	Employability	Covers the soft, verbal and reasoning skills Concepts which helps he students for attaining better employment
4	21UC2204	Corporate Readiness Skills	HSS	0	0	4	0	2	Nil	Retained	No Change	Employability	Covers the soft, verbal and reasoning skills Concepts which helps he students for attaining better employment
5	21UC0010	Universal Human Values & Professional	HSS	2	0	0	0	2	Nil	Retained	No Change	Employability	Covers essentials of entrepreneurship thinking
6	20UC0007	Indian Heritage and Culture	HSS	2	0	0	0	0	Nil	Retained	No Change	Employability	Cotemporary knowledge as required for entrance tests of PSU Graduate engineer trainees
7	20UC0008	Indian Constitution	HSS	2	0	0	0	0	Nil	Retained	No Change	Employability	Cotemporary knowledge as required for entrance tests of PSU Graduate engineer trainees
8	20UC0009	Ecology & Environment	HSS	2	0	0	0	0	Nil	Retained	No Change	Employability	Cotemporary knowledge as required for entrance tests of PSU Graduate engineer trainees

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9	21UC0011	Gender Sensitization	HSS	2	0	0	0	2	Nil	Retained	No Change	Employability	Cotemporary knowledge as required for entrance tests of PSU Graduate engineer trainees
10	20MT1101	Mathematics for Computing	BS	2	2	0	2	4.5	Nil	Retained	No Change	Skill Development	Covers the applications of mathematics for computation in domain courses
11	21MT2102	Mathematics for Engineers	BS	2	1	0	0	3	Nil	Retained	No Change	Skill Development	Covers the applications of mathematics for circuit branches which helps the students for attaining better employment
12	20EE2104	Mathematical Transforms for Signal	BS	2	1	0	0	3	Nil	Retained	No Change	Skill Development	Covers the applications of mathematics for circuit branches which helps the students for attaining better employment
13		Science Elective - 1	BS	3	1	0	0	4	Nil	Retained	No Change	Employability	Enhances the general science knowledge for engineers
14		Science Elective – 1I	BS	3	1	0	0	4	Nil	Retained	No Change	Employability	Enhances the general science knowledge for engineers
15	21EE2103	Electromagnetic Fields and Engineering	BS	3	1	0	0	4	Nil	Retained	No Change	Employability	Enhances the general science knowledge for engineers
16	21UC3105	Problem Solving Skills-I	BS	0	0	2	2	1.5	Nil	Retained	No Change	Employability	Enhances the general science knowledge for engineers
17	21UC3206	Problem Solving Skills-II	BS	0	0	2	2	1.5	Nil	Retained	No Change	Employability	Enhances the general science knowledge for engineers
18	21SC1101	Computational Thinking for Structured	ES	3	0	2	6	5.5	Nil	Retained	No Change	Employability	Coversthe programming Concepts which helps the students for attaining better employment

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19	20ME1103	Design Tools Workshop – I	ES	0	0	4	0	2	Nil	Retained	No Change	Skill Development	Covers the design tools workshop Concepts which helps the students for attaining better employment
20	21SC1202	Data Structures	ES	3	0	2	4	5	20SC1101	Retained	No Change	Skill Development	Covers the programming Concepts which helps the students for attaining better employment
21	21EC1202	Computer Organization & architecture	ES	2	0	0	0	2	NIL	Retained	No Change	Employability	Covers the hardware aspects of computer architecture which help for employment in semiconductor industry
22	20EE1201	Basics of Electrical & Electronics	ES	3	1	2	0	5	Nil	Retained	No Change	Employability	Basic knowledge of electrical and electronic devices which is very much essential prerequisite for electrical core subjects
23	20SC1203	Object Oriented Programming	ES	2	0	4	0	4	Nil	Retained	No Change	Employability	develops modern programming structures
24	20EC1101	Digital Logic & Processors	ES	3	0	2	0	4	Nil	Retained	No Change	Employability	Covers the hardware aspects of computer architecture which help for employment in semiconductor industry
25	21EE2203	Electrical Power Generation,	PC	3	0	0	0	3	Nil	NEW	Academic Peers	Employability	Covers the knowledge required for materials and measurements necessary for electrical engineering
26	21EE2101	Electrical Circuits	PC	3	0	2	0	4	Nil	NEW	Academic Peers	Employability	Covers the knowledge required for materials and measurements necessary for electrical engineering
27	21EE2102	Electrical Machines	PC	3	0	2	0	4	Nil	Retained	No Change	Employability	Covers the core engineering Concepts which helps the students for attaining better employment in EEE core companies
28	21EE2201	Analog Electronics	PC	3	1	2	0	5	Nil	NEW	Academic Peers	Employability	Covers the knowledge required for materials and measurements necessary for electrical engineering

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29	21EE3103	Power System Analysis	PC	3	0	0	0	3	Nil	NEW	Academic Peers	Employability	Covers the knowledge required for materials and measurements necessary for electrical engineering
30	21EE2202	Industrial Applications of Electrical	PC	3	0	2	0	4	21EE2102	Retained	No Change	Employability	Covers the core engineering Concepts which helps the students for attaining better employment in EEE core companies
31	21EE2204	Power Electronics	PC	3	0	2	0	4	21EE2101	Retained	No Change	Employability	Covers the core engineering Concepts which helps the students for attaining better employment in EEE core companies
32	21EE3101	Control Systems	PC	3	0	2	0	4	Nil	Retained	No Change	Employability	Covers the core engineering Concepts which helps the students for attaining better employment in EEE core companies
33	21EE3202	Power System Protection and Control	PC	3	0	2	0	4	Nil	Retained	No Change	Employability	Covers the core engineering Concepts which helps the students for attaining better employment in EEE core companies
34	21EE3102	Measurements and Instrumentatio	PC	3	0	2	0	4	Nil	NEW	Industry Expert	Employability	Covers the core engineering Concepts which helps the students for attaining better
35	21EE3104	AI Techniques fcr Electrical Engineering	PC	3	0	2	0	4	Nil	Retained	No Change	Entrepreneursh ip	Covers the core engineering Concepts which helps the students for attaining better employment in EEE core companies
36	21EE3201	Embedded Controllers & Applications	PC	3	0	2	0	4	Nil	Retained	No Change	Employability	Covers the core engineering Concepts which helps the students for attaining better employment in EEE core companies
37	21EE3231	Distribution System Practices	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment
38	21EE3232	Distributed Energy Resources and	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment

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39	21EE3233	Energy Management Systems and	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment
40	21EE4131	Smart Grid Communicatio n and	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment
41	21EE4132	Internet Of Things and Smart Grid	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment
42	21EE3221	Solar PV and Micro Energy Technologies	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment
43	21EE3222	Wind and Energy Storage Technologies	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment
44	21EE3223	Energy Management and Green	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment
45	21EE4121	AI and IoT for Green Energy Integration	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment
46	21EE4122	Grid Integration of Renewable	PE	3	0	0	0	3	Nil	NEW	Industry Expert	Employability	Covers the core engineering Concepts which helps the students for attaining better
47	21EE3241	Power Train Design for Electric Vehicle	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment
48	21EE3242	Battery State Estimation Algorithms for	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment

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49	21EE3243	Charging Stations for Electric	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment
50	21EE4141	AI and IoT for Electric Vehicle	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment
51	21EE4142	Communication Protocols & Testing of	PE	3	0	0	0	3	Nil	NEW	Industry Expert	Employability	Covers the core engineering Concepts which helps the students for attaining better
52	21EE3211	Industrial Automation and Robotics	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment
53	21EE3212	Introduction To Industrial Internet of	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment
54	21EE3213	Industrial Drives and Control77	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment
55	21EE4111	Industrial Communication Protocols and	PE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment
56	21EE4112	Smart Sensors and Sensor Networking	PE	3	0	0	0	3	Nil	Retained	No Change	Entrepreneurship	Covers the advanced Concepts in smart grid technologies which helps the students for attaining better employment
57	OE	Foreign Language Elective(OE-5)	OE	2	0	0	0	2	Nil	Retained	No Change	Employability	Covers the foreign language requirement to be able to work or study abroad
58	21BT40A1	IPR Patent Laws	OE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the practical knowledge on tools required for required for technical problem solving

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59	21BT40A9	Biomaterials	OE	3	0	0	0	3	Nil	Retained	No Change	Employability	Covers the practical knowledge on tools required for required for technical problem solving
60	21IE2040	Social Internship	PR	0	0	0	4	1	Nil	Retained	No Change	Employability	Covers the advanced Concepts in industrial automation technologies which helps the students for attaining better employment
61	21IE3041	Technical Internship	PR	0	0	0	4	1	Nil	Retained	No Change	Employability	Covers the advanced Concepts in industrial automation technologies which helps the students for attaining better employment
62	21IE4042	Industry Internship	PR	0	0	0	4	1	Nil	Retained	No Change	Employability	Covers the advanced Concepts in industrial automation technologies which helps the students for attaining better employment
63	19TS6004	Skilling for Engineers-4	PR	0	0	0	6	1.5	Nil	NEW	Industry Expert	Skill Development	Covers the advanced Concepts in renewable energy technologies which helps the students for attaining better employment
64	21IE2046E	Project Based Learning -1	PR	0	0	0	6	1.5	Nil	NEW	Industry Expert	Skill Development	Covers the advanced Concepts in renewable energy technologies which helps the students for attaining better employment
65	21IE2047	Project based learning -2	PR	0	0	0	6	1.5	Nil	NEW	Industry Expert	Skill Development	Covers the advanced Concepts in renewable energy technologies which helps the students for attaining better employment
66	21IE3043	Term paper	PR	0	0	0	4	1	Nil	Retained	No Change	Skill Development	Covers the practical knowledge on tools required for required for technical problem solving
67	21IE3044	Mid Grad Capstone Project – I	PR	0	0	0	8	2	Nil	NEW	Industry Expert	Skill Development	Covers the practical knowledge on tools required for required for technical problem solving
68	21IE3045	Mid Grad Capstone Project – II	PR	0	0	0	8	2	Nil	NEW	Industry Expert	Skill Development	Covers the practical knowledge on tools required for required for technical problem solving

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69	21IE4048/21IE4051/21IE4050	Project / Internship - 1/Practice	PR	0	0	0	16	4	Nil	Retained	No Change	Skill Development	Covers the practical knowledge on tools required for required for technical problem
70	21IE4049/21IE4052/21IE4050	Project / Internship 2/Practice	PR	0	0	0	16	4	Nil	Retained	No Change	Skill Development	Covers the practical knowledge on tools required for required for technical problem

Percentage of Courses REVISED / NEW =14/70=20%

Percentage of Courses focusing on Employability= 50/70=71.43%

Percentage of Courses focusing on Entrepreneurship= 07/70=10%

Percentage of Courses focusing on Skill Development = 17/70=24.28%

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21EE2103: Electromagnetic Fields and Engineering Materials

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-requisite: NIL**

Mapping of the Course Outcomes with Student Outcomes

CO. No.	Course Outcome	PO/ PSO	BTL
CO1	Apply Coulomb's and Gauss's laws to different electrostatic field distributions	PO-1, PO-5/2	3
CO2	Apply Biot-Savart's and Ampere's laws to different magnetic field distributions	PO-1, PO-5/2	3
CO3	Understand force existence in different field distributions and inductance phenomenon	PO-1, PO-5/1	2
CO4	Apply Maxwell's equations for time varying fields	PO-1, PO-5/2	3

Review of Coordinate Systems and vector algebra, Electrostatics: Coulomb's Law, Electric Field Intensity, Electric Flux Density, Gauss's Law, Divergence, Electric field and potential due to point, line, plane and spherical charge distributions

Conductors and Insulators, Behavior of conductors in an electric field, Dielectrics and Capacitance: potential and EFI due to an electric dipole, dipole moment and Polarization, capacitance of parallel plates, spherical and co-axial cables

Magnetostatics: Biot-Savart's law, Ampere's law, Curl, Faraday's law, Lorentz force, Inductance, Magnetomotive force, Reluctance, Magnetic circuits, Self and Mutual inductance of simple configurations.

Electrical Engineering Materials, Crystal Structures and defects, Ceramic materials, Insulating Materials, Magnetic Materials-Basics, Properties and Applications; Ferrites, Ferro-magnetic materials and components, Conductors, Photo-conductivity, Basics of Nano materials and superconductors.

Text Books:

1. Elements of Electromagnetic – Matthew N.O. Sadiku, Oxford Univ. Press, 3rd ed., 2001.
2. Electromagnetic Fields and Wave Theory –GSN Raju, Pearson Education 2006.
3. Fundamentals of Engineering Electromagnetics by Sunil Bhooshan, Oxford higher Education.

Reference Books:

1. Engineering Electromagnetics: Nathan Ida, Springer(India) Pvt.Ltd., New Delhi, 2nd ed., 2005.
2. Engineering Electromagnetics – William H. Hayt Jr. and John A. Buck, TMH, 7th ed., 2006.

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20EE2104: Mathematics For Signal Processing

L-T-P-S: 2-1-0-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO NO	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	understand basic concepts related to Signals and Systems	PO1	2
CO2	Apply Fourier series and transforms to various periodic and aperiodic waveforms	PO1	3
CO3	Apply Laplace transforms and its properties to various signals	PO1	3
CO4	Apply Z transforms and its properties to various signals	PO1	3

Syllabus: Introduction: Classification of signals, Continuous time signals and its classifications, Standard continuous time signals, Classification of continuous time systems, Discrete time signals and its classifications, Concept of frequency in discrete time signals, Standard discrete time signals, Discrete time systems, Classification of discrete time systems, Nyquist rate, Sampling theorem, Aliasing, Convolution, Correlation. Fourier series: Introduction, Dirichlet Conditions, Determination of Fourier Coefficients, Wave symmetry, Exponential form of Fourier series. Fourier Transform: Introduction, Condition for existence of Fourier Integral, Fourier Transform of arbitrary signals, standard signals and signals involving Impulse and Signum functions, Properties of Fourier Transform, Power Spectral Density, Nyquist Theorem, System Analysis using Fourier Transform. Laplace Transform: Introduction, Review of Laplace transform, Inverse Laplace transform, Properties of Laplace transforms, relation between Laplace transform and Fourier transform. Laplace transforms of various signals. Z-Transform: Introduction, Concept of Z-transform of a discrete sequence, region of convergence (ROC) for Z-transforms, constraints on ROC for various classes of signals, Inverse z-transform, Properties of Z-transforms.

Text Books :

1. Proakis, J. G. (2001). Digital signal processing: principles algorithms and applications. Pearson Education India.

2. Oppenheim, A.V. & Willsky (1997).A.S., Signals and Systems. Prentice Hall of India 2 nd ed

Reference Books :

1. Haykin, S., & Van Veen, B. (2007). Signals and systems. John Wiley & Sons.

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20EE1201: Basics of Electrical and Electronics Engineering

L-T-P-S: 3-1-2-0 **Credits: 5** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the methods to solve electrical circuit using nodal and mesh analysis and apply various network theorems.	PO1,5/ PSO1	2
CO2	Analyze the various properties of Ac circuits and understand the concept of resonance.	PO1,5/ PSO1	3
CO3	Understand the working of active circuit elements.	PO1,5/ PSO1	2
CO4	Understand the applications of semiconductor devices	PO1,5/ PSO1	2
CO5	Demonstrate various experiments related to basics of electrical and electronics concepts.	PO1,5/ PSO1	4

Syllabus:

Mesh and Nodal Analysis, Theorems: Introduction to network elements, Mesh and Node Analysis. **Network Theorems:** - Superposition, Reciprocity, Thevenin's, Norton's, Maximum power transfer, star/delta transformation and source transformation. - Simple numerical problems. **Fundamentals of AC, Resonance:** RMS and average values and form factor of Sinusoidal wave form, steady state analysis of R, L and C (in series, parallel and series parallel combinations) with sinusoidal excitation, concept of reactance, impedance, susceptance and Admittance, Phase and Phase difference, concept of power factor, Real and Reactive powers, j-notation, complex and polar forms of representations, complex power. Series and parallel resonance, bandwidth, selectivity, Q factor, current locus diagrams. **Basic active Circuits elements:** P & N - type semiconductors, P-N junction, forward bias and reverse bias, V-I characteristics, ideal and practical diodes, approximate model, diode data sheet, types of diodes and variants (Introductory level only), Types of transistors (PNP and NPN). **Applications of active elements:** Clippers, Clampers, Rectifiers - HWR, FWR with and without capacitive filters. Power supply with ripple reduction and regulation, Zener diode as a voltage regulator. **Applications of Transistor:** Transistor as an amplifier, switching transistors, power transistors (low, medium and large power), key parameter from data sheet. **Analog & Digital ICs:** 7805, 7905, IC 741, IC 555, LM 339, LM723.

Text Books:

1. John Bird. Electrical Circuit Theory and Technology, Routledge publishers, 6th edition, 2017.
2. Electronic Devices and Circuit Theory 12th Edition - Robert L. Boylestad

Reference Books:

1. A Sudhakar, Shyam Mohan S Palli, Circuits and Networks: Analysis and Synthesis, TMH, 5e
2. David A. Bell, Electronic Devices and Circuits, 5th Edition.

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22SC1203: Object Oriented Programming

L-T-P-S: 2-0-4-0 **Credits: 4** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand basic Concepts of OOP, fundamentals of java and apply the concepts of classes and objects through Java Language. Apply constructors, Overloading, parameter passing.	PO3, PO5/PSO1	2
CO2	Apply access control, Inheritance, Packages.	PO3, PO5/ PSO2	3
CO3	Apply Interfaces, Exception Handling, multi- threading, I/o.	PO3, PO5/ PSO2	3
CO4	Apply collection framework and event driven programming.	PO3, PO5/ PSO2	3
CO5	Apply object-oriented programming concepts to write programs and Analyses requirements and design to implement lab-based project with SDLC in a group of students.	PO7, PO9, PO10/ PSO1	4

Syllabus:

Introduction: Object-Oriented Programming, OOP Principles, Encapsulation, Inheritance and Polymorphism Java as a OOPs & Internet Enabled language, The Byte code, Data types, Variables, Dynamic initialization, scope and life time of variables, Arrays, Operators, Control statements, Type Conversion and Casting, Compiling and running of simple Java program.

Classes and Objects: Concepts of classes and objects, Declaring objects, Assigning Object Reference Variables, Methods, Constructors, Access Control, Garbage Collection, Usage of static with data and methods, usage of final with data,

Overloading methods and constructors, parameter passing - call by value, recursion, Nested classes.

Inheritance: Inheritance Basics, member access rules, Usage of super key word, forms of inheritance, Method Overriding, Abstract classes, Dynamic method dispatch, Using final with inheritance, String handling functions.

Packages and Interfaces: Packages, Class path, Importing packages, differences between classes and interfaces, Implementing & Applying interface.

Exception Handling: Exception Handling fundamentals, Collections Framework.

Text books:

1. Herbert Schildt, "The Complete Reference Java", 7th edition TMH.
2. Timothy A. Budd, "An Introduction to Object-Oriented Programming", 3/e, Pearson, 2008.

Reference books:

1. Deitel&Deitel, "'Java – How to program", 6th edition, PHI, 2007
2. Cay.S.Horstmann and Gary Cornell "Core Java 2, Vol 1, Fundamentals", Seventh Edition, Pearson Education.

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21EE2101: Electrical Circuits

L-T-P-S: 3-0-2-0 **Credits: 4** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand two port network parameters and their relations	PO1,5/ PSO1	2
CO2	Analyze the transient behaviour of DC / AC circuits.	PO1,5/ PSO1	4
CO3	Understand the network topology and apply three phase circuit balanced and unbalanced circuits.	PO1,5/ PSO1	3
CO4	Understand magnetic circuit behaviour in series and parallel circuits.	PO1,5/ PSO1	2

Syllabus:

Two port Networks: One port and two port networks, two port network parameters: Z, Y, Transmission and Hybrid parameters and their relationships. **Transients:** Response of R-L, R-C, R-L-C (Series and parallel combinations) for impulse, step, ramp excitations. Transient response of R-L, R-C, R-L-C circuits (Series and parallel combinations) for D.C and sinusoidal excitations, initial conditions, time domain and Laplace transform methods of solutions. **Three Phase Circuits:** Three phase circuits-phase sequence, star and delta connection, Relation between line and phase voltages and currents in balanced systems, Analysis of balanced and unbalanced 3 phase circuits. **Network Topology** - definitions, graph, tree, basic cut-set and basic tie set matrices for planar network, Loop and Nodal methods of analysis of networks, duality and dual networks. **Magnetic circuits:** concept of mutual inductance, dot convention, coefficient of coupling, Magnetic Circuits, Analysis of series and parallel magnetic circuits

Text books:

1. M. E. Van Valkenberg, "Network Analysis", Prentice-Hall of India Pvt. Ltd., 3rd edition, 1998
2. William Hayt and jack E. Kemmerly, "Engineering circuit analysis" Tata Mc Graw-Hill Companies, 5th edition.

Reference Books:

1. Charles K Alexander, Mathew N O Sadiku, "Fundamentals of Electric Circuits", Tata McGraw Hill Education Pvt. Ltd., Third Edition.
2. D. Roy Choudhury, "Networks and Systems", New Age International Limited publishers
3. J. Edminister & M. Nahvi, "Electric circuits", Schaum's outlines Tata Mc Graw Hill Publishing Company Ltd., 1999.
4. Mohd. H. Rashid, "Spice for circuits & Electronics using PSPICE", Prentice-Hall of India, 2nd edition.

21EE2102: Electrical Machines

L-T-P-S: 3-0-2-0 **Credits: 4** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No.	Course outcome	PO/PSO	BTL
1	Understand the basic principles of electro mechanical energy conversion.	PO1 /PSO1	2
2	Compute the performance of DC machines.	PO4, /PSO1	3
3	Select a suitable technique to find the voltage regulation of an alternator and analyze the load sharing.	PO4, PO5/PSO1	4
4	Determine the performance of Transformers.	PO4, PO5/PSO1	4
5	Test the performance of Electrical Machines.	PO1, PO4/PSO1	4

Syllabus:

Electromechanical Energy Conversion: Basic principle Energy, Lorentz force equation, general expression of stored magnetic energy and Coenrgy. Force and Torque equations of single and multiple excited systems. Working principle and construction of DC machines, methods of excitation. EMF equation. **DC. Generators**: Circuit models, Armature reaction, commutation process, Compensating winding, Characteristics of various types of generators. **DC. Motors:** Torque equation and types of DC motors. **Performance of DC Machines**- Testing- Direct, indirect methods of DC machines. **Transformers:** Principle, construction and operation of single phase transformers, phasor diagram, equivalent circuit, voltage regulation, losses and efficiency. Testing- Open & short circuit tests, All-day efficiency, Separation of hysteresis and eddy current losses, Autotransformer, Three phase Transformer, Scott connections, cooling methods. **Synchronous Machines:** Alternators-Constructional features. Cylindrical rotor machine- Synchronous Generator- Generated e.m.f., circuit model and phasor diagram, armature reaction, synchronous impedance, voltage regulation - EMF, MMF, ZPF methods. Parallel operation of Alternators-Synchronization and load division

Text books

1. P.S. Bimbra "Electrical Machines" 7th ed., Khanna Publishers., 2007.
2. I.J Nagrath& D.P Kothari "Electrical Machines"4th ed., Tata Mc Graw-Hill, 2010.
3. Stephen J Chapman, Electric Machinery Fundamentals, Fourth Edition, McGraw Hill, Singapore 2005.

Reference books

1. M.G Say "Performance and Design of A.C Machines" 3rd ed., CBS Publishers, 2002.
2. A.E.Fitzgerald, C Kingsley and S Umans "Electric Machinery" 7th ed., McGraw Hill, 2013.

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21EE2103: Electromagnetic Fields and Engineering Materials

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-requisite: NIL**

Mapping of the Course Outcomes with Student Outcomes

CO. No.	Course Outcome	PO/ PSO	BTL
CO1	Apply Coulomb's and Gauss's laws to different electrostatic field distributions	PO-1, PO-5/2	3
CO2	Apply Biot-Savart's and Ampere's laws to different magnetic field distributions	PO-1, PO-5/2	3
CO3	Understand force existence in different field distributions and inductance phenomenon	PO-1, PO-5/1	2
CO4	Apply Maxwell's equations for time varying fields	PO-1, PO-5/2	3

Review of Coordinate Systems and vector algebra, Electrostatics: Coulomb's Law, Electric Field Intensity, Electric Flux Density, Gauss's Law, Divergence, Electric field and potential due to point, line, plane and spherical charge distributions

Conductors and Insulators, Behavior of conductors in an electric field, Dielectrics and Capacitance: potential and EFI due to an electric dipole, dipole moment and Polarization, capacitance of parallel plates, spherical and co-axial cables

Magnetostatics: Biot-Savart's law, Ampere's law, Curl, Faraday's law, Lorentz force, Inductance, Magnetomotive force, Reluctance, Magnetic circuits, Self and Mutual inductance of simple configurations.

Electrical Engineering Materials, Crystal Structures and defects, Ceramic materials, Insulating Materials, Magnetic Materials-Basics, Properties and Applications; Ferrites, Ferro-magnetic materials and components, Conductors, Photo-conductivity, Basics of Nano materials and superconductors.

Text Books:

1. Elements of Electromagnetic – Matthew N.O. Sadiku, Oxford Univ. Press, 3rd ed., 2001.
2. Electromagnetic Fields and Wave Theory –GSN Raju, Pearson Education 2006.
3. Fundamentals of Engineering Electromagnetics by Sunil Bhooshan, Oxford higher Education.

Reference Books:

1. Engineering Electromagnetics: Nathan Ida, Springer(India) Pvt.Ltd., New Delhi, 2nd ed., 2005.
2. Engineering Electromagnetics – William H. Hayt Jr. and John A. Buck, TMH, 7th ed., 2006.

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20EE2104: Mathematics for Signal Processing

L-T-P-S: 2-1-0-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO NO	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	understand basic concepts related to Signals and Systems	PO1	2
CO2	Apply Fourier series and transforms to various periodic and aperiodic waveforms	PO1	3
CO3	Apply Laplace transforms and its properties to various signals	PO1	3
CO4	Apply Z transforms and its properties to various signals	PO1	3

Syllabus: Introduction: Classification of signals, Continuous time signals and its classifications, Standard continuous time signals, Classification of continuous time systems, Discrete time signals and its classifications, Concept of frequency in discrete time signals, Standard discrete time signals, Discrete time systems, Classification of discrete time systems, Nyquist rate, Sampling theorem, Aliasing, Convolution, Correlation. Fourier series: Introduction, Dirichlet Conditions, Determination of Fourier Coefficients, Wave symmetry, Exponential form of Fourier series. Fourier Transform: Introduction, Condition for existence of Fourier Integral, Fourier Transform of arbitrary signals, standard signals and signals involving Impulse and Signum functions, Properties of Fourier Transform, Power Spectral Density, Nyquist Theorem, System Analysis using Fourier Transform. Laplace Transform: Introduction, Review of Laplace transform, Inverse Laplace transform, Properties of Laplace transforms, relation between Laplace transform and Fourier transform. Laplace transforms of various signals. Z-Transform: Introduction, Concept of Z-transform of a discrete sequence, region of convergence (ROC) for Z-transforms, constraints on ROC for various classes of signals, Inverse z-transform, Properties of Z-transforms.

Text Books :

1. Proakis, J. G. (2001). Digital signal processing: principles algorithms and applications. Pearson Education India.

2. Oppenheim, A.V. & Willsky (1997).A.S., Signals and Systems. Prentice Hall of India 2 nd ed

Reference Books :

1. Haykin, S., & Van Veen, B. (2007). Signals and systems. John Wiley & Sons.

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21EE2201: Analog Electronics

L-T-P-S: 3-1-2-0 **Credits: 5** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	BTL
CO1	Analyze behavior of BJT as an amplifier	PO2	4
CO2	Analyze behavior of FET as an amplifier	PO2	4
CO3	Design OP-AMP circuits for Signal conditioning and Instrumentation	PO3	5
CO4	Design oscillator circuits	PO5	5
CO5	Investigate the usage of Analog electronic circuits for amplification, instrumentation, and oscillator applications	PO4, PO9	4

Transistors: Concepts of amplifier, Q point, load line analysis, Biasing of BJT, Self-Bias-CE, High and low frequency –small signal models of Transistors, Expression of voltage gain, current gain, input & output impedance, Designing CE amplifier, FET fundamentals, Configurations, current-voltage characteristics, Biasing of JFET, Biasing of MOSFET FET small signal model, Design and analysis of RC coupled amplifier, Concept of Feedback, Feedback amplifier configurations, Emitter follower. **Op-amps:** Ideal OPAMP, Concept of differential amplifier, CMRR, Open & closed loop circuits, importance of feedback loop (positive & negative), inverting & non-inverting amplifiers, Voltage follower, Adder, Design and analysis of Integrator & Differentiator, Comparator, Schmitt Trigger, Instrumentation Amplifier. Filter Circuits: Design and Analysis of Low pass, High pass, Bandpass, Band reject filters **Design and analysis ofOscillators:** Barkhausen criterion, Colpitt, Hartley's, RC Phase shift, Wien bridge, & Crystal oscillators.**555 applications:** Design and analysis of Monostable &Astable multi vibrators using 555 and their applications.

Textbooks:

1. Muhammad H. Rashid, "Microelectronic Circuit Analysis and Design", Oxford Press.
2. Sedra& Smith, "Micro-Electronic Circuits theory and applications" 2nd edition, Cengage Learning.

Reference Books:

1. JacobMillman& Christos C. Halkias, "Integrated Electronics", Tata -McGraw Hill, 2nd Edition,(2010).
2. Robert L. Boylestad and Louis Nashelsky, "Electronic Devices and Circuit Theory", PHI. 9th Edition.

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21EE2201: Industrial Applications of Electrical Machines

L-T-P-S: 3-0-2-0 **Credits: 4** **Pre-requisite: 21EE2102**

Mapping of the Course Outcomes with Student Outcomes

C.O. No.	Course outcome	PO/PSO	B.T.L
CO 1	Understand the concepts of the 3- phase induction motor	4, 5 /1	2
CO 2	Select different speed control and starting methods of induction machine.	4, 5/1	3
CO 3	Analyze the performance of 3-phase synchronous motor	4, 5/1	4
CO 4	Select suitable motor for particular industrial applications.	4, 5/1	3
CO 5	Test the performance of Motors for various applications.	1, 4/1	4

Syllabus:

Induction Machines: Constructional features, production of torque, phasor diagram, equivalent circuit, performance analysis, torque-slip characteristics. Testing-No load, blocked rotor test & load test. Effect of rotor resistance, Circle diagram, crawling & cogging. Generator Operation, Starting- Starting methods of squirrel cage and wound rotor induction motor.

Single phase induction motors- Constructional features, double revolving field theory, equivalent circuit, determination of parameters. Split phase starting methods &applications.

Induction Motor Drives: frequency control principles – operation with constant ratio of terminal voltage to frequency, chopper-based rotor resistance control, VSI fed induction motor control, back-to-back converter based slip energy recovery

Synchronous Motor drives- Operating characteristics, V-curves, Salient pole Machine- Two reaction theory, analysis of phasor diagram, power angle characteristics, determination of Xd and Xq. Line commutated inverter based synchronous motor drive operation

DC Motor drives: Three Phase half & fully controlled rectifier fed drives, Chopper controlled drives, Speed control of a separately excited DC drive with inner current loop and outer speed loop

Advanced Industrial Drives: Introduction to principles of vector control and direct toque control of Induction motor drives, Control of PMSM, BLDC drives, Introduction to vector control of BLDC drives

Text Books:

1. "Electrical Machines", I.J Nagrath& D.P Kothari, 3rd ed., Tata Mc Graw-Hill, 2009.
2. G.K.Dubey, Power Semi conductor controlled Drives, New Age Int. Pub.

Reference Books:

1. "Theory of Alternating Current Machinery" by Alexander S Langsdorf,2nd ed., Tata Mc Graw-Hill,2001.
2. "Vector Control of Electric Drives": Peter Vas, Oxford Publishers

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21EE2203: Electrical Power Generation, Transmission and Distribution

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/ PSO	Blooms Taxonomy Level (BTL)
CO1	Understand working of various generating stations and economical aspects of generation	1, 3/1	2
CO2	Analyse parameters of over-head transmission lines and underground cables	1, 2/1	4
CO3	Analyse the performance of overhead transmission lines and AC/DC distribution.	1, 3/1	4
CO4	Analyse Mechanical Sag, corona, Insulators, and substation layouts.	1, 3/1	4

Syllabus

Generating stations: Organization of power sector in India, Layout & Operation of Thermal, **Introduction:** Organization of power sector in India, Layout & Operation of Thermal, Hydro, Nuclear and combined cycle power stations. Overview of Solar, Wind Power Plant and Fuel Cells. Economics of generation, load curves, Demand Factor, load factor, diversity factor, Plant Capacity Factor, Plant Use Factor & Utilization Factor, Characteristics of Tariff, Types of Tariff.

Transmission line parameters: Types of conductors - calculation of resistance for solid conductors - Calculation of inductance for single phase and three phase, single and double circuit lines, concept of GMR & GMD, Calculation of capacitance for 2 wire and 3 wire systems, effect of ground on capacitance, capacitance calculations for symmetrical and asymmetrical single and three phase, single and double circuit lines. **Underground cables** Types of cables, grading concepts, Capacitance of three core belted type cable. Cable sizing. **Transmission line theory** : Introduction, short transmission line, medium transmission line, evaluation of A,B,C,D Constants, Surge Impedance Loading of Long Lines, Ferranti effect, elementary concepts of AC and DC distribution. **Corona**- factors affecting corona, critical voltages and power loss; Radio interference due to Corona. **Insulators:** Types of Insulators, String efficiency and Methods for improvement, calculation of string efficiency, Capacitance grading and Static Shielding. Mechanical sag.

Substation practice: Classification of substations, layout, and bus bar arrangements.

Text Books:

1. J B Gupta "A Course in Power Systems" S. K. Kataria& sons, 15th Edition, 2013.
2. C. L. Wadhwa "Electrical Power Systems" New Age International (P) Limited Publishers, 6th Edition, 2010.

Reference Books:

1. J. Nagarath and D.P Kothari "Power System Engineering" Tata Mc Graw-Hill, 2nd Edition, 2008.
2. Soni, Gupta and Bhatnagar "A Course in Electric Power" Dhanpat Rai & Sons.
3. S. N. Singh "Electric Power Generation, Transmission & Distribution" Prentice Hall India.

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21EE2204: Power Electronics

L-T-P-S: 3-0-2-0 **Credits: 4** **Pre-requisite: 21EE2101**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Select appropriate switch for a given power converter	PO1	3
CO2	Design DC-DC converters	PO3,PO5/PSO1	5
CO3	Evaluate the performance of Switch-Mode PWM Inverter	PO3,PO5/PSO2	5
CO4	Analyze the performance of phase controlled converters	PO2,PO7/PSO1	4
CO5	Test the power electronic converters by hardware realization and MATLAB software.	PO4,PO5	4

Syllabus:

Power Semiconductor devices: Ideal Switch Characteristics, Power Diode, SCR, Brief overview of these devices with their characteristics, ratings and applications: IGBT, MOSFET, SiC and GaN power devices. Gate drive circuit design for MOSFET and IGBT. Power loss calculation: Switching losses and Conduction losses.

DC-DC converters: Concept of Volt-sec balance, Charge-sec balance and Small Signal ripple approximation, Ideal analysis of non-isolated DC-DC converters: Buck, Boost, Buck- Boost, Boundary conditions between CCM and DCM. Introduction to isolated Power supplies: Fly-back, forward and Push-pull converters.

INVERTERS: Voltage source inverters: single phase inverters-performance analysis and switch rating determination, three phase square wave inverters (120, 180 modes of operation), PWM inverters: Sinusoidal PWM uni-polar and bipolar schemes and their application to three phase inverters for speed control of AC drives.

Line frequency phase controlled converters: Concept of phase control, Single-Phase fully controlled converter with R, RL and RLE load (DC drives control), Three-Phase fully controlled Converter, Estimation of line current harmonics, Input Power Factor and distortion factor. Effect of source inductance. Front end Power factor correction concept and Active PWM rectifiers.

AC voltage controllers: Single Phase AC Voltage controllers with R, RL Loads along with applications.

Text Books:

1. M. H. Rashid, "Power Electronics, circuits, devices and applications" 3rd Edition, Prentice Hall (India) Publications.
2. Robert W. Erickson, "Fundamentals of Power Electronics", Kluwer Academic Publishers, (2004).

Reference Books:

1. John G.Kassakian, Marfin F Sehelchet, George C Verghese ,"Principles of Power Electronics" First Edition, Pearson Publications (2010).
2. M.D.Singh and Khanchandani, "Power Electronics", 2nd edition , TMH Publications.
3. Dr. P.S Bimbra ,"Power Electronics" Khanna Publishers,(2012).

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21EE3101: Control Systems

L-T-P-S: 3-0-2-0 **Credits: 4** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the basics of Control system components and its modelling.	PO1, PO5/ PSO1	2
CO2	Analyse the control systems under time domain and stability analysis.	PO1, PO5/ PSO1	4
CO3	Analyze the control systems under frequency domain analysis.	PO2, PO5/ PSO1	4
CO4	Analyze the state space model equations and Understand the control though PLC	PO2, PO5/ PSO1	4
CO5	Test the operation of control systems using software & prototype models	PO1, PO5/ PSO2	4

Syllabus:

Control System Concepts: Control system terminology, examples of simple control systems, open loop and closed loop control systems, Types of control systems. **Mathematical models of physical systems**: Analogy with mechanical systems, Formulation of differential equations for electrical systems Transfer functions of open and closed loop systems, DC & AC servomotors, block diagram representation of control systems, signal flow graph, Mason's gain formula. **Time domain analysis**: Standard test signals – step, ramp, parabolic and impulse; impulse response, characteristic equation of feedback systems, transient response of first order and second order systems to standard test signals, time domain specifications, steady state error and error constants, Introduction to P, PI, PID controllers. **Stability analysis**: Concept of stability and conditions for stability, Routh – Hurwitz criterion, dominant poles of transfer function. **Root Locus Technique**: The root locus concept, basic properties, magnitude and angle conditions, properties and construction of the complex root loci. **Frequency response Analysis & Design**: Introduction, frequency response specifications, correlation between time and frequency response, specifications, polar (Nyquist) plot, Bode plot, phase margin and gain margin; stability analysis from Nyquist plot effect of adding poles & zeros to G(s) H(s) on the shape of polar plots. Preliminary design considerations – Introduction to lead, lag, lead - lag compensation techniques in frequency domain.

State space analysis: Concepts of state, state variables, state vector, input vector, output vector; development of state models for simple systems, solution of state equation, the state transition matrix and its properties; characteristic equation and transfer function from state models,. Concepts of controllability and observability. **Process control through PLC:** Basic PLC architecture - CPU, memory, I/O Modules, programming formats, I/O devices, PLC programming- input/contact and output/coil instructions, control process to PLC logic diagram, ladder diagram for basic control processes.

Text books

1. J Nagrath& M Gopal, "Control System Engineering", 5th Edition,New Age International Publication, New Delhi (2011).
2. J W Werb& Ronald A Reis, "Programmable Logic Controllers Principles and Applications", 5th Edition, Pearson Publications

Reference books

1. K Ogata, "Modern Control Engineering", Fifth Edition, Prentice Hall India Publication, New Delhi ,
2. M.Gopal, "Control Systems Principles and Design", Fourth Edition, Tata Mc-Graw Hill Publications,

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21EE3102: Electrical Measurements

L-T-P-S: 3-0-2-0 **Credits: 4** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

Co. No.	Course outcome	PO/PSO	BTL
1	Understand the important aspects of torques generated in instruments	1, 4/1	2
2	Analyse the measurement of Voltage, current & power	1, 4/1	4
3	Analyse the measurement of physical parameters (RLC) & frequency and their instruments	1, 4/1	4
4	Understand the basic concepts of transducers and analyze the working of Oscilloscopes	1, 4/1	4

Syllabus:

Introduction to Measuring Instruments: Classification —deflecting, control and damping torques — Ammeters and Voltmeters — PMMC, moving iron type instruments — expression for the deflecting torque and control torque — Errors and compensations, extension of range using shunts and series resistance. Electrostatic Voltmeters-electrometer type and attracted disc type — Extension of range of E.S. Voltmeters. **Potentiometers & Instrument Transformers:** Principle and operation of DC. Crompton's potentiometer—standardization — Measurement of unknown resistance, current, voltage. A.C. Potentiometers: polar and coordinate types standardization — applications. CT and PT — Ratio and phase angle errors.

Measurement of Power & Energy: Single phase dynamo meter watt meter, LPF and UPF, Double element and three element dynamo meter watt meter, expression for deflecting and control torques — Extension of range of watt meter using instrument transformers — Measurement of active and reactive powers in balanced and unbalanced systems. Single phase induction type energy meter — driving and braking torques — errors and compensations — testing by phantom loading using R.S.S. meter. Three phase energy meter — tri-vector meter, maximum demand meters. **Bridges:** Method of measuring low, medium and high resistance — sensitivity of wheat-stone's bridge — Carey foster's bridge, kelvin's double bridge for measuring low resistance, measurement of high resistance — loss of charge method. Measurement of inductance- Factor – Maxwell's bridge, Hay's bridge, Anderson's bridge, Owen's bridge. Measurement of capacitance and loss angle – Desauty Bridge. Wien's bridge — Schering Bridge. **Transducers:** Definition of transducers, Classification of transducers, Advantages of Electrical transducers, Characteristics and choice of transducers; Principle operation of LVDT and capacitor transducers; LVDT Applications, Strain gauge and its principle of operation, gauge factor, Thermistors, Thermo couples, Piezo electric transducers, photovoltaic, photo conductive cells, photo diodes. **CRO:** Cathode ray oscilloscope-Cathode ray tube-time base generator- horizontal and vertical amplifiers-CRO probes-applications of CRO- Measurement of phase and frequency-lissajous patterns.

Text Books:

1.Electrical and Electronic Measurements and Instrumentation, R. K. Rajput, S. Chand & Company Ltd.
2.Electrical Measuring Instruments and Measurements, S. C. Bhargava, BS Publications.

Reference Books:

1. Electrical & Electronic Measurement & Instruments, A.K.Sawhney Dhanpat Rai & Co. Publications.
2. Electrical and Electronic Measurements, G. K. Banerjee, PHI Learning Pvt. Ltd.

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21EE3103: Power System Analysis & Stability

L-T-P-S: 3-0-2-0 **Credits: 4** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO. No	Course outcome	PO/PSO	BTL
1	Apply the network matrices for solution of power flow problems	1, 2/2	3
2	Apply the reactance diagrams for symmetrical short circuit faults in a power system	1, 2/2	3
3	Analyze unsymmetrical faults in a power system using Symmetrical components	1, 2/1	4
4	Understand various aspects of power system stability	1, 2/1	2

Syllabus:

Power Flow Solutions: Network model formulation, Formation of YBUS by Direct Inspection Method, Formation of ZBUS, Power flow problem formulation, GS method, NR Method (Polar Coordinate Approach), FDLF.

Symmetrical Fault Analysis: Representation of Power Systems Components, Per Unit System, Reactance diagrams, change of base values, Short circuit of synchronous machine unloaded, Calculation of symmetrical short circuit currents for simple systems.

Unsymmetrical Fault Analysis: Symmetrical components transformation, Sequence Impedance and Networks of Power System Components, Unsymmetrical Faults on an Unloaded Generator and Power Systems.

Power System Stability: Dynamics of a synchronous machine, Swing equation, power angle equation, Single machine connected to infinite bus, two machine system, steady state stability, Transient stability analysis using Equal Area Criterion, critical clearing angle.

Text Books:

1. John J Grainger,William D Stevenson,"Power System Analysis", 4th edition ,TMH Companies,(2005).
2. C.L.Wadhwa ,"Electrical Power Systems", New Age International (P) Limited,(2008).

Reference Books:

1. I.J.Nagarath and D.P.Kothari ,"Modern Power System Analysis", 3rd Edition,Tata McGraw Hill,(2008).
2. B.R. Gupta "Power System Analysis and Design", 3rd edition wheeler publishers (2003).

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21EE3104: AI Techniques in Electrical Engineering

L-T-P-S: 3-0-2-0 **Credits: 4** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO NO	COURSE OUTCOME	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the neural network models, different architectures with different learning types and various algorithms for ANN to solve the load forecasting problems in Power systems	PO1,PO4/ PSO1	2
CO2	Apply ANN paradigms in Electrical Engineering	PO6,PO5/PSO1	3
CO3	Apply the fuzzy logic concept, fuzzy sets, with suitable membership function with proper de-fuzzification methods Electrical Engineering	PO1,PO4/PSO1	3
CO4	Apply the different cross over methods and their elitism, convergence of algorithm Electrical Engineering	PO1,PO5,PO6/ PSO1	3
CO5	Train and test various ANN' s for various applications	PO2, PO5/ PSO1	3

Syllabus:

Artificial Neural Networks: Introduction Models of Neuron Network – Architectures – Hebbian learning – Supervised learning – Unsupervised learning – Reinforcement learning. **ANN Paradigms**: Multi – layer perceptron using Back propagation Algorithm (BPA) – Radial Basis Function Network – Hopfield Network – Application to Load forecasting, Electrical Drives. **Fuzzy Logic**: Introduction – Fuzzy versus crisp – Fuzzy sets – Membership function – Basic Fuzzy set operations – Fuzzy Inference – Fuzzy Rule based system–Defuzzification methods – Application to Load Frequency Control, Electrical Drives. **Genetic Algorithms:** Introduction– Encoding – Fitness Function– Reproduction operators–Genetic Modeling – Genetic operators–Cross over – Single site cross over – Two point cross over – Multi point cross over – Uniform cross over – Mutation operator – Elitism - Generational cycle – convergence of Genetic Algorithm – Application to economic dispatch, Electrical Drives.

Text Books:

1. Daniel Graupe-Principles of Artificial Neural Networks-World Scientific publishing Company (2013)
2. S.Rajasekaran and G.A.V.Pai Neural Networks, Fuzzy Logic & Genetic Algorithms, PHI, New Delhi, 2003.

Reference Books:

1. James A freeman, David M Skapura, ' Neural Networks', Addison – Wesley, an imprint of Pearson Education, II Edition , 2000.
2. S N Sivanandam, S sumathi, S. N deepa, ' Introduction to Neural Networks using Matlab 6.0, Tata McGraw Hill Publishing Company Private Limited, 2006.
3. K Sundareswaran, 'Fuzzy Logic Systems', Jaico Publishing House, 2005.

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21EE3201: Embedded Controllers and Applications

L-T-P-S: 3-0-2-0 **Credits: 4** **Pre-requisite: NIL**

Mapping of the Course Outcomes with Student Outcomes

C.O. No.	Course outcome	Mapped SO	B TL
CO1	Examine 8051 programming for embedded control	PO2	4
CO2	Design 8051 based Interface for embedded control	PO3	5
CO3	Analyse PIC programming for embedded control	PO2	4
CO4	Design PIC based Interface for embedded control	PO3	5
CO5	Test 8051 and PIC microcontroller usage for embedded systems	PO4, PO12	4

SYLLABUS:

8051 Microcontroller functional aspects: Microcontroller families, 8051 Architecture- Signal Description, Register organization, Internal RAM, Special Function Registers, Addressing modes, Instruction set, Interrupts, Timer/Counter module, Serial Data Communication module, and RS-232C Standard.

8051 Programming & Interfacing:, Simple Programs involving Arithmetic and Logical Instructions, Timers/Counters, Serial Communication & Interrupts. Matrix Key Board interface, Stepper Motor interface, LCD interface

PIC Microcontroller functional aspects: Introduction, Architectural overview, Memory organization, interrupts and reset, I/O ports, Timers, C Programming PIC microcontroller

PIC microcontrollers Interface Applications: DAC Interfacing, ADC Interfacing, Digital relaying, Closed loop control of dc motor, speed encoder interface using CCP module

TEXT BOOKS:

1. 1.Mazidi&McKinley "The 8051 Micro controller and Embedded systems: using assembles and C, 2nd edition,2007.
2. **Mazidi&McKinley, "PIC Microcontroller and Embedded Systems: Using assembly and C for PIC 18", 1st edition, 2008**

REFERENCE BOOKS:

1. Rajkamal, "Microcontrollers - Architecture, Programming, Interfacing & System Design", 2nd edition, Pearson Education,2009.
2. Ted Van Sickle, "Programming Microcontrollers in C", 2nd edition, 2001.

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21EE3202: Power System Protection & Control

L-T-P-S: 3-0-2-0 **Credits: 4** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

C.O. No.	Course outcome	PO/PSO	BTL
1	Understand the principle of protective relays & circuit breakers	2/1	2
2	Apply overcurrent, distance and differential schemes for the protection of power system equipment	1, 2, 5/2	3
3	Analyze over voltage protection and economic operation of power system	1, 2/1	4
4	understand automatic generation control and voltage regulators	1, 2/1	1

Syllabus:

Power System Protection: Introduction, need for protective systems, nature and causes of faults, essential qualities of protection, zones of protection, primary and backup protection, Classification of protective relays & Schemes- over current, differential and distance protection, Introduction to Digital Protection, Arc voltage, Arc interruption, re-striking and recovery voltage, resistance switching, current chopping, Classification of circuit breakers and their ratings.

Protection against Over Voltages: Causes of over voltages, ground wires, lightning arresters, **Neutral Grounding:** Necessity of earthling, step voltage, Types of neutral grounding.

Economic Dispatch: Optimal operation of generators on a Bus Bar, optimal unit commitment, optimum generation scheduling with and without constraints. To be moved to PSAS

Automatic Generation Control & Automatic Voltage Regulator: Load frequency control single area (Single area case), Load frequency control and economic dispatch control, Introduction to two area load frequency control, automatic voltage control, AVR block diagram, PV curves.

STATCOM, Tap Changing transformers , Advanced control concepts (ECC, SCADA, PMU, WEMS, State estimation , contingency analysis), de-regulated power system concepts

Text Books:

1. D. P. Kothari, I. J Nagrath, "Modern Power System Analysis", 3rd Edition, Tata Mc-Graw Hill Publications.
2. Badri Ram, D N Vishwakarma, "Power System Protection and Switchgear", Tata Mc-Graw Hill Publications.

Reference Books:

1. Jhon J Grainger, William D Stevenson Jr., "Power System Analysis", Tata Mc-Graw Hill Publications.
2. Sunil S Rao, "Switch Gear Protections", Khanna Publications.
3. C L Wadhwa, "Electrical Power Systems", New Age International (P) Ltd..
4. Van. C. Warrington A.R., "Protective Relays"Vol. 1 & 2, Chapman & Hall.

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21EE3211: Industrial Automation and Robotics

L-T-P-S: 3-0-0-0 **Credits: 4** **Pre-requisite: NIL**

Mapping of Course Outcomes to Program outcomes:

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply the principle of automation	1/1	3
CO2	Analyze control systems in automation	2/1	4
CO3	Apply the fundamentals of Industrial Robots	1/1	3
CO4	Analyze the robotic end effectors and Sensors	2/1	4

Syllabus:

Introduction: Definition of industrial automation, Mechanization vs automation, advantages of automation, goals of automation, reasons for automation, social issues of automation, types of automation, current emphasis in automation, Controllers Employed in Automated Systems, Case Studies.

Computer Based Industrial Control: Introduction & Automatic Process Control, Building Blocks of Automation Systems: LAN, Analog & Digital I/O Modules Distributed Control System: Functional Requirements, Configurations & some popular Distributed Control Systems. Industrial automation and Case studies.

Fundamentals of Industrial Robots-Specifications and Characteristics, Criteria for selection. Dynamic properties of robots-stability, control resolution, spatial resolution, accuracy, repeatability, compliance, work cell control, Interlocks Robotic Control Systems-Robot Motions, Drives, Actuators, Robot controllers, Power transmission systems.

Robotic End Effectors and Sensors-Transducers and sensors: sensors in robotics and their classification, vision sensors, touch (tactile) sensors, proximity and range sensors, force and torque sensing. End Effectors-Types, grippers, various process tools as end effectors, Robot-End effectors interface, Active and passive compliance, Gripper selection and design.

Robot Programming: Level of robot programming, Language based programming, task level programming, Robot programming synthesis, Industrial Applications and Case Studies

Text Books:

1. "Automation, Production Systems & Computer Integrated Manufacturing", Mikell P. Groover, PHI Learning Pvt. Ltd. New Delhi, 3rd Edition 2012.
2. "Industrial Robotics, Technology, Programming & Applications",Groover

Reference Books:

1. An Introduction to Robot Technology (Vol. I-V) Phillipe Collet Prentice Hall Coiffet and Chirooza Kogan.
2. S.R. Deb, Robotics and Flexible Automation, Tata mc Graw Hill.
3. A.K Gupta, S.K. Arora, Industrial Automation and Robotics, Laxmi Publication (P) Ltd..

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21EE3212: Introduction to Industrial Internet of Things

L-T-P-S: 2-0-2-0 **Credits: 4** **Pre-requisite: NIL**

Mapping of Course Outcomes to Program outcomes:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the Industry 4.0 Globalization	1/2	2
CO2	Understand the Model and architecture of IIOT	1/2	2
CO3	Understand the IIoT Computing	1/2	2
CO4	Understand the Various Applications of IIoT	1/2	2

Syllabus:

Industry 4.0- Globalization: The Fourth Revolution, LEAN Production Systems , Sensing & actuation, Communication, Networking types.

Cyber Physical Systems and Next Generation Sensors: Collaborative Platform and Product Lifecycle Management.

Basics of Industrial IoT: Industrial Processes Industrial Sensing & Actuation, Industrial IoT: Business Model and Reference Architecture, Industrial IoT- Layers: IIoT Sensing-Part I, Part II, IIoT Processing, IIoT Networking.

Industrial IoT Computing: Big Data Analytics and Software Defined Networks, Data Center Networks, Industrial IoT: Security and Fog Computing - Fog Computing in IIoT, Security in IIoT

Industrial IoT Application Domains: Healthcare, Power Systems, Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries, Real case studies.

Text Books:

1. Industry 4.0: The Industrial Internet of Things", by Alasdair Gilchrist (Apress), 2017.
2. "Industrial Internet of Things: Cybermanufacturing Systems"by Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer), 2017.

Reference Books:

1. Hands-On Industrial Internet of Things: Create a powerful Industrial IoT by Giacomo Veneri, Antonio Capasso, Packt, 2018.

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21EE3213: Industrial Drives and Control

L-T-P-S: 3-0-0-0 **Credits: 4** **Pre-requisite: 21EE2204**

Mapping of Course Outcomes to Program outcomes:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand Basics of Electric Drives and Dynamics	1/1	2
CO2	Understand Closed loop control of DC drives	1/1	2
CO3	Understand the Control schemes of BLDC motors	1/1	2
CO4	Understand the Programmable control of Drives	1/1	2

Syllabus:

Electrical drives: An introduction to electrical drives, parts of electrical drives, types of drives-ac/dc , choice of electrical drives,

Dynamics and control of electrical drives: industrial load types -continuous and batch processes, sensors- voltage, current, speed, choice and sizing of drive components, dynamics of drive system: starting, braking and speed control.

Closed loop control of DC drives: phase controlled and chopper controlled DC drives, controller design

Closed loop control of Induction motor drives: V/f control, direct torque control, controller design

BLDC motor control: Torque-speed characteristics, Controllers-Microprocessor based controller. Sensor less control.

Stepper motor control: Stepper Motors - Dynamic characteristics, Drive systems and circuit for open loop control, closed loop control of stepping motor.

Programmable Logic Controller (PLC) Basic PLC programming and Basic PLC functions: Programming on / off inputs to produce on / off outputs, PLC programming examples. Motor control schemes.

Text books

1. R Krishnan," Electric Motor Drives, Modeling, Analysis, and Control", Pearson Education,2001.
2. G. K. Dubey & C. R. Kasaravada ,"Power Electronics & Drives", Tata McGraw Hill,1993.

Reference books

1. G. K. Dubey ,"Power Semiconductor controlled drives", Prentice Hall Inc., New Jersey(1989).
2. VedamSubrahmanyam," Electrical Drives concepts and Applications", Tata McGraw Hill publishers (2008).
3. P. V. Rao, "Power semiconductor Drives", B. S. Publications (2007).
4. V. R. Moorthi, "Power Electronics Devices, Circuits and Industrial Applications", Oxford University Press (2010).

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21EE4111: Industrial Communication Protocols & Cyber Security

L-T-P-S: 2-1-0-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes to Program outcomes:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the communication technology protocols & standards	1/2	2
CO2	Understand the information security and measurement technology	1/2	2
CO3	Understand the introduction to cyber crime	1/2	2
CO4	Understand the hacking and cyber-security models	6/2	2

Syllabus

Different types of Communication technologies for the smart grid, Modbus - Modbus Protocol Overview - PROFIBUS-FMS, DP, PA and technology overview - DNP3- IP based Real Time data Transmission, Substation communication network.

PROTOCOL & STANDARDS

Introduction to Industrial Network Technology CAN and CiA (CAN in Automation)- Technical Overview - Application Layers- CAN Kingdom- CAN open -Introduction-Benefits and Challenges Of Interoperability, Model For Smart Grid Network Interoperability, Approach to Smart Grid Interoperability Standards, IEC61850, GOOSE.

INFORMATION SECURITY AND MEASUREMENT TECHNOLOGY

Introduction – Encryption and Decryption Authentication, Digital signature, Message digest, cyber security standards. Communication and Measurement - Monitoring, GIS and Google Mapping Tools-

Introduction to Cyber Crime - Classification of Cyber Crimes- Reasons for Commission Of Cyber Crimes - Malware – Types -Cyber Security Initiatives in India -Counter Cyber Security initiatives in India -Wireless Security - Major Issues With WLAN - Secure WLAN- Wi-Fi at Home.//

HACKING AND CYBER-SECURITY MODELS

Identifying a target-Vulnerability- Attack tools-Attack methods-Cyber security architecture • SGCG reference architecture - ISA-62443: zones and conduits and Smart Grids - Smartphone Security- Smartphone Security Guidelines- Communicating Securely (Through Voice and Messages) with a Smartphone- Secure Voice Communication- Sending Messages Securely

Text books:

1. JanakaEkanayake, N. Jenkins, K. Liyanage, J. Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley.
2. James Momoh "Smart grid: Fundamental of Design and analysis" ,John Wiley & sons Limited IEEE Press (2012).

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21EE4112: Smart Sensors and Sensor Networking

L-T-P-S: 2-0-2-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes to Program outcomes:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the basics of smart sensors and micromachining	2	2
CO2	Understand the sensor communication:	5	3
CO3	Understand the packaging, testing and reliability of smart sensors:	3	2
CO4	Understand the wireless sensor networks:	2	2

Syllabus:

Basics of smart sensors and micromachining: Introduction, Mechanical-Electronic transitions in sensing, nature of sensors, overview of smart sensing and control systems, integration of micromachining and microelectronics, introduction to micromachining, bulk micromachining, wafer bonding, surface micromachining, other micromachining techniques for Sensor Design.

Sensor Communication and MEMS: Wireless zone sensing, surface acoustical wave devices, intelligent transportation system, RF-ID, Micro optics, micro-grippers, micro-probes, micro- mirrors, FEDs, communications for smart sensors – sources and standards, automotive protocols, industrial networks, office and building automation, home automation, protocols in silicon, other aspects of network communications.

Packaging, Testing and Reliability of Smart Sensors: Introduction, Semiconductor packaging applied to sensors, reliability implications, testing smart sensors.

Unit Standards for Smart Sensors: Introduction, setting the standards for smart sensors and systems, IEEE 1451.1, IEEE 1451.2, IEEE P1451.3, IEEE 1451.4, extending the systems to network.

Introduction to Wireless Sensor Networks: Motivations, Applications, Performance metrics, – energy harvesting wireless sensors, Power sources for WSN – Power generation – conversion

Text Books:

1. Understanding Smart Sensors- Randy Frank, 2nd Edition. Artech House Publications, 2013.

Reference Books:

1. G. K. Ananthasuresh, K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat, V. K. Aatre, Micro and Smart Systems: Technology and modeling, Willey Publications,2012.

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21EE3221: Solar PV and Micro-Energy Technologies

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-requisite: NIL**

CO#	Course Outcome	PO/PSO	BTL
CO1	Interpret principles and control of Solar PV Energy system	PO1 / PSO1	2
CO2	Model and Select Solar PV energy system components	PO5 / PSO1	3
CO3	Interpret and Model dynamics of fuel cell energy conversion	PO1 / PSO1	3
CO4	Demonstrate ultra-micro-energy energy conversion technologies	PO5 / PSO1	2

Syllabus:

Solar PV energy conversion: Generic Photovoltaic Cell, Equivalent Circuits, Cells to Modules to Arrays, I –V Curve, Impacts of Temperature and Insolation, Shading impacts on I–V curves, I–V Curves for different loads, MPPT, System sizing, System Performance, Economics

Modelling of Solar PV system components: Mathematical models -PV cell, PV Array, Battery pack, dc-dc converter, P&O MPPT technique, DC bus voltage regulation

Fuel Cell energy conversion: PEM Fuel Cells, Solid Oxide Fuel Cells, Electrolyzers, Power Electronic Interfacing Circuits, Standalone and Grid Connected Fuel Cell Power Generation Systems, Hybrid Fuel Cell Based Energy System Case Studies, Dynamic models and control of PEM, Solid Oxide Fuel Cells

Micro Energy Sources: Ocean Thermal energy conversion, Geo-thermal energy conversion, Tidal Energy conversion, Biomass energy, Bio gas plants

Text books:

1. H.P. Garg & J. Prakash, "Solar Energy - Fundamentals and Applications", Indian Edition - First Revised Edition, Mc Graw Hill Education.
2. M. H. Nehrir, C. Wang, "Modeling and Control of Fuel Cells: Distributed Generation Applications", Wiley-IEEE Press, 1st Edition, 2009.

Reference books:

1. Solar Photovoltaics, Fundamentals, Technologies and Applications, Second Edition, Chetan Singh Solanki, PHI Learning Private Limited (2012).
2. Hand Book of Fuel Cells - Fundamentals and Technology and Application, Wiley & Sons Publishers.
3. MichealBoxwell, "Solar Electricity Handbook", Green Stream publishing.
4. G.D.Rai, "Non conventional Energy", Khanna Publishers.

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21EE3222: Wind and Energy Storage Technologies

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Interpret principles and control of Wind Energy Conversion	PO1 / PSO1	2
CO2	Model and Select Solar Wind energy conversion system components	PO2 / PSO1	3
CO3	Interpret and Model Electro-chemical energy storage components	PO2 / PSO1	3
CO4	Interpret and Model Mechanical energy storage components	PO2 / PSO1	3

Syllabus

Wind Energy Conversion System: Components of WECS, Power obtained from the wind, Power Regulation, yaw control, Pitch control, stall control, Schemes for Maximum Power Extraction, Wind Turbines & Generators: Fixed-speed Induction Generator (FSIG) based Wind Turbines, Doubly Fed Induction Generator (DFIG) based Wind Turbines, Fully Rated Converter-based (FRC) Wind Turbines.

Modelling of WECS components: Mathematical models for DFIG, PMSG, Stand alone and Grid Connected WECS system control, Models for MPP

Electro-chemical Energy Storage: Batteries - lead acid, lithium ion, flow, design considerations, life cycle and reliability study, Ultra-capacitors - operation, applications, Model for lead acid battery and ultra-capacitor.

Mechanical Energy Storage: Models for pumped hydro, compressed gas, flywheel storage, System cost and efficiency, Thermal storage- Materials, Design considerations, Solar thermal energy storage.

Text books:

1. S. Chowdhury, S. P. Chowdhury, P. Crossley, "Microgrids and Active Distribution Networks", IET Power Electronics Series, 2012.
2. Ali Keyhani Mohammad Marwali and Min Dai, Integration and Control of Renewable Energy in Electric Power System, John Wiley publishing company, 2nd Edition, 2010.
3. G. D. Rai, "Non-Conventional Energy Sources", Khanna Publishers, First edition.

Reference books:

1. John Twidell& Toney Weir: E&F.N. Spon, "Renewable Energy Sources", Taylor &Francis New York, 2nd edition.

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21EE3223: Energy Management and Green Buildings

L-T-P-S: 2-1-0-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply energy audit for energy management in buildings	PO2 / PSO1	3
CO2	Interpret energy conservation opportunities in electrical systems	PO7/ PSO2	2
CO3	Identify energy management strategies for energy efficiency	PO7/ PSO1	3
CO4	Identify practices for energy efficiency green buildings	PO2 / PSO1	3

Syllabus

Energy Audit: Need, types, methodology and approach, Instruments for energy audit, Energy Management Approach, Understanding Energy Costs, Bench marking, Energy performance, matching energy usage to requirements, maximizing system efficiency, Return of Investment.

Energy conservation opportunities: Energy conservation in HVAC, Refrigeration and Air Conditioning, Pumping Systems, lighting control, lighting control, Energy Conservation Building Code, Energy Conservation opportunities in Transformers and cables, Transmission lines.

Energy Management: Definition and Objective of Energy Management, General Principles, Energy Management Strategy, Energy Balance sheet and Management Information System (MIS), Energy Modelling and Optimization, Demand Side management (DSM), Peak Demand control- Methodologies.

Green Building Practices: Energy efficiency-life cycle perspective, Environmental product declaration, Building information model, choice of heat insulation materials, high thermal mass materials, phase change materials, Green building certifications.

Text books:

1. Industrial Energy Management: Principles and Applications by Giovanni and Petrecca, The Kluwer international series-207 (1999)
2. Guide to Electric Load Management by Anthony J.Pansini, Kenneth D.Smalling, Pennwell pub (1988)

Reference books:

1. Energy Management Hand book by Turner, Wayne C, Lilburn, The Fairmont press, 2001
2. Handbook of Energy Audits by Albert Thumann, Fairmont Pr; 5th edition (1998).
3. Recommended practice for Energy Conservation and cost effective planning in Industrial facilities by IEEE Bronze book, IEEE Inc, USA.
4. Energy Management Principles: C.B. Smith (Pergamon Press)
5. Bureau of Energy Efficiency Publications-Rating System, Teri Publications – Griha Rating System, Leeds Publications.

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21EE4121: AI and IoT for Green Energy Integration

L-T-P-S: 2-0-2-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO	Description	PO/PSO	BTL
CO1	Utilize AI techniques for PV based Power generation	PO4	3
CO2	Utilize AI techniques for wind and hybrid power generation	PO4	3
CO3	Demonstrate IoT devices and tools for Green energy systems	PO2	2
CO4	Build IoT Systems for Green Energy Integration	PO7	3

Syllabus:

AI for solar PV Power generation: Fuzzy logic based PV MPP techniques, RMSE and MAPE analysis for short term irradiance, solar energy and load forecasting, Machine learning algorithms for short term irradiation and temperature forecasting, Day ahead power output forecasting for PV systems with regression, machine learning and deep learning techniques, case studies

AI for Wind and Hybrid Power generation: Wind speed forecasting, Frequency control of induction generator using genetic algorithm, stochastic wind generation and congestion management, Intelligent Energy Management System of Hybrid Solar/Wind/Battery Power Sources, Islanding detection, case studies

IoT Devices and Tools for Green Energy systems: Sensors- temperature, vibration, irradiance, wind speed, PIR, proximity, current, voltage Controllers, networking, Cloud computing, Data analytics

IoT Applications for green energy systems: Cloud based Real- time Monitoring systems: PV Power output, State of Health of Battery Storage, wind turbine vibration, M2M communication case study

Text Books:

1. AI and IoT in Renewable Energy, **Shaw,** R.N., **Mendis,** N., **Mekhilef, S., Ghosh,** A, Springer, 2011
2. Applications of AI and IoT in Renewable Energy, R.N., **Mendis, N., Mekhilef, S., Ghosh,** A, Elsevier, 2021

Reference Books:

1. Introduction to AI Techniques for Renewable Energy System, Suman Lata Tripathi, Mithilesh Kumar Dubey, Vinay Rishiwal, Sanjeevikumar Padmanaban, CRC Press, Edition 1, 2021

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21EE4122: Grid Integration of Renewable Energy Sources

L-T-P-S: 2-0-2-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO	Description	PO/PSO	BTL
CO1	Apply the control principles for PV - grid integration control	PO5	3
CO2	Apply the control principles for wind power integration control	PO4	3
CO3	Identify power quality challenges in grid integration of renewable energy	PO4	3
CO4	Identify challenges in grid integration of multiple renewable sources	PO5	3

Syllabus:

PV Integration Technology: Photovoltaic (PV) inverter topologies- configurations and control strategies, Grid codes and technical regulations of Solar PV integration
Wind Power Integration Technology: Wind power and voltage control for synchronous and induction generators-based integration; active and reactive power control, Grid codes and technical regulations of Wind power integration
Power quality management: THD, voltage sag, voltage swell, frequency change and its effects, network voltage management, frequency management, effects on system stability
Challenges: Integrating multiple renewable energy sources; DC link integration; AC link integration; HFAC link integration; islanding and interconnection

Text Books:

1. Renewable Energy Grid Integration, Marco H. Balderas, Nova Science Publishers, New York, 2009
S. Borlase, "Smart Grids, Infrastructure, Technology and Solutions", CRC Press, 1st Edition, 2013

Reference Books:

1. Grid integration of solar photovoltaic systems, Majid Jamil, M. Rizwan, D.P.Kothari, CRC Press (Taylor & Francis group), 2017
2. Wind Power Integration connection and system operational aspects, B. Fox, D. Flynn L. Bryans, N. Jenkins, M. O' Malley, R. Watson and D. Milborrow, IET Power and Energy Series 50 (IET digital library), 2007

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Distribution System Practices

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-requisite: 21EE2203**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the basic structure of distribution system and compute AT&C loss.	PO1 / PSO2	2
CO2	Apply the knowledge for erection and commissioning of a substation.	PO1 / PSO2	3
CO3	Understand the various protection systems deployed in distribution system.	PO1 / PSO2	2
CO4	Test and understand the test results of various distribution system equipment.	PO1 / PSO2	3

Syllabus:

Power Distribution Network: Types of distribution system, AT&C Loss, calculation of aggregate technical and commercial loss, measures to reduce technical and commercial losses, power distribution from distribution substation to end consumers, categories of consumers, functions of power distribution companies.

Substation Erection and Commissioning: Various types of distribution substations, technical specifications of distribution substation equipment, procedure for erection and commissioning of distribution substation, different mounting structures for the transformer, installation procedure of Switchgear, power factors correction panels and control panels, substation automation System (SAS) in power distribution network, importance of capacitor bank.

Distribution System Protection: Various distribution system protections, surge voltages along with various surge protection devices, importance of lightening arrestor (LA) in distribution network, earthing of distribution system, different grounding systems.

Testing of the Equipment in Power Distribution: Testing of distribution transformer and associated components, routine test on the equipment, importance of insulation resistance testing, polarisation index and absorption index, importance of magnetic balance test of transformer, test the earthing resistance in distribution system, various tests on current transformer, capacitive voltage transformer, lightning arrestor, circuit breaker, energy meter etc. to ensure their healthiness.

Text Books:

1. Participant handbook, Engineer – Distribution, PSS/Q7001, Version 1.0, NSQF Level 6.
2. Electric Power Distribution, A.S. Pabla, Tata McGraw-Hill Education, 2004.

Reference Books:

1. Sallam, A. A., & Malik, O. P. (2018). Electric distribution systems, Wiley Online Library.

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21EE3232: Distributed Energy Resources and Smart Grids

L-T-P-S: 2-0-2-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand different types of distributed energy resources	PO2 / PSO1	2
CO2	Apply the principles for integrating DERs to grid	PO5 / PSO1	3
CO3	Understand smart grid objectives and its activities in India	PO3 / PSO1	2
CO4	Monitor various applications in smart grid with its smart infrastructure.	PO2 / PSO2	3

Syllabus:

Distributed Energy Resources: Introduction, combined heat and power (CHP) systems, solar photovoltaic (PV) systems, Wind energy conversion systems (WECS), small-scale hydroelectric power generation, batteries, ultra-capacitors, flywheels.

Integration of Distributed Generation to Grid: Introduction, concepts of micro grid, typical micro-grid configurations, AC and DC micro grids, interconnection of micro-grids, protection and control issues in micro-grids, technical and economic advantages of micro-grid, challenges and disadvantages of micro-grid.

Introduction to Smart Grid: Introduction to smart grid, architecture of smart grid, smart grid standards and policies, smart grid components, smart grid technologies, the fundamental components of smart grid designs, and smart-grid activities in India.

Smart Grid Monitoring: Load dispatch centers, wide-area monitoring system (WAMS), PMU; Smart sensors/telemetry, advanced metering infrastructure (AMI);smart metering; demand side management and demand response programs, demand pricing and time of use, real time pricing, peak time pricing, smart grid system monitoring and self-healing.

Text Books:

1. S. Borlase, "Smart Grids, Infrastructure, Technology and Solutions", CRC Press, 1st Edition, 2013.
2. G. Masters, "Renewable and Efficient Electric Power System", Wiley–IEEE Press, 2nd Edition, 2013.

Reference Books:

1. INIEWSKI , Smart Grid Infrastructure and Networking, McGraw-Hill Education India Pvt.Ltd (2012), 1 st Edition.
2. James Momoh, Smart Grid: Fundamentals of Design and Analysis, IEEE Computer Society Press (2012).
3. EkanayakeJ.,Jenkins N., Liyanage K., Wu, J., Yokoyama A., Smart Grid: Technology and applications, Wiley Publications.
4. Momoh J., Smart Grid: Fundamentals of design and analysis, John Wiley & Sons. Flick T., Morehouse J., Securing the smart grid: Next generation power grid security, paperback).

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21EE3233: Energy Management Systems and SCADA

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand SCADA and its architecture.	PO1 / PSO1	2
CO2	Understand the application of SCADA in various utilities.	PO5 / PSO1	2
CO3	Apply the knowledge in analyzing various real time applications on transmission side.	PO5 / PSO1	3
CO4	Apply the knowledge in analyzing various real time applications on distribution side.	PO5 / PSO1	3

Syllabus:

Introduction to SCADA: Data acquisition systems, Evolution of SCADA, Communication technologies, Monitoring and supervisory functions, SCADA applications in Utility Automation, Industries, SCADA System Components. SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system - single unified standard architecture -IEC 61850. SCADA Communication.

SCADA Applications: Utility applications, Transmission and Distribution sector -operations, monitoring, analysis and improvement. Industries - oil, gas and water.

Energy Management Systems (EMS): Introduction- Smart substations - Substation Automation - Feeder Automation, SCADA – Remote Terminal Unit – Intelligent Electronic Devices – Protocols, Phasor Measurement Unit – Wide area monitoring protection and control, Smart integration of energy resources – Renewable, intermittent power sources – Energy Storage.

Distribution Management System (DMS): Introduction – Volt / VAR control – Fault Detection, Isolation and Service Restoration, Network Reconfiguration, Outage management System, CIS & GIS, Load Management Systems, functions of load management systems: Load analysis and forecasting, remote automatic meter reading, electricity purchase management and electricity theft prevention.

Text Books:

1. Handschin, E. "Energy Management Systems", Springer Verlag, 1990.
2. Clarke, Gordon, Deon Reynders, and Edwin Wright. Practical modern SCADA protocols: DNP3, 60870.5 and related systems. Newnes, 2004.

Reference Books:

1. Turner, W. C, " Energy Management Handbook", 5 th Edition, 2004.
2. Wiebe, Michael, "A Guide to Utility Automation: AMR, SCADA, and IT Systems,"Pennwell Books, 1999.
3. Bailey, D., and E. Wright, "Practical SCADA for industry," illustrated ed. Great Britain: Newnes, 2003.

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21EE4131: Smart Grid Communication and Cybersecurity

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the communication technologies for smart grid	PO1/ PSO2	2
CO2	Analyze the information security of smart grid and measurement technologies	PO5/ PSO2	3
CO3	Understand the substation standards for communication	PO1/ PSO2	2
CO4	Analyze the hacking and cybersecurity aspects in smart grids	PO5 / PSO2	3

Syllabus:

Communication Technologies for the Smart Grid: Different types of Communication technologies for the smart grid. Standards for information exchange, DNP3. Fiber Optical Networks, WAN based on Fiber Optical Networks, IP based Real Time data Transmission

Information Security for the Smart Grid and Measurement Technology: Introduction – Encryption and Decryption Authentication, Digital signature, Message digest, cyber security standards. Communication and Measurement - Monitoring, Advanced metering infrastructure-GIS and Google Mapping Tools, Multi Agent Systems (MAS) Technology for Smart Grid Implementations.

Interoperability and Standards: Introduction-Benefits and Challenges Of Interoperability, Model For Smart Grid Network Interoperability, Approach to Smart Grid Interoperability Standards, IEC61850, GOOSE. **Hacking and Cyber-security:** Identifying a target-Vulnerability- Attack tools-Attack methods-Cyber security architecture, SGCG reference architecture - ISA-62443: zones and conduits and Smart Grids.

Text Books:

1. Janaka Ekanayake , Kithsiri Liyanage , Jianzhong Wu , Nick Jenkins, "Smart Grid: Technology and Applications" first Edition, John Wiley & sons Limited (2012).
2. James Momoh "Smart grid: Fundamental of Design and analysis" ,John Wiley & sons Limited IEEE Press (2012).

Reference Books:

1. Eric D. Knapp,Raj Samani "Applied Cyber Security and the Smart Grid", Elsevier Inc.
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press.
3. Jean Claude Sabonnadiere, NouredineHadjsaid, "Smart Grids", Wiley Blackwell.

21EE4132: INTERNET OF THINGS AND SMART GRID ANALYTICS

L-T-P-S: 2-0-2-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand network protocols and standards	PO1 / PSO1	2
CO2	Analyze IoT architecture and data analytics architecture	PO5/ PSO2	3
CO3	Understand various applications of IoT to Smart Grids	PO5/ PSO2	2
CO4	Analyze the Big Data Analytics	PO5/ PSO2	3

Syllabus:

Networking Protocols and Standards for Internet of Things: Introduction, IoT Data Link Protocols, Network Layer Routing Protocols, Network Layer Encapsulation Protocols, Session Layer Protocols, IoT Management Protocols, Security in IoT Protocols, IoT Challenges.

IoT Architecture: Introduction, Architectural Approaches, Business Architecture, Functional Architecture, Application Architecture, Data and Analytics Architecture, Technology Architecture, Security and Governance.

Applications of IOT to Smart Grid: Energy monitoring, energy harvesting, smart parking, smart medium access in mobile IOT.

Introduction to Big Data Analytics: Attributes of Big Data: Volume of data, velocity of data, variety of data; Overview of big data analytics, benefits of big data analytics, big data analytics for smart grids, big data analytics tools.

Smart Grid Data Management and Applications: Smart Meter Data Management: Smart metering architecture, challenges and opportunities, smart meter data management, future trends and issues; PHEVs: Internet of Vehicles: Convergence of PHEVs and internet of vehicles, electric vehicles management, future trends and issues; Smart Buildings: Concept of smart buildings, challenges and opportunities, different approaches for establishing smart buildings, future trends and issues.

Text Books:

1. Al-Turjman, Fadi. *Smart Grid in IoT-enabled Spaces: The Road to Intelligence in Power*. CRC Press, 2020.
2. Misra, Sudip, and Samaresh Bera. *Smart Grid Technology: A Cloud Computing and Data Management Approach*. Cambridge University Press, 2018.

Reference Books:

1. Geng, Hwaiyu, ed. *Internet of things and data analytics handbook*. John Wiley & Sons, 2017.

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21EE3241: POWER TRAIN DESIGN FOR ELECTRIC VEHICLE

L-T-P-S: 2-1-0-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the History, Economics, Environmental issues and power train of Electric Vehicles	-	2
CO2	Analyze the dynamics of EV	PO2/ PSO1	4
CO3	Select and size the power train for 2W	PO1/ PSO1	3
CO4	Select and size the power train for 4W	PO1/ PSO1	3

Syllabus:

HISTORY, ECONOMIC & ENVIRONMENTAL IMPACT OF ELECTRIC VEHICLE

History of EV, Case studies on Economic and Environment aspects of EV, EV markets – Supply and demand, Economical analysis with case study, Environmental impact analysis with case study. Impact of different transportation technologies on environment and energy supply.

Power train components: BEV, HEV, PHEV and FCEV including working of Fuel cell, **Super capacitor, energy management, Hybrid sources.**

INTRODUCTION TO EV DYNAMICS

Motion and dynamic equations of electric vehicles, General description of vehicle movement, Vehicle resistance, Dynamic equation, Tire Ground Adhesion and maximum tractive effort, different drive cycles for, Drive cycles for vehicle emission, fuel consumption and performance testing.

2W POWER TRAIN SIZING

Chassis, differential and transmission selection for different drive trains, Battery, converter and motor drive sizing for different 2W drive trains. Analysis on the effect of sizing of different components for different drive cycles

4W POWER TRAIN SIZING

Chassis, differential and transmission selection for different drive trains, Battery, converter and motor drive sizing for different 4W drive trains. Analysis on the effect of sizing of different components for different drive cycles

Text books:

1. "A History of Electric Vehicles" by Nigel Burton, Edition -1, Crowood Publisher.
2. "Electric Cars: The Ultimate Guide for Understanding the Electric Car And What You Need to Know" by Brad Durant

Reference books:

1. "Electric Vehicle Technology Explained" by James Larminie and John Lowry.

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BATTERY STATE ESTIMATION ALGORITHMS FOR ELECTRIC VEHICLE

L-T-P-S: 2-1-0-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Select suitable battery for electric vehicle	PO1	3
CO2	Analyze the key functions of Battery management systems	PO2	4
CO3	Analyze various mathematical models of battery	PO2	4
CO4	Evaluate Algorithms for SOC estimation of battery	PO3	5

Syllabus:

Battery specifications and L-ion chemistry

Battery specifications, cell-module-pack formation and specification calculation, working principle of Li-ion cell, materials used for various components of Li-ion cell, different li-ion chemistries and there specification comparison

Functions of battery-management systems

BMS architecture, BMS functionality: Sensing and High Voltage Control, Protection-isolation, overvoltage, overcurrent protection, Performance-Battery pack energy and power calculations using HPPC, Balancing- passive and active cell balancing, Interface, and Diagnostics

Battery Modelling

Simple OCV model, Rint model, Thevinins model, Hysteresis effect and ESC model of battery cell.Charge, discharge tests to determine battery cell parameters,

SOC estimation

Stoichiometry for SOC estimation, Look-table method and Coulomb counting methods and their limitation for accurate state estimation. Linear and nonlinear Kalman filter based estimation techniques

Text books:

1. Battery management systems: Battery Modeling , Gregory L.Plett, Artech house, 2015.
2. Battery management systems: Equivalent circuit methods , Gregory L.Plett, Artech house, 2015.

Reference books:

1. Hybrid Electric vehicles-Principles and Applications with practical perspectives, Chris Mi, M. AbdulMasrur and David Wenzhong Gao, Wiley Publications,*1* edition 2011
2. Electric and Hybrid Vehicles power sources, models, sustainability, infrastructure and the market, Edited by Gianfranco Pistoia, Elsevier 1 edition 2010.
3. Electric and Hybrid Vehicles Design Fundamentals, by Iqbal Hussain, CRC Press2nd edition, 2010.

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21EE3143: CHARGING STATION FOR ELECTRIC VEHICLE

L-T-P-S: 2-0-2-0 **Credits: 3** **Pre-requisite: 20EE2204**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Analyze Power electronic converters for electric vehicle charging applications	PO2 / PSO1	4
CO2	Develop control algorithms for various electric vehicle charging modes	PO5 / PSO1	3
CO3	Analyze control of Fast charging station	PO3	4
CO4	Demonstrate installation of charging station	PO6, PO7	2
CO5	Test power converters used for electric vehicle charging	PO4, PO5	4

Syllabus:

Charger Topologies

Charging time and charging speed, Defining power levels- Normal charging, Semi-fast charging, Overview of power levels ,DC conductive charging, AC conductive charging, Low power Charger, Automotive standard charger, High power topologies, Multi-port Charger.

Power Electronics for EV Battery Charging

Forward/ Flyback Converters, Half-Bridge DC–DC Converter, Full-Bridge DC–DC Converter, Power Factor Correction, Bidirectional Battery Chargers, Dual active bridge dc-dc converter, Solar charging station.

Charging Modes

Constant-current charging, Constant-voltage charging, Pulse Charging, Reflex charging, Float charge, Trickle Charge, Load management at charging station and peak load management

Charging Infrastructure

Charger - Existing National & International Charger Architecture Standards - SAE J1773, VDE-AR-E 2623-2-2, JEVS G105-1993 (CHAdeMO), CCS, Type-1 AC, Type-2 AC, Bharat DC-001, Bharat AC-001.

Cords and Cables, Earthing, Fault Protection, Testing, Charging Safety, Protection against electric shock, Digital Communication between EV and Charging Station.

Installation

Govt. of India guideline on Public Charging Stations, IEC Standards- 60068-2(1, 2, 14, 30), 61683, 60227, 60502, 60947 part I,II, III and 61215.

Site assessment, EVSE Typical Site Plans, Design Guidelines and Site Drawings, Planning Considerations, Station Configuration, Selection and erection of electrical equipment - Isolation, switching and control.

Text books:

1. Power Electronics by Daniel W.Hart.
2. Power Electronics for Renewable Energy Systems, Transportation and industrial Applications by Haitham Abu-Rub, Mariusz Malinwoski, Kamal Al-Haddad.

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21EE4141: AI & IT FOR ELECTRIC VEHICLE

L-T-P-S: 2-0-2-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Demonstrate IoT devices and tools	PO2	2
CO2	Operate the cloud system Environment	PO4	3
CO3	Utilize AI and ML Techniques	PO2	3
CO4	Utilize AI techniques for EV Applications	PO7	3
CO5		PO4, PO5	

Syllabus:

IoT Devices and Enabling Technologies: Sensor Devices- temperature, vibration, irradiance, wind speed, PIR, proximity, current, voltage Controllers, Actuators, Networking and Communication Protocols, Data analytics using AI and ML for – smart cities, smart grid, smart building, electrical vehicles Cloud Computing: Basics-Cloud systems, Cloud computing protocols, Role of Web services, Deployment Models- Public, Community, Hybrid, Private Clouds, Cloud Analytics over Thingspeak, Google Firebase, AWS-console, Functions. Database Services-Relational DBMS, RDS Services. AI and ML on Cloud: Data Pre-processing techniques in Machine Learning, Data-handling, importing libraries, Data pre-processing using python, Missing data, Categorical Data. Regression and Classification algorithms in ML. Cloud based Real- time Monitoring systems, M2M communications, Case Studies Applications: Electric Vehicle Battery state estimation, health monitoring, SOL determination, Power management, Charging optimization and Electric Drive applications, Online vehicle Assistance

Text books:

1. Artificial Intelligent Techniques for Electric and Hybrid Electric Vehicles, Chitra A., P. Sanjeevikumar, Jens Bo Holm-Nielsen and S. Himavathi

2. Internet of Things An Application Based approach Using Arduino Platform and Firebase by SOURAV KUMAR BHOI, Independently published (May 31, 2018)

3. Hybrid Electric Vehicles-Principles and Applications with practical perspectives, Chris Mi, M. Abdul Masrur and David Wenzhong Gao, Wiley Publications,1 edition 2011

4. AWS Certified Machine Learning Specialty: MLS-C01 Certification Guide By Somanath Nanda, Weslley Moura · 2021

Reference Books:

1. Electric and Hybrid Vehicles power sources, models, sustainability, infrastructure and the market, Edited by Gianfranco Pistoia, Elsevier 1 edition 2010.

2. Electric and Hybrid Vehicles Design Fundamentals, by Iqbal Hussain, CRC Press2nd edition, 2010. 7. Role of Single Board Computers (SBCs) in Rapid IoT Prototyping, By G. R. Kanagachidambaresan · 2021

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21EE4142: COMMUNICATION PROTOCOLS & TESTING OF ELECTRIC VEHICLE

L-T-P-S: 2-0-2-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Analyse the protocols used for Electric Vehicle communication	PO1, PO5	2
CO2	Apply the communication protocols for fault diagnostics of Electric Vehicle	PO1, PO3	3
CO3	Analyze the intricacies of integrating HV and LV components of vehicle	PO1, PO6	4
CO4	Understand the overview of system engineering/system validation	PO1, PO3	2
CO5	Test electric vehicle fault		

Syllabus:

Introduction to serial communication protocols: SPI I2C CAN, CAN standard, CAN message: Arbitration, message types, valid frame, error checking CANbus: Transceiver features, CAN physical layer, CAN connectors, Bit Timing, Error Handling, High Layer Protocols: IEC 61851, SAE J2601, Vehicle to Vehicle communication protocols Common Sensors modules used in EV: Air Bag, ABS, Window Mirror, Cruise Control, Transmission control, CAN Interface with Sensor Modules Power Distribution Box, Components like HVDC Relays connections, Insulation Monitoring Devices Fuses, BTMS, Driveline Cooling, Coolant tanks, Level Sensors, Vehicle Wiring, Terminals, Electrical Distribution Boards, Temperature Considerations for wiring, Cable selection, Instrument Panel, HVIL,24V converters, Junction boxes or Fuse Boxes, Fuses, derating, EMI and EMC. V cycle, reliability calculations, DFMEA/FMEA analysis, Design for manufacturing, servicing & data analytics, supply chain management

Text books:

1."A History of Electric Vehicles" by Nigel Burton, Edition -1, Crowood Publisher.

2."Electric Cars: The Ultimate Guide for Understanding the Electric Car And What You Need to Know" by Brad Durant

Reference Books:

1."Electric Vehicle Technology Explained" by James Larminie and John Lowry

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21EE40A1-RENEWABLE ENERGY RESOURCES

L-T-P-S:3-0-0-0 **Credits: 3** **Pre-requisites: NIL**

MAPPING OF CO/PO:

CO No	COs	PO / PSO	BTL
CO1	Understand the different solar thermal applications and solar photovoltaic cells	PO-4,PO-10/ PSO-1	2
CO2	Understand the operation of wind turbine ,different types of wind turbines and wave energy conversion	PO-4,PO-10/ PS0-1	2
CO3	Understand the energy conversion of Tidal, ocean thermal and various the geo thermal power plants	PO-4,PO-10/ PS0-1	2
CO4	Understand the operation of Bio energy conversion method and the different bio gas plants	PO-4,PO-10/ PS0-1	2

Syllabus

Extraterrestrial solar radiation, terrestrial solar radiation, solar thermal conversion,flat plate and concentrated solar thermal collectors, solar ponds, solar heating/cooling technique, solar distillation, photovoltaic energy conversion, solar cells – 4 models.

Planetary and local winds, vertical axis and horizontal axis wind mills, principles of wind power, maximum power, actual power, wind turbine operation, yaw control, pitch control and stall control mechanisms, derivation of power coefficient.

Ocean temperature differences, principles of OTEC plant operations, wave energy, devices for energy extraction, tides, simple single pool tidal system.

Origin and types, Bio fuels, classification, direct combustion for heat and electricity generator, anaerobic digestion for biogas, biogas digester, power generation.

Biomass energy conversion technologies, Biogas generation – classification of Biogas plants.

Micro hydro electric systems- different types of turbines.

Text books

1. Godfrey Boyle "Renewable Energy", Oxford Publications, Second edition.
2. G. D. Rai, "Non-Conventional Energy Sources", Khanna Publishers, First edition.

Reference books

1. Roger H.Charlier, Charles W. "Ocean Energy- Tide and Tidal Power"ISBN: Library of Congress Control Number: 2008929624_c Springer-VerlagBrerlin Heidelberg 2009.
2. John Twidell& Toney Weir: E&F.N. Spon, "Renewable Energy Sources", Taylor & Francis New York, 2nd edition.
3. John F.Walker&N.Jenkins, "Wind Energy Technology", John Willey and Sons Chichester, U.K – 1997

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21EE40B1-ENERGY ESTIMATION AND AUDIT

L-T-P-S:3-0-0-0 **Credits: 3** **Pre-requisites: NIL**

MAPPING OF CO/PO:

CO No:	CO	PO/PSO	BTL
CO1	Understand the present power scenario in India and need for energy estimation and Audit.	PO2,PO10/ PSO1	2
CO2	Understand the operation of Induction motors and various energy conservation opportunities	PO2,PO10/ PSO1	2
CO3	Understand the basics of transformers, cables and their energy conservation opportunities.	PO2,PO10/ PSO1	2
CO4	Understand Lighting systems, pumping systems and their energy conservation opportunities.	PO2,PO10/ PSO1	2

SYLLABUS

Basics of Electrical Systems: Electrical power scenario in India, Structure of Electrical System, Energy billing, Electrical load management, Maximum demand control, Case studies on Domestic, Commercial and Industrial applications. **General Aspects of Energy Auditing**: Introduction - Types of Energy Auditing - Benefits of Energy Audit - Requirements to conduct Energy Audit - Methodology for Energy Audit - Energy Audit Report – Energy Conservation Building Code.

Induction Motors: Operation of Induction Motor - Special Design feature for high efficiency motor - Torque - Speed Characteristics - Operating parameters of motor - Losses - Measurement of efficiency - Determination of energy saving - determination of Load - Assessment of economic feasibility - choice of energy efficient motor - Effect of variation of voltage on the performance of motor - effect of load variations on efficiency and power factor - unbalanced phase voltage - insulation system.

Transformers and Cables: Transformers Introduction - Transformer Losses - Fixed Losses - Load Losses. Evaluation of Transformer Losses - Case Studies - reduction in Transformer Losses.Energy conservation opportunities in transformers. Cables: Introduction- Selection of Cable - Construction - Insulation - inner sheath - armouring - outer sheath - specifications - Tests- Installation. Energy conservation aspects.**Lighting**: Lighting terminology, Aspects of Lighting System Designing, Various means for Energy Saving - use of natural day light - reduction in light fixture - high efficiency lamps and luminaries – Constructional details of incandescent lamp, Construction and operation of Fluorescent tube light, Lighting energy audit.

Pumping Systems: Pumps classification, Pumping System characteristics, Pump curves - pump operating point - Factors affecting pump performance, Assessment of pumps, Energy Conservation Opportunities in Pumping Systems.

Text books:

1. Electrical Wiring, Estimating and Costing Dr.S.L.Uppal. Khanna Publishers.
2. Electrical Design Estimating and Costing.K.B.Raina&S.K.Battacharya. New age international (p) limited. Publishers.

Reference Books:

1. Energy Auditing in Electrical Utilities Rajiv Shankar. Viva Books First 2010.
2. Energy Engineering and Management AmlanChakrabarthi PHI Learning Pvt Ltd Second Printing 2011.

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Annexure-III

Course structure and Syllabus Revision for 2021-22 M.Tech-PS & M.Tech PED programs

1. Course structure for 2021-2022 admitted M.Tech-PS program

Course Code	Course Name	Course Category	L	T	P	S	Cr	Pre- Requisite	Course/Revise d Course/ Retained	Changes Proposed by	Employability/ Entrepreneurship	Justification
21EE51021	Power System Dynamics & stability	PC	3	1	0	0	4	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for employability in core sector and further study
21EE5102	Advanced Power System Analysis	PC	3	1	2	0	5	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for employability in core sector and further study
21EE5103	Deregulated Operation of Power Systems	PC	3	1	0	0	4	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for employability in core sector and further study
21EE5114	Mocern Control Theory	PC	3	1	0	0	4	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for employability in core sector and further study
21EE5201	Real Time Control of Power System	PC	3	1	2	0	5	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for employability in core sector and further study
21EE5202	AI Techniques in Power Systems	PC	3	1	0	0	4	Nil	Revised		Employability	Covers the advanced topics which enable for employability in core sector and further study

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21EE5214	Smart Grids Technologies	PC	3	1	0	0	4	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for employability in core sector and further study
21EE5203	Digital Protection of Power Systems	PC	3	1	0	0	4	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for employability in core sector and further study
21EE51S1	Reactive Power Compensation & Management	PE	3	0	0	0	3	Nil	Revised		Employability	Covers the advanced topics which enable for employability in core sector and further study
21EE51S2	Distribution System Planning &	PE	3	0	0	0	3	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for employability in core sector and further study
21EE51S3	Power System Reliability		3	0	0	0	3	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for employability in core sector and further study
21EE52D1	Alternative Sources of Electrical Energy	PE	3	0	0	0	3	Nil	Retained	No Changes	Entrepreneurship	Covers the advanced topics which enable for employability in core sector and further study
21EE51B2	Digital Signal Processors and Applications	PE	3	0	0	0	3	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for employability in core sector and further study
21EE51B3	Optimization Techniques	PE	3	0	0	0	3	Nil	Retained	No Changes	Entrepreneurship	Covers the advanced topics which enable for employability in core sector and further study
21EE52C1	FACTS	PE	3	0	0	0	3	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for employability in core sector and further study

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21EE52C2	Energy Conservation & Audit	PE	3	0	0	0	3	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for employability in core sector and further study
21EE52C3	Adaptive Control Systems	PE	3	0	0	0	3	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for employability in core sector and further study
21EE51B1	Floating Solar and Off Shore Wind Technologies	PE	3	0	0	0	3	Nil	New	Industry Expert	Enterpreneurship	Covers the advanced topics which enable for employability in core sector and further study
21EE52D2	Power Quality	PE	3	0	0	0	3	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for employability in core sector and further study
21EE52D3	Energy Management Systems	PE	3	0	0	0	3	Nil	New	Academic Peer	Employability	Covers the advanced topics which enable for employability in core sector and further study
21IE5149	Seminar	Project	0	0	4	0	2	Nil	Retained	No Changes	Skill Development	Covers the advanced topics which enable for employability in core sector and further study
21IE5250	Term Paper	Project	0	0	4	0	2	Nil	Retained	No Changes	Skill Development	Covers the advanced topics which enable for employability in core sector and further study
21IE6050	Dissertation	Project	0	0	72	0	36	Nil	NEW		Skill Development	Covers the advanced topics which enable for employability in core sector and further study

Percentage of Courses focusing on Employability= 18/23=78.26%
Percentage of Courses focusing on Entrepreneurship= 2/23=9%
Percentage of Courses focusing on Skill Development = 3/23=13%

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2. Course wise Syllabus revision of approved structure as mentioned in point 2

SNO	Course Code	Course Name	Course Category	Existing Syllabus	New Syllabus	Topics Added/ Removed / Replaced	Change in Outcome	Justification for the Modification	Revision Percentage
1	21EE5202	AI Techniques in	PC	-	21EE5202 Syllabus	Revised	Yes		
2	21EE51S1	Reactive Power Compens	PE	-	21EE51S1 Syllabus	Revised	Yes		
3	21EE51B1	Floating Solar and Off Shore	PE	-	21EE51B1 Syllabus	New	Yes		
4	21EE52D3	Energy Management	PE	-	21EE52D3 Syllabus	New	Yes		
5	21IE6050	Dissertation	Project	-	21IE6050 Syllabus	NEW	Yes		

Percentage of Courses REVISED / NEW =5/23=21%

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21EE5101: POWER SYSTEM DYNAMICS & STABILITY

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No:	CO	PO/PSO	BTL
1	Analyze Synchronous Machine modeling	PO-1	4
2	Analyzingpower system stability	PO-2	4
3	Analyze Small signal stability	PSO-1	4
4	Analyze Excitation systems and Voltage Stability	PO-2	4

SYLLABUS:

SYNCHRONOUS MACHINE MODELING: Modeling of Synchronous Machine, Park's Transformation, Per Unit representation, Equivalent Circuits of Synchronous Machine, Steady State & Transient Analysis, Vector diagrams in steady state and transient state, power angles curves of a salient pole machine. **POWER SYSTEM STABILITY: Basic Concepts and Definitions,**Classifications,Review of Steady state and Transient state stability, Numerical method to determine transient stability, classical model of a multi machines systems. **SMALL SIGNAL STABILITY:** Small signal stability of a single machine infinite bus system, Effects of excitation systems, Power system stabilizers, Sub Synchronous Resonance. **EXCITATION SYSTEMS:** Typical Excitations configurations and Automatic Voltage regulators, Effect of excitation on (a) Power limits, (b) Transient stability, (c) Dynamic stability, **VOLTAGE STABILITY:** Basic Concepts Related to Voltage Stability – Voltage Collapse – Voltage Stability Analysis – Prevention of Voltage Collapse. Introduction to Frequency Stability.

TEXT BOOKS:

1. Power System Stability and Control – Prabha Kundur, TATA McGRAW – HILL, 2006.
2. Power System Stability by Kimbark, Vol- I, II & III – 1968, Dover Publication Inc, Newyork-1968.

REFERENCE BOOKS:

1. Power System Dynamics Stability & Control – K.R.Padiyar, 2nd Edition, B.S. Publication 2002.

Power System Control and Stability – P. M. Anderson & A.A. Fouad , 2nd Edition, Wiley IEEE press-2002.

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21EE5102: ADVANCED POWER SYSTEM ANALYSIS

L-T-P-S: 3-1-2-0 **Credits: 5** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No:	CO	PO/PSO	BTL
1	Understand the modeling aspects of power system components and form the network matrices	PO-1	2
2	ApplymathematicalmethodsforthesolutionofPowerflowproblem	PSO-2	3
3	Analyzeofpowersystemwithsymmetricalandunsymmetricalfaults	PO-3	4
4	Analyze the operation of power system under different contingencies	PSO-1	4
5	Analyze the Power system problems using computer programming.	PO-5	4

Network Modeling-Single phase and three phase modeling of alternators, transformers and transmission lines, Conditioning of Y Matrix- Incidence matrix method, Method of successive elimination, Triangular factorization. **Load flow analysis**- Newton Raphson method, Fast decoupled method, AC-DC load flow-Single and three phase methods-Sequential solution techniques and extension to multiple and multi-terminal DC systems, Load flow with FACTS devices. **Distribution load flow.Fault studies**- 3-ϕ analysis of balanced and unbalanced faults-fault calculations-Short circuit faults-open circuit faults. **System Contingency Analysis** – Z_{bus} Method in Contingency Analysis, Adding and Removing Multiple Lines, PiecewiseSolution of Interconnected Systems, Analysis of Single Contingencies, Analysis of MultipleContingencies, Contingency Analysis of DC Model, System Reduction for Contingency andFault Studies.

TEXT BOOKS:

1. D. P. Kothari, I. J. Nagrath,' Modern Power System Analysis', Tata McGraw Hill-Education, New Delhi, 2003.
2. Arrillaga, J and Arnold, C. P., 'Computer analysis and power systems' John Wiley and Sons, New York, 1997

REFERENCE BOOKS:

1. Grainger, J. J. and Stevenson, W. D. 'Power System Analysis' Tata McGraw Hill, New Delhi, 2003.
2. HadiSaadat, 'Power System Analysis', Tata McGraw Hill, New Delhi, 2002.
3. Pai, M. A., 'Computer Techniques in Power System Analysis', Tata McGraw Hill, New Delhi, 2006.
4. P. Venkatesh,B V Manikandan,S Charles Raja and A Srinivasa Rao, "Electric Power System Analysis, Security & Deregulation", PHI, 2012.

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21EE5103: DEREGULATED OPERATION OF POWER SYSTEMS

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No:	CO	PO/PSO	BTL
1	Understand the market operations in the electricity market under deregulated environment, Open Access Same-time Information System (OASIS) and Available Transfer Capability (ATC).	PO-1	2
2	Analyze the concepts of Electricity Pricing.	PO-5	4
3	Analyze the Power System Operation in Competitive Environment and Market Power.	PO-5	4
4	Analyze the concepts of Transmission Pricing and Congestion pricing.	PSO-1	4

SYLLABUS

Key Issues in Electric Utilities Introduction – Restructuring models – Independent System Operator (ISO) – Power Exchange - Market operations – Market Power – Standard cost – Transmission Pricing – Classification of congestion management methods, Calculation of ATC, Non-market methods, Market based methods, Nodal pricing– Management of Inter zonal/Intra zonal Congestion. Open Access Same-time Information System (OASIS)Structure of OASIS - Posting of Information – Transfer capability on OASIS. **Available Transfer Capability (ATC)** Transfer Capability Issues – ATC – TTC – TRM – CBM Calculations – Calculation of ATC based on power flow. **Electricity Pricing** Introduction – Rolled-in transmission pricing methods- Marginal transmission pricing paradigm, , Composite pricing paradigm, Merits and de-merits of different paradigms,-Electricity Price Volatility Electricity Price Indexes – Challenges to Electricity Pricing – Construction of Forward Price Curves – Short-time Price Forecasting. **Power System Operation in Competitive Environment** Introduction – Operational Planning Activities of ISO- The ISO in Pool Markets – The ISO in Bilateral MarketsOperationalPlanning Activities of a GENCO. **Market Power** :Introduction - Different types of market Power– **Exercising Market Power** - Examples,**Transmission Cost Allocation Methods** :Introduction - Postage Stamp Rate Method - Contract Path Method - MW-Mile Method – Unused Transmission Capacity Method - MVA-Mile method – Comparison of cost allocation methods.

TEXT BOOKS:

1. Loi Lei Lai, "Power System Restructuring and Deregulation", John Wiley & Sons Ltd., England, 2001.
2. Kankar Bhattacharya, "Operation of Restructured Power System", Math H.J. Boller and JaapE.DaalderKulwer Academic Publishers, 2001.

REFERENCE BOOKS:

1. Mohammad Shahidehpour and Muwaffaqalomoush, "Restructured Electrical Power Systems", Marcel Dekker, Inc., 2001.
2. P. Venkatesh,B V Manikandan,S Charles Raja and A SrinivasaRao, "Electric Power System Analysis, Security & Deregulation", PHI, 2012

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21EE5114: MODERN CONTROL THEORY

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the basics of Z-Transforms and Digital control systems DCS components	PO-5	2
CO2	Apply various stability analysis technics to digital control systems	PO-1	3
CO3	Apply various stability analysis technics to non-linear control systems	PSO-2	3
CO4	Apply the basics of optimal control problem to state feedback controller design	PO-1	3

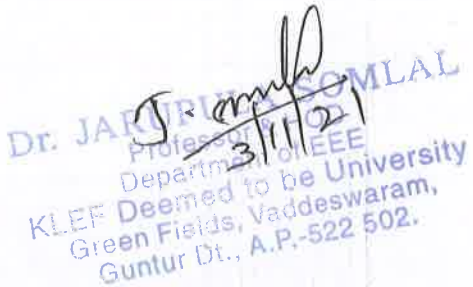
DIGITAL CONTROL SYSTEMS: Introduction to Discrete Time Systems, Necessary for Digital Control System, Spectrum Analysis of Sampling Process, Signal Reconstruction, Difference Equations, Z transforms, and the Inverse Z transform, Pulse Transfer Function, Time Response of Sampled Data Systems, Stability using Jury Criterion, Bilinear Transformation. **POLE PLACEMENT TECHNIQUES** Controller Design by State Feedback, Necessary and Sufficient Condition for Arbitrary Pole Placement-State Regulator Problem and State Regulator Design, Evaluation of State Feedback Gain Matrix K, Selection of Location of Desired Closed Loop Poles, State Observer Design, Full Order/Reduced Order Observer Design, Observer Based State Feedback Control, Separation Principle. **NONLINEAR CONTROL SYSTEM** Introduction, Properties of Nonlinear System, Behavior of Non-Linear System, Classification of Nonlinearities, Common Physical Nonlinearities: Saturation, Friction, Backlash, Dead -Zone, Relay, On-Off Nonlinearity, Nonlinear Spring, Limit cycle, Jump resonance. Phase -Plane Method, Singular points, Stability of Nonlinear System, Construction of Phase Trajectories, Describing Functions Method, Stability Analysis by Describing Function Method. Lyapunov's Stability Analysis, Lyapunov'sStability Criterion, Direct Method of Lyapunov and the Linear Systems, Method of Construction of Lyapunov Functions for Nonlinear Systems. **OPTIMAL CONTROL** formulation of the optimal control problem – method of calculus of variations – use of Hamiltonian method – pontryagin's minimum principle - optimal control problem – hamilton – jacobi approach – continuous time linear state regulator matrix riccati equation.

TEXT BOOKS:

1. Discrete Time Control Systems-K.Ogata Pearson Education-2005.
2. Digital Control systems and State Variables methods by M.Gopal-2006.

REFERENCE BOOKS:

1. Modern Control System Theory by M. Gopal – New Age International – 2005
2. M. Gopal : Modern Control Systems Theory, Wiley Eastern Limited, New Delhi, 1996.



21EE5201: REAL TIME CONTROL OF POWER SYSTEMS

L-T-P-S: 3-1-2-0 **Credits: 5** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Analyze the load frequency control of power system	PO-2	4
CO2	Analyze the economic operation of power system	PO-4	4
CO3	Understand Computer control of power systems	PSO-1	2
CO4	Analyze the security control and state estimation	PSO-1	4

System optimization-strategy for two generator systems-generalized strategies-effect of transmission losses-Sensitivity of the objective function-Formulation of optimal power flow-solution by Gradient method-Newton's method - Unit Commitment, Hydro-Thermal Coordination.**Load frequency control**-AGC multi area system, static and dynamic response, Load frequency control of 2-area system, **Security control**- Security analysis and monitoring, generator and line outages by linear sensitivity factors, **State estimation**- Power system state estimation, Weighted least square state estimation, state estimation of AC network, Treatment of bad data – network observability and pseudo measurements.

TEXT BOOKS:

1. Allen J. Wood and Bruce F. Wollenberg "Power Generation, Operation & Control" 2nd edition, John Wiley and Sons, 1996.
2. I.J. Nagarath& D. P. Kothari , "Modern power system analysis" 3rd Edition, TMH, New Delhi, 2003.

REFERENCE BOOKS:

1. I. Elgard , "Electric Energy Systems Theory – An Introduction" TMH, 1983.
2. Abhijit Chakrabarti&SunitaHalder" Power System Analysis operation and Control " 1st edition, PHI, 2006.
3. Mahalanabis A.K., Kothari D.P. and Ahson S.I., "Computer aided power system analysis and control", 4th Edition, 2011, TMH.
4. J.J.Grainger, W.D.Stevenson JR, Power system analysis, Tata McGraw Hill N.D. 2007.
5. A. Handschin and E. Petroiaenu," Energy Management Systems, Operations and Control of Electric Energy Transmission Systems", Springer-Verlag, Berlin, Heidelberg, 1991.

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21EE5202: AI TECHNIQUES IN POWER SYSTEMS

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No:	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the neural network, different architectures with different learning types and various algorithms for ANN to solve the load forecasting problems in Power systems.	PO-1	2
CO2	Apply the fuzzy logic concept, fuzzy sets, with suitable membership function with proper de-fuzzification method to control the load frequency in power systems	PSO-2	3
CO3	Understand the Genetic algorithm, encoding, Genetic operators, Reproduction operators, mutation operators, fitness functions, Genetic modeling	PO-1	2
CO4	Apply the different cross over methods and their elitism, convergence of algorithm and able to develop and analyze the algorithm to economic dispatch problem.	PSO-2	3

Artificial Neural Networks: Introduction Models of Neuron Network – Architectures –Hebbian learning –Supervised learning – Unsupervised learning – Reinforcement learning. **ANN Paradigms:** Multi – layer perceptron using Back propagation Algorithm (BPA) –Radial Basis Function Network -Hopfield Network – Application to Load forecasting. **Fuzzy Logic:** Introduction – Fuzzy versus crisp – Fuzzy sets – Membership function – Basic Fuzzy set operations –Fuzzy Inference – Fuzzy Rule based system–Defuzzification methods – Application to Load Frequency Control. **Genetic Algorithms:** Introduction–Encoding – Fitness Function–Reproduction operators–Genetic Modeling – Genetic operators–Cross over – Single site cross over – Two point cross over – Multi point cross over – Uniform cross over – Mutation operator – Elitism - Generational cycle – convergence of Genetic Algorithm – Application to economic dispatch.

Text Books:

1. S.Rajasekaran and G.A.V.Pai Neural Networks, Fuzzy Logic & Genetic Algorithms, PHI, New Delhi, 2003.
2. Rober J. Schalkoff, Artificial Neural Networks, Tata McGraw Hill Edition, 2011

Reference Books:

1. James A freeman, David M Skapura, ' Neural Networks', Addison – Wesley, an imprint of Pearson Education, II Edition , 2000
2. S N Sivanandam, S sumathi, S. N deepa, ' Introduction to Neural Networks using Matlab 6.0, Tata Mc Graw Hill Publishing Company Private Limited, 2006
3. K Sundareswaran, 'Fuzzy Logic Systems', Jaico Publishing House, 2005

21EE5203: DIGITAL PROTECTION OF POWER SYSTEMS

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the operation of protective equipment and adaptive protection	PO-3	2
CO2	Apply various transforms for digital protection of power system	PO-3	3
CO3	Analyze the microprocessor based relays for the protection of power system equipment	PO-4	4
CO4	Analyze travelling wave, AI and FPGA based relays for the protection of power system equipment	PO-4	4

Protection of Power System Equipment - summation transformer, phase-sequence current segregating network.Load shedding and frequency relays; Out of step relaying; Re-closing and synchronizing - adaptive protection – integrated protection and control.

Digital Protection: Developments in computer relaying – mathematical basis for protective relaying algorithms, Fourier Transforms – Discrete Fourier transforms –Walsh - Hadamard, Haar - wavelet transforms, digital relaying algorithms,.

Microprocessor based protection relays – Working principles of μP based over current, directional, distance, current differential relays and frequency relays - microprocessor implementation of digital distance relaying algorithms.

Modern trends in protection - New developments in relaying principles –travelling wave propagation – types of travelling wave relays- AI based numerical protection – FPGA based relays.**Introduction to micro grid protection.**

TEXT BOOKS:

1. Badri Ram & DN Viswakarma, "Power System Protection & Switch Gear", Tata McGraw Hill Publishing Company Limited, New Delhi (1995).

REFERENCE BOOKS:

1. Power System Protection – Static relays T.S.MadhavaRao, TMH, 2010.
2. Digital Protection for Power Systems A.T.Johns and S.K.Salman, 1995.
3. Computer Relaying for power Systems A.G.Phake, James S.Thorp, John–Wiley and sons
4. Protective relaying principles and applications J.Lewis Blackburn, Marcel & Dekker

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21EE5214: SMART GRID TECHNOLOGIES

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the basic concepts of smart grid, terminology, challenges and initiatives.	PO-1	2
CO2	Understand various smart operations of power system structure, components, and monitoring techniques.	PO-4	2
CO3	Apply smart metering and advanced metering infrastructure with monitoring, protection and measuring units.	PSO-2	3
CO4	Apply various communication protocols and cyber-security importance in smart grid.	PO-4	2

INTRODUCTION TO SMART GRID - Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers,functions, opportunities, challenges and benefits, Difference between conventional & SmartGrid, National and International Initiatives in Smart Grid.**SMART GRID TECHNOLOGIES** Technology Drivers, Smart energy resources, Smart substations, Substation Automation,Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring,Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation - service restoration, Outage management, High-Efficiency Distribution Transformers,Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).**SMART METERS AND ADVANCED METERING INFRASTRUCTURE** - Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits,AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor MeasurementUnit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.High Performance Computing for Smart Grid Applications**COMMUNICATION SYSTEMS**-Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUDcomputing to make Smart Grids smarter, Cyber Security for Smart Grid.

TEXT BOOKS

1. Stuart Borlase "Smart Grid: Infrastructure, Technology and Solutions", CRC Press 2017.
2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley 2012.

REFERENCES BOOKS

1. Control and Optimization Methods for Electric Smart Grids, AranyaChakraborthy, Marija D Ilic Editor, Springer Publications.
2. Smart Grid Fundamentals of Design and Analysis, James Momoh, Wiley IEEE Press, Ed 2012.

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21EE51S1: REACTIVE POWER COMPENSATION AND MANAGEMENT

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO	Blooms Taxonomy Level (BTL)
CO1	Understand the importance of load compensation in symmetrical as well as un symmetrical loads	PO-1	2
CO2	Understand various compensation methods in transmission lines	PO-2	2
CO3	Apply model for reactive power coordination	PO-2	3
CO4	Understand demand side reactive power management & user side reactive power management	PSO-1	2

LOAD COMPENSATION: Objectives and specifications – reactive power characteristics – inductive and capacitive approximate biasing – Load compensator as a voltage regulator – phase balancing and power factor correction of unsymmetrical loads- example.: Steady – state reactive power compensation in transmission system: Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation – examples.

TRANSIENT STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEMS: Characteristic time periods – passive shunt compensation – static compensations- series capacitor compensation –compensation using synchronous condensers –: Reactive power coordination: Objective – Mathematical modeling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady –state variations – effects of under voltages – frequency – Harmonics, radio frequency and electromagnetic interferences. **DEMAND SIDE MANAGEMENT:** Load patterns – basic methods load shaping – power tariffs- KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels: Distribution side Reactive power Management: System losses –loss reduction methods – examples – Reactive power planning – objectives – Economics Planning capacitor placement – retrofitting of capacitor banks .

USER SIDE REACTIVE POWER MANAGEMENT: KVAR requirements for domestic appliances – Purpose of using capacitors – selection of capacitors – deciding factors – types of available capacitor, characteristics and Limitations.

REACTIVE POWER MANAGEMENT IN ELECTRIC TRACTION SYSTEMS AND ARC FURNACES: Typical layout of traction systems – reactive power control requirements – distribution transformers- Electric arc furnaces – basic operations-furnaces transformer –filter requirements – remedial measures –power factor of an arc furnace

TEXT BOOKS:

1. T.J.E.Miller, "Reactive power control in Electric power systems", John Wiley and sons, 1982.
2. D. M. Tagare, "Reactive power Management", Tata McGraw Hill, 2004.

REFERENCE BOOKS:

1. Hong Chen, "Practices of reactive power management and compensation", PJM Interconnection, Norristown, PA;
2. T E Miller, "Reactive Power Control in Power Systems", John Wiley, 1982.

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21EE51S2: DISTRIBUTION SYSTEM PLANNING & AUTOMATION

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome(CO)	PO	Blooms Taxonomy Level (BTL)
CO1	Understand the power and its quality and system planning	PO-2	2
CO2	Analyze the design and operation of distribution feeders and loading of transformers.	PO-2	4
CO3	Understand the consumer services in distribution system.	PSO-1	2
CO4	Analyze the capacitor importance in distribution system and the SCADA with required components and its function.	PSO-1	4

Introduction: GeneralConcepts,Distribution of Power,Quality of supply, System Study, Benchmarking, Electricity Reforms, Future of Distribution Systems.**System Planning:** Planning Process, Planning Criteria and Standards, System Development, Dispersed Generation, Distribution System Economics and Finance, Mapping, Enterprise Resource Planning, Modelling, System Calculations, Introductory Methods, Netwrok Elements, Load Flow, Automated Planning, Fault Studies, Effect of Abnormal Loads, Line Circuits, Urban Distribution, Outsourcing.**Design and Operation:**Engineering Design, Operation Criteria and Standards, Sub Transmission, Sub Station and Feeder, Low Voltage three phase or single phase, Practices, Location of Sectionalizer, Voltage Control, Harmonics, Load Variations,Impact Loading of Transformers, Ferro resonance, System Losses, Energy Management, Model Distribution System.**Consumer Services:** Supply Industry, Natural Monopoly, Regulations, Other Legal Provisions, Distribution Code, Consumer Care, Standards, Consumer Code Requirements, Consumer Factors, Least Cost of Supply, Revenue and Return, Load Management, Energy Audit, Theft of Electricity, Metering of Energy, Periodical Testing of Meters, Consumer Load Monitoring.**Power Capacitors:** Reactive Power,Series and Shunt Capacitors, System Harmonics, HT Shunt Capacitors Installation Requirement, Size of Capacitators for power Factor Improvement, LT Capacitors, Construction Features, Failures.**Distribution Automation:**Distribution Automation(DA), Project Planning, Definition, Communications, Sensors, Supervisory Control and Data Acquisition(SCADA), Consumer Information Service (CIS), Geographical Informational Systems (GIS), Automatic Meter Reading (AMR), Automation Systems.

Text Books:

1. Electrical Power Distribution Engineering by TuranGonen, McGraw Hill, 1986.

Reference Books:

1. Electrical Power Distribution by A. S. Pabla, TMH, 5th Ed., 2004.
2. Electrical Power Distribution by V Kamaraju, TMH,2009

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21EE51S3: FLOATING SOLAR & OFF- SHORE WIND TECHNOLOGIES

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO. No	Course Outcome	PO	BTL
1	understand the selection of floating solar power plant	PO-3	2
2	understand different layouts and selection of converters	PO-4	2
3	understand the operation of off shore wind power plants	PO-4	2
4	Analyze the operation of floating solar and off shore power system	PO-3	4

Concept of Floating Solar PV System – **Selection of Floating Solar PV Plant**: Site Survey of Floating Solar PV Plant, Dam Dimension calculations, Environment factor assessment, Power evacuation level, pontoon angle, Magnetic North & True North with variation of azimuth angle, Temperature factor - **Selection of floating pontoon:** Types of Pontoon, Specification of main Pontoons, Selection criteria for PV module pontoons, etc,. – **Preparation of Floating Solar PV Plant**: Overall plant layout, DC blocking layout, Earthing Layout for Floating solar Power Plant, Connection of Leap frog method for string connection – PV Modules & Sizing – Inverter Selection & Sizing – HT Switch & Sizing.

Overview of offshore wind technology - Energy Conversion Systems for Offshore Wind Turbines - Modelling and Analysis of Drivetrains in Offshore Wind Turbines - Fixed and Floating Offshore Wind Turbine Support Structures – **Offshore Wind Turbine Controls** - Operation and Maintenance Modelling - Supervisory Wind Farm Control - Offshore Transmission Technology - Grid Integration and Control for Power System Operation Support.

Text Books:

1. Marco Rosa-Clot Giuseppe Marco Tina, "Submerged and Floating Photovoltaic Systems", Springer Publishers, ISBN: 9780128121498
2. Olimpo Anaya-Lara, John Olav Tande, KjetilUhlen, Karl Merz, "Offshore Wind Energy Technology", Wiley Publishers, ISBN: 978-1-119-09780-8

21EE51E1: POWER SYSTEM RELIABILITY

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

Co. No:	Course Outcomes	PO/PSO	BTL
CO 1	Understand the system reliability concepts	PO-8	2
CO 2	Apply the frequency and duration techniques for component repairable system.	PO-9	3
CO 3	Apply the network reliability concepts togeneration system reliability analysis.	PO-8	3
CO 4	Apply the network reliability concepts to transmission and distribution system reliability analysis.	PSO-2	3

Network Modelling and Reliability Analysis: Reliability concepts – exponential distributions – meantime to failure – series and parallel system – MARKOV process – recursive technique - Bath tub curve - reliability measures MTTF, MTTR, MTBF.**Frequency & Duration Techniques:**Frequency and duration concept – Evaluation of frequency of encountering state, mean cycle time, for one , two component repairable models – evaluation of cumulative probability and cumulative frequency of encountering of merged states. **Generation System Reliability Analysis:** Reliability model of a generation system– recursive relation for unit addition and removal – load modeling - Merging of generation load model – evaluation of transition rates for merged state model – cumulative Probability, cumulative frequency of failure evaluation – LOLP, LOLE. **Transmission System Reliability Analysis:** System and load point reliability indices – Weather effects on transmission lines – Weighted average rate and Markov model.: **Distribution System Reliability Analysis:**Basic Techniques – Radial networks – Evaluation of Basic reliability indices, performance indices - Load point and system reliability indices – Customer oriented, loss and energy oriented indices – Examples. Parallel Configuration: Basic techniques – Inclusion of bus bar failures, scheduled maintenance – Temporary and transient failures – Weather effects –Evaluation of various indices – Examples.

Text Books:

1. R. Billinton, R.N.Allan, "Reliability Evaluation of Power systems" second edition, Springer.
2. Charles E. Ebeling, "An Introduction to Reliability and Maintainability Engineering", TATA Mc Graw- Hill – Edition.

Reference Books:

1. R. Billinton, R.N.Allan, "Reliability Evaluation of Engineering System", Plenum Press, New York.
2. Eodrenyi, J., "Reliability modelling in Electric Power System", John Wiley, 1980

21EE51B2: DIGITAL SIGNAL PROCESSORS AND APPLICATIONS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand components of digital signal processing	PO-2	2
CO2	Understand Architecture of TMS320C5X, TMS320C6X and ADSP-21XXprocessors	PSO-1	2
CO3	Understand programming of functional units of TMS320C5X, TMS320C6X and ADSP-21XX	PO-2	2
CO4	Apply Signal conditioning and PWM applications with TMS320C5X, TMS320C6X and ADSP-21XX processors	PSO-2	3

FUNDAMENTALS OF DIGITAL SIGNAL PROCESSING: Review of DSP fundamentals. Issues involved in DSP processor design - speed, cost, accuracy, pipelining, parallelism, quantization error, etc. Key DSP hardware elements - Multiplier, ALU, Shifter, Address Generator, etc.**TMS320C5X PROCESSOR 9 Architecture**: Assembly language syntax - Addressing modes – Assembly language Instructions - Pipeline structure, Operation – Block Diagram of DSP starter kit – Application Programs for processing real time signals.**TMS320C6X PROCESSOR 9 Architecture:** of the C6x Processor - Instruction Set - DSP Development System: Introduction– DSP Starter Kit Support Tools- Code Composer Studio - Support Files - Programming Examples to Test the DSK Tools – Application Programs for processing real time signals. **ADSP PROCESSORS 9 Architecture of ADSP-21XX:** and ADSP-210XX series of DSP processors- Addressing modes and assembly language instructions –**Software development tools:** assembler, linker and simulator. Applications using DSP Processor - spectral analysis, FIR/IIR filter, linear-predictive coding, etc.

TEXT BOOKS:1. Avtar Singh and S. Srinivasan, Digital Signal Processing – Implementations using DSP Microprocessors with Examples from TMS320C54xx, cengage Learning India PrivateLimited, Delhi 2012

2. B.Venkataramani and M.Bhaskar, "Digital Signal Processors – Architecture", TATA McGraw-Hill Education, 2002.

REFERENCES:1. Programming and Applications" – Tata McGraw – Hill Publishing Company Limited. NewDelhi, 2003.

2. RulphChassaing, Digital Signal Processing and Applications with the C6713 and C6416DSK, A JOHN WILEY & SONS, INC., PUBLICATION, 2005 5. User guides Texas Instrumentation, Analog Devices, Motorola.

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21EE51B3: OPTIMIZATION TECHNIQUES

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No:	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand classical optimization techniques, describe clearly the problems with and without constraints, identify its parts and analyze the individual functions, Feasibility study for solving an optimization problem.	PO-6	2
CO2	Apply mathematical translation of the verbal formulation of an optimization problem and design algorithms of linear programming problems, the repetitive use of which will lead reliably to finding an approximate solution.	PSO-2	3
CO3	Analyze and measure the performance of an algorithm of different methods to solve non-linear programming problems, study and solve optimization problems.	P-11	4
CO4	Analyze optimization techniques using algorithms. Investigate study, develop, organize and promote innovative solutions for various applications.	PO-12	4

Classical Optimization Techniques: Single variable optimization, multi-variable optimization with no constraints, with equality and inequality constraints, Karush- Kuhn- Tucker constraints.

Linear Programming (LP): Geometry of LP problem, graphical solution, simplex algorithm, two-phases of simplex algorithm, duality, dual simplex method, quadratic programming.

Non-Linear Programming: One-dimensional optimization – Fibonacci method, golden section method, quadratic and cubic interpolation methods, Newton's method.Unconstrained optimization - Steepest descent method, conjugate gradient method, Davidon-Fletcher-Powell method.Constrained Optimization - Augmented Legrangian multiplier method, Branch and bound method

Non-traditional Optimization Methods and Applications: Genetic algorithms (G A), G A Operators, G A for constrained optimization.Particle swarm optimization (PSO).

Text Books:

1. S.S. Rao, 'Engineering Optimization : Theory andPractice.III Edition, New Age International (p) Limited Publications

2. Kalyanmoy Deb, 'Optimization for Engineering Design', PHI Learning Private Limited.

Reference Books:

1. PurnachandraBiswal, ' Optimization in Engineering', Scitech Publications (India) PVT Ltd.

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21EE52C1: FACTS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

Co.No:	Course Outcomes	PO/PSO	BTL
CO 1	Understand theimportance of FACTS devices and their applications to the Power Systems.	PO-8	2
CO 2	Analyzethe static shunt compensation and operation of devices under this category.	PO-9	4
CO 3	Analyze thestatic series compensation and operation of devices under this category.	PO-8	4
CO 4	Analyze the operation and applications of devices like UPFC and IPFC.	PO-9	4

FACTS CONCEPT AND GENERAL SYSTEM CONSIDERATIONS: Transmission interconnections, Power Flow in AC system, Dynamic stability Considerations and the importance of the controllable parameters, Introduction to Facts devices, Basic types of FACTS Controllers, benefits from FACTS controllers.**STATIC SHUNT COMPENSATION:** Objectives of shunt compensation, Methods of controllable VAR generation, variable impedance type static VAR generators (SVC): TCR, TSR, TSC, FC-TCR, TSC-TCR, switching converter type VAR generators: STATCOM, Comparison between SVC and STATCOM, STATCOM for transient and dynamic stability enhancement.**STATIC SERIES COMPENSATION: Objectives** of series compensation, variable impedance type static series controllers: GCSC, TSSC, TCSC, switching converter type controller: SSSC, Operation and Control External system Control for series Compensator SSR and its damping – Static Voltage and Phase angle Regulators - TCVR and TCPAR – Operation and Control.**UPFC AND IPFC:**The unified power flow Controller – Operation –Comparison with other FACTS devices – control of P and Q – dynamic performance – special Purpose FACTS controllers – Interline Power flow Controller – Operation and Control- Application and HVDC controlled link.

TEXT BOOKS:

1. FACTS: Modelling and Simulation in Power Networks, By Enrique Acha, Claudio R. Fuerte-Esquivel, Hugo Ambriz-Pérez, César Angeles-Camacho WILEY
2. K.R.Padiyar "FACTS Controller in power Transmission and Distribution" New Age Int Publisher,2007
3. Flexible AC Transmission Systems: Modelling and Control, By Xiao-Ping Zhang, Christian Rehtanz, Bikash Pal

REFERENCE BOOKS:

1. N.G Hingorani&L.Gyugyi " Understanding FACTS: Concepts and Technology of Flexible AC Transmission System" , IEEE Press,2000
2. Ned Mohan et.al "Power Electronics" John wiley& Sons,2 nd edition ,2002
3. T.J.E Miller, "Reactive power control in electric Systems" John willey& sons,1982.

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21EE52C2: ENERGY CONSERVATION & AUDIT

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the concept of Energy Audit and Energy Management	PO-2	2
CO2	Analyze the various characteristics of energy efficient motors	PO-3	4
CO3	Analyze the different energy instruments and importance of power factor improvement	PO-3	4
CO4	Analyze the economic aspects of electrical energy	PO-2	4

Syllabus:

BASIC PRINCIPLES OF ENERGY AUDIT: Energy audit- definitions, concept, types of audit, energy index, cost index, pie-charts, Sankey diagrams, load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit. **ENERGY MANAGEMENT:**Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting - Energy manger, Qualities and functions, language, Questionnaire - check list for top management. Demand side management. **ENERGY EFFICIENT MOTORS:** Energy efficient motors, factors affecting efficiency, loss distribution, constructional details, characteristics - variable speed, variable duty cycle systems, RMS hp- voltage van at ion-voltage unbalance- over motoring- motor energy audit. **POWER FACTOR IMPROVEMENT, LIGHTING AND ENERGY INSTRUMENTS:** Power factor - methods of improvement, location of capacitors, PF with non linear loads, effect of harmonics on PF , PF motor controllers - Good lighting system design and practice, lighting control, lighting energy audit - Energy Instruments- watt meter, data loggers, thermocouples, pyrometers, lux meters, tongue testers, application of PLC's. **ECONOMIC ASPECTS AND ANALYSIS:** Economics Analysis - Depreciation Methods, time value of money, rate of return, present worth method, replacement analysis, life cycle costing analysis - Energy efficient measures- calculation of simple payback method, net present worth method - Power factor correction, lighting - Applications of life cycle costing analysis, return on investment.

TEXT BOOKS:

1. W.C.Turner, "Energy management hand book", John wiley and sons Energy management and good lighting practice: fuel efficiency- book let 12-EEO
2. W.K. Murphy, G- MckayButier worth, "Energy management", Heine mann publications, 2007.

REFERENCE BOOKS:

1. Paulo Callaghan, "Energy management", Mc-graw Hill Book company, 1st edition, 1998
2. Giovanni and Petrecca, "Industrial Energy Management: Principles and Applications", The Kluwer international series-207 (1999)

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21EE52C3: ADAPTIVE CONTROL SYSTEMS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the elements of probability and Stochastic processes	PO-2	2
CO2	Understand parametric and non-parametric system models	PSO-1	2
CO3	Understand adaptive control techniques to linear systems	PO-2	2
CO4	Apply adaptive control process and asses stability of linear systems	PSO-2	3

Elements of probability theory: definition of probability and random variable, probability functions, expected value, mean and covariance, independence and correlation, Gaussian distribution and its properties. **Stochastic processes and system models:** Elements of the theory of stochastic processes, mean value function and covariance kernel, independent and correlated stochastic processes, stationery and non sequence model, Gaussian white process.**Non parametric methods & parametric methods:** Nonparametric methods: Transient analysis-frequency analysis-Correlation analysis-Spectral analysis.Liner Regression: The Lease square estimate-best liner unbiased estimation under linear constraints-Prediction error methods: Description of Prediction error methods-Optimal Prediction – relationships between Prediction error methods and other identification methods theoretical analysis. **Adaptive control schemes**Introduction – users- Definitions-auto tuning-types of adaptive control-gain scheduling controller-model reference adaptive control schemes – self tuning controller. MRAC and STC: Approaches – The Gradient approach – Lyapunov functions – Passivity theory – pole placement method Minimum variance control – Predictive control. **Adaptive control and application:** Stability – Convergence – Robustness – Application of adaptive control, direct model reference adaptive control. Introduction: Basic approaches to adaptive control. Applications of adaptive control. Identification: Error formulations linear in the parameters. Direct adaptive control: Linear error equations with dynamics. Gradient and pseudo-gradient algorithms. Strictly positive real transfer functions. Kalman-Yacubovitch-Popov lemma.Passivity theory.

TEXT BOOKS:

1. Dan Simon, "Optimal State Estimation", Wiley Intersience, 2006.
2. S. Sastry and M. Bodson, Adaptive Control: Stability, Convergence, and Robustness, Prentice-Hall, 1989.

REFERENCE BOOKS:

1. K.J. Astrom and B. Wittenmark, Adaptive Control, Addison-Wesley, 2nd edition, 1995.
2. I.D. Landau, R. Lozano, and M. M'Saad, Adaptive Control, Springer Verlag, London, 1998.
3. Meditch, "Stochastic Optimal Linear Estimation and Control" Mc-Graw Hill Company, 1969.
4. K.S. Narendra and A.M. Annaswamy, Stable Adaptive Systems, Prentice-Hall, 1989.

21EE52D1: ALTERNATIVE SOURCES OF ELECTRICAL ENERGY

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the concept of Renewable energy resources, Distribution Generation	PO-2	2
CO2	Analyze the working of Photovoltaic Power Plants	PO-3	4
CO3	Analyze the working of wind power plant and fule cells	PO-3	4
CO4	Analyze the importance of energy storage systems in Distributed Generation	PO-2	4

Syllabus: Introduction: Renewable Sources of Energy – Grid–Supplied Electricity – Distributed Generation – Renewable Energy Economics – Calculation of Electricity Generation Costs –Demand–Side Management Options – Supply–Side Management Options – Modern Electronic Controls of Power Systems. **Photovoltaic Power Plants:** Solar Energy – Generation of Electricity by Photovoltaic Effect –Dependence of a PV Cell Characteristic on Temperature – Solar Cell Output Characteristics – Equivalent Models and Parameters for Photovoltaic Panels –Photovoltaic Systems – Applications of Photovoltaic Solar Energy – Economical Analysis of Solar Energy. **Wind Power Plants**: Appropriate Location –Evaluation of Wind Intensity –Topography –Purpose of the Energy Generated –General Classification of Wind Turbines –Rotor Turbines –Multiple–Blade Turbines –Drag Turbines –Lifting Turbines –Generators and Speed Control Used in Wind Power Energy –Analysis of Small Generating Systems. **Fuel Cells:** The Fuel Cell –Low – and High–Temperature Fuel Cells –Commercial and Manufacturing Issues –Constructional Features of Proton Exchange–Membrane Fuel Cells –Reformers – Electrolyzer Systems and Related Precautions –Advantages and Disadvantages of Fuel Cells – Fuel Cell Equivalent Circuit –Practical Determination of the Equivalent Model Parameters – Aspects of Hydrogen as Fuel.**Storage Systems:** Energy Storage Parameters – Lead–Acid Batteries – Ultra capacitors –Flywheels – Superconducting Magnetic Storage System – Pumped Hydroelectric Energy Storage – Compressed Air Energy Storage –Storage Heat –Energy Storage as an Economic Resource

Text Books:

1. Felix A. Farret, M. Godoy Simo`es, Integration of Alternative Sources of Energy, John Wiley & Sons, 2006.
2. Remus Teodorescu, Marco Liserre, Pedro Rodríguez, Grid Converters for Photovoltaic and Wind Power Systems, John Wiley & Sons, 2011.

Reference Books:

1. Gilbert M. Masters, Renewable and Efficient Electric Power Systems, John Wiley & Sons, 2004

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21EE52D2: POWER QUALITY

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand basic power quality issues	PO-1	2
CO2	Understand conventional loop control for voltage and current balance	PSO-1	2
CO3	Apply DSTATCOM for power quality restoration	PO-2	3
CO4	Apply combined compensation techniques for power quality restoration and fault ride through.	PSO-2	3

INTRODUCTION- Characterization of Electric Power Quality: Transients, short duration and longduration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations,Power frequency variation, Power acceptability curves – power quality problems: poor loadpower factor, Non linear and unbalanced loads, DC offset in loads, Notching in load voltage,

Disturbance in supply voltage – Power quality standards. Low Voltage Ride Through, High Voltage Ride Through.

CONVENTIONAL LOAD COMPENSATION METHODS -Principle of Load compensation and Voltage regulation – Classical load balancing problem: Open loop balancing – Closed loop balancing, Current balancing – Harmonic reduction andvoltage sag reduction – Analysis of unbalance – instantaneous real and reactive powers –Extraction of fundamental sequence component.

LOAD COMPENSATION USING DSTATCOM - Compensating single phase loads – Ideal three phase shunt compensator structure –Generating reference currents using instantaneous PQ theory – Instantaneous symmetricalcomponents theory – Generating reference currents when the source is unbalanced –Realization and control of DSTATCOM – DSTATCOM in Voltage control mode.SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM-Rectifier supported Dynamic Voltage Restorer – DC Capacitor supported DVR – DVRStructure – voltage Restoration – Series Active Filter – Unified Power Quality Conditioner- Wind power interconnection requirement - Fault ride through techniques.

TEXT BOOKS:

1. ArindamGhosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002
2. R.C. Duggan, Mark.F.McGranaghan,SuryaSantoas and H.WayneBeaty, "Electrical Power System Quality", McGraw-Hill, 2004.
3. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publication, 1994.
4. Math H J Bollen, "Understanding Power Quality Problems: voltage sags and Interruptions", iley-IEEE Press, 2000. Indian Reprint – 2013

REFERENCE BOOKS:

1 Jos Arrillaga and Neville R. Watson ," Power system harmonics",Wiley,2003.

2. Derek A. Paice , "Power Electronics Converter Harmonics :Multipulse Methods for CleanPower",Wiley,1999.

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21EE52D3: ENERGY MANAGEMENT SYSTEMS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand data acquisition components of power system	PO-2	2
CO2	Understand energy data monitoring, reporting and communication	PO-2	2
CO3	Apply supervisory control for energy management	PO-5	3
CO4	Understand Energy management center functions	PSO-1	2

General Theory: Purpose and necessity, general structure, data acquisition, transmission and monitoring, general powersystem hierarchical structure, overview of the methods of data acquisition systems, commonly acquired data, transducers, RTUs, data concentrators, various communication channels, cables, telephone lines, power line carrier, microwaves, fiber- optical channels and satellites.**Supervisory and Control Functions:** Data acquisitions, status indications, measured values, energy values, monitoring alarm and event application processing. Control function: ON/OFF control of lines, transformers, capacitors and applications in process industry, valve, opening, closing etc. Regulatory functions: set points and feed-back loops, time tagged data, disturbance data collection and analysis, calculation and report preparation. **MAN- Machine Communication:** Operator consoles and VDUs, displays, operator dialogues, alarm and event loggers, mimic diagrams, report and printing facilities. **Data bases - SCADA, EMS and network data bases:** SCADA system structure - local system, communication system and central system, Configuration- non-redundant single processor, redundant dual processor, multi control centers, system configuration. Performance considerations: real time operation system requirements, modularization of software programming languages.**Energy Management Center** Functions performed at a centralized management center, production control and load management, economic dispatch, distributed centers and power pool management.

Textbooks:

1. TorstenCegrell, Power System Control Technology, Prentice Hall International, 1986
2. Stuart A. Boyer, SCADA: Supervisory Control And Data Acquisition, The Instrumentation, Systems and Automation Society, 4th edition, 2009.
3. Krishna Kant, Computer-Based Industrial Control, PHI Learning,2nd edition, 2013.
4. Bela G. Liptak, Instrument Engineers Handbook, Volume 3: Process Software and Digital Networks, CRC Press, 4th edition, 2011.
5. Behrouz Forouzan, Data Communications and Networking, McGraw-Hill,5thedition, 2012.

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3. Course structure for 2021-2022 admitted M.Tech-PED program

Course Code	Course Name	Category	L	T	P	S	Cr	Pre-Requisite	Course/Revised	Changes Proposed by	Employability/	Justification
21EE5111	Modeling and Analysis of Electrical Machines	PC	3	1	0	0	4	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for Employability in core sector and further study
21EE5211	Switched Mode Power Supplies	PC	3	1	2	0	5	Nil	New		Employability	Covers the advanced topics which enable for Employability in core sector and further study
21EE5113	Power Electronic Control of Drives	PC	3	1	0	0	4	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for Employability in core sector and further study
21EE5114	Modern Control Theory	PC	3	1	0	0	4	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for Employability in core sector and further study
21EE5112	Advanced Power Converters	PC	3	1	2	0	5	Nil	Retained	No Changes	Employabili	Covers the advanced topics which enable for Employability in core sector and further study
21EE5212	Advanced Electrical Drives	PC	3	1	0	0	4	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for Employability in core sector and further study
21EE5214	Smart Grids Technologies	PC	3	1	0	0	4	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for Employability in core sector and further study
21EE5116	FPGA controllers and Applications	PC	3	1	0	0	4	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for Employability in core sector and further study

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21EE51E1	Microcontrollers and Applications	PE	3	0	0	0	3	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for Employability in core sector and further study
21EE51E2	Digital Simulation of Power Electronic Systems	PE	3	0	0	0	3	Nil	NEW		Employability	Covers the advanced topics which enable for Employability in core sector and further study
21EE51E3	Industrial Control Electronics	PE	3	0	0	0	3	Nil	Retained	No Changes	Employability	Covers the advanced topics which enable for Employability in core sector and further study
21EE51S3	Floating Solar and Off Shore Wind Technologies	PE	3	0	0	0	3	Nil	NEW		Entrepreneurship	Covers the advanced topics which enable for Employability in core sector and further study
21EE51B2	Digital Signal Processors and Applications	PE	3	0	0	0	3		Retained	No Changes proposed	Employability	Covers the advanced topics which enable for Employability in core sector and further study
21EE51B3	Optimization Techniques	PE	3	0	0	0	3	Nil	Retained	No Changes proposed	Entrepreneurs	Covers the advanced topics which enable for Employability in core sector and further study
21EE52C1	FACTS	PE	3	0	0	0	3	Nil	Retained	No Changes proposed	Employability	Covers the advanced topics which enable for Employability in core sector and further study
21EE5213	Electric Vehicle Technology	PE	3	0	0	0	3	Nil	REVISED	ACADEMIC PEERS	Employability	Covers the advanced topics which enable for Employability in core sector and further study

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21EE52C2	Energy Conservation & Audit	PE	3	0	0	0	3	Nil	Retained	No Changes Proposed	Employability	Covers the advanced topics which enable for employability in core sector and further study
21EE52C3	Adaptive Control Systems	PE	3	0	0	0	3	Nil	Retained	No Changes proposed	Employability	Covers the advanced topics which enable for employability in core sector and further study
21EE52D2	Power Quality	PE	3	0	0	0	3	Nil	Retained	No Changes proposed	Employability	Covers the advanced topics which enable for Employability in core sector and further study
21EE52D3	Energy Management Systems	PE	3	0	0	0	3	Nil	Revised	No Changes proposed	Employability	Covers the advanced topics which enable for Employability in core sector and further study
21IE5149	SEMINAR	Project	0	0	4	0	2	Nil	Retained	No Changes proposed	Skill Development	Covers the advanced topics which enable for Employability in core sector and further study
21IE5250	TERM PAPER	Project	0	0	4	0	2	Nil	Retained	No Changes proposed	Skill Development	Covers the advanced topics which enable for Employability in core sector and further study
21IE6050	Dissertation	Project	0	0	72	0	36	Nil	NEW	No Changes proposed	Skill Development	Covers the advanced topics which enable for Employability in core sector and further study

Percentage of Courses focusing on Employability= 18/23=78.26%
Percentage of Courses focusing on Entrepreneurship= 2/23=9%
Percentage of Courses focusing on Skill Development = 3/23=13%

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4. Course wise Syllabus revision of approved structure as mentioned in point 2

SNO	Course Code	Course Name	Course Category	Existing Syllabus		New Syllabus	Topics Added/ Removed / Replaced	Change in Outcome	Justification for the Modification	Revision Percentage
1	21EE5211	Switched Mode Power Supplies	PC	-		21EE5202 Syllabus	Revised	Yes		
2	21EE5213	Electric Vehicle Technology	PE	-		21EE5131 Syllabus	Revised	Yes		
3	21EE51B1	Floating Solar and Off Shore Wind Technologies	PE	-		21EE51B1 Syllabus	New	Yes		
4	21EE52D3	Energy Management Systems	PE	-		21EE52D3 Syllabus	New	Yes		
5	21IE6050	Dissertation	Project	-		21IE6050 Syllabus	NEW	Yes		

Percentage of Courses REVISED / NEW =5/23=21%

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21EE5111: MODELING AND ANALYSIS OF ELECTRICAL MACHINES

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Apply the basic concepts of Electromagnetic Energy Conversion Principles to DC Machines	PO1	3
CO2	Understand the performance of electrical machines through mathematical modeling	PO2	2
CO3	Illustrate the dynamic behaviour of electrical machines under different operating conditions	PSO2	3
CO4	Analysis of special machines	PO2	4

Basic Concepts and Dc machine: Principles of Electromagnetic Energy Conversion, General expression of stored magnetic energy, co-energy and force/torque, example using single and doubly excited system. The Primitive Machine Equations. Mathematical model of a separately excited DC motor, DC series motor and DC Shunt motor-Voltage and torque equation of dc machine.

Basic Concepts of Rotating Machines: Calculation of air gap mmf and per phase machine inductance using physical machine data; Induction machine: Three phase symmetrical induction machine in phase variable form; Application of reference frame theory to three phase symmetrical induction Machine. Dynamic direct and quadrature axis model in arbitrarily rotating reference frames.

Synchronous Machine: Three phase salient pole synchronous machines in phase variable form. Voltage and torque equation of salient pole synchronous machine including damper winding in stator reference frame.Voltage and torque equation of salient pole synchronous machine including damper winding in rotor reference frame. Determination of Synchronous Machine Dynamic Equivalent Circuit Parameters.

Special Machines: Permanent magnet synchronous machine: Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines. Construction and operating principle, dynamic modeling and self controlled operation; Analysis of Switch Reluctance Motors. Analysis and dynamic modeling of two phase asymmetrical induction machine and single phase induction machine.

Text Books:

1. Charles Kingsley, Jr., A.E. Fitzgerald, Stephen D.Umans, 'Electric Machinery', Tata McgrawHill, 5th Edition, 1992.

2. Generalized Theory of Electrical Machines – P.S.Bimbra- Khanna publications-5th edition 1995

Reference Books:

1. R. Krishnan, 'Electric Motor & Drives: Modeling, Analysis and Control', Prentice Hall of India, 2nd Edition, 2001.

2. Miller, T.J.E., 'Brushless Permanent Magnet and Reluctance Motor Drives', Clarendon Press, 1st Edition, 1989

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21EE5112: ANALYSIS OF POWER CONVERTERS

L-T-P-S: 3-1-2-0 **Credits: 5** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No:	CO	PO/PSO	BLOOMS TAXANOMY LEVEL-BTL
1	Analyze the various high power controller converters and power factor correction.	PO2	4
2	Analyze the performance of Switch-Mode PWM and different control techniques for Inverters	PSO1	4
3	Analyze the operation of multi-level to inverters and Z-source inverter.	PO-5	3
4	Understand the various applications of power converters with solar systems	PO-2	2
5	Demonstrate and test basic power electronic converters by hardware realization and MATLAB software.	PO-3	4

LTPC -3-1-2-5

HIGH POWER ELECTRONIC CONVERTERS : Multi-pulse SCR Rectifiers, Performance parameters - Six-pulse, 12-pulse and 24- pulse SCR rectifier, Effect of line and leakage inductances, Power factor control. Pulse Width Modulated Rectifiers: Properties of ideal rectifier, realization of near ideal rectifier, control of the current waveform PWM, single phase and three-phase converter systems.

SWITCH-MODE DC-AC INVERTERS: Basic Concepts- PWM Principles- Sinusoidal Pulse Width Modulation in Single Phase Inverters-Choice of carrier frequency in SPWM- Bipolar and Unipolar Switching - Blanking Time -Maximum Attainable DC Voltage - Switch Utilization. Six step inverters, voltage control & PWM strategies, and implementation aspects, Modification of power circuit for Four quadrant operation,Pulse width modulation techniques (hysteresis, SVM), Selective Harmonic Reduction Techniques.

MULTILEVEL INVERTERS AND IMPEDANCE SOURCE INVERTERS: Multilevel concept – Classification of multilevel inverters – Diode clamped multilevel inverter –improved diode Clamped inverter –Flying capacitors multilevel inverter - Cascaded multilevel inverter -Multilevel inverter -features of multilevel inverters – comparisons of multilevel converters. – PWM techniques for MLI.- Quasi –Z source Inverters, control methods,

POWER CONVERTERS APPLICATIONS: Lighting, pumping and refrigeration Systems: Electronic ballast, LED power drivers for indoor and outdoor applications. PFC based grid fed LED drivers, PV / battery fed LED drivers. PV fed power supplies for pumping and refrigeration Applications.

Text books:

1. M.H. Rashid : Power Electronics Handbook, Butterworth-Heinemann, 4th edition, 2017.
2. N. Mohan, T.M. Undeland, W.P. Robbins: Power Electronics: Converters, Applications, John Wiley & Sons, 3rd edition, 2003.

References:

1. Umanand, L.: Power Electronics: Essentials and Applications, John Wiley India, 1st Edition, 2009.
2. Jayant Baliga B: Fundamentals of Power Semiconductor Devices, Springer, 1st Edition 2008.
3. Bin Wu: High Power Converters and AC Drives, Wiley-Interscience, 2nd Edition, 2017.
4. Derek A Paice: Power Electronic Converter Harmonics Multipulse Method for Clean Power, IEEE Press, 1995

21EE5113: POWER ELECTRONIC CONTROL OF DRIVES

L-T-P-S: 3-0-2-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No:	CO	PO/PSO	BLOOMS TAXANOMY LEVEL
CO1	Analyze ac-dc and dc-dc converter fed DC motor drives,	PO1	4
CO2	Understand converter fed stator side control of Induction Motor drives.	PSO1	2
CO3	Analyze rotor side control and slip power recovery scheme of 3-phase Induction Motor drives	PO11	4
CO4	Analyze frequency control of Synchronous Motor drives for variable speed operation	PO2	4
CO5	Demonstrate and test various electrical drives by hardware and MATLAB software tools.	PO-3	4

Controlled Converter fed DC Motor Drives: Steady state analysis of the single and three phase fully controlled converter fed series and separately excited D.C motor drives: Continuous and discontinuous conduction mode, control of output voltage by sequence and sector control. Chopper fed DC Motor Drives:Four quadrant chopper circuit – Chopper for inversion – closed loop control of chopper fed dc drive –Steady state analysis of chopper controlled DC motor drives.

VSI and CSI fed Induction Motor Drives: Scalar control- Voltage fed Inverter control-Open loop volts/Hz control-Speed control with slip regulation-Speed control with torque and Flux control-Current controlled voltage fed Inverter Drive. Current-Fed Inverter control-Independent current and frequency control-Speed and flux control in Current-Fed Inverter drive-Volts/Hz control of Current-Fed Inverter drive-Efficiency optimization control by flux program.

Rotor Side Control of Induction Motor: Rotor resistance control- fixed resistance control, variable resistance control-converter controlled rotor resistance control, Slip power recovery schemes- Static Kramer drive-Phasor diagram-Torque expression-Speed control of a Kramer drive-Static scherbius drive-Modes of operation.

Synchronous Motors: Speed control of synchronous motors, field oriented control, load commutated inverter drives, switched reluctance motors and permanent magnet motor drives.

TEXT BOOKS

1. Power Electronics and Motor Control – Shepherd, Hulley, Liang – II Edition, Cambridge University Press
2. R. Krishnan, 'Electric Motor Drives – Modeling, Analysis and Control', Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.
3. BimalK .Bose, 'Modern Power Electronics and AC Drives', Pearson Education Pvt. Ltd., New Delhi, 2003.

REFERENCES

1. Power Electronic Circuits, Devices and Applications – M. H. Rashid – PHI.
2. Control of Induction Motors - Andrzej M. Trzynadlowski
3. Fundamentals of Electric Drives – G. K. Dubey – Narosa Publications – 1995.

21EE5114: MODERN CONTROL THEORY

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the basics of Z-Transforms and Digital control systems DCS components	PO-5	2
CO2	Apply various stability analysis technics to digital control systems	PO-1	3
CO3	Apply various stability analysis technics to non-linear control systems	PSO-2	3
CO4	Apply the basics of optimal control problem to state feedback controller design	PO-1	3

DIGITAL CONTROL SYSTEMS: Introduction to Discrete Time Systems, Necessary for Digital Control System, Spectrum Analysis of Sampling Process, Signal Reconstruction, Difference Equations, Z transforms, and the Inverse Z transform, Pulse Transfer Function, Time Response of Sampled Data Systems, Stability using Jury Criterion, Bilinear Transformation. **POLE PLACEMENT TECHNIQUES** Controller Design by State Feedback, Necessary and Sufficient Condition for Arbitrary Pole Placement-State Regulator Problem and State Regulator Design, Evaluation of State Feedback Gain Matrix K, Selection of Location of Desired Closed Loop Poles, State Observer Design, Full Order/Reduced Order Observer Design, Observer Based State Feedback Control, Separation Principle. **NONLINEAR CONTROL SYSTEM** Introduction, Properties of Nonlinear System, Behavior of Non-Linear System, Classification of Nonlinearities, Common Physical Nonlinearities: Saturation, Friction, Backlash, Dead -Zone, Relay, On-Off Nonlinearity, Nonlinear Spring, Limit cycle, Jump resonance. Phase -Plane Method, Singular points, Stability of Nonlinear System, Construction of Phase Trajectories, Describing Functions Method, Stability Analysis by Describing Function Method. Lyapunov's Stability Analysis, Lyapunov'sStability Criterion, Direct Method of Lyapunov and the Linear Systems, Method of Construction of Lyapunov Functions for Nonlinear Systems. **OPTIMAL CONTROL** formulation of the optimal control problem – method of calculus of variations – use of Hamiltonian method – pontryagin's minimum principle - optimal control problem – hamilton – jacobi approach – continuous time linear state regulator matrix riccati equation.

TEXT BOOKS:

1. Discrete Time Control Systems-K.Ogata Pearson Education-2005.
2. Digital Control systems and State Variables methods by M.Gopal-2006.

REFERENCE BOOKS:

1. Modern Control System Theory by M. Gopal – New Age International – 2005
2. M. Gopal : Modern Control Systems Theory, Wiley Eastern Limited, New Delhi, 1996.

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21EE5211: SWITCHED MODE POWER SUPPLIES

L-T-P-S: 3-1-2-0 **Credits: 5** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No:	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
1	Analyze the Non-isolated dc-dc converter under CCM and DCM operation	PO2	4
2	Apply the modeling of SMPS and output stage amplification.	PO2	3
3	Analyze the Isolated dc-dc converters under various modes and high frequency transformer design.	PO2	4
4	Apply the various modes of bidirectional dc-dc converters in different control strategy.	PSO2	3
5	Demonstrate and test the performance of SMPS circuits using hardware and MATLAB software tools.	PO2	4

NON-ISOLATED DC-DC CONVERTER:buck, boost, buck-boost, CUK, SEPIC; continuous conduction mode and discontinuous conduction mode analysis; non-idealities in the SMPS.

SMPS AND GAIN AMPLIFICATION: Modeling and control of SMPS, duty cycle and current model control, canonical model of the converter-High frequency output stage in SMPS: voltage doubler and current doubler output rectifiers.

ISOLATED DC-DC CONVERTERS: Fly-back, forward, push-pull, half bridge and full bridge topologies; transformer design for high frequency isolation

DAB AND RESONANT SMPS: Bidirectional dc-dc converters-DAB –Voltage control –Current Control- Resonant SMPS: load resonant converters, quasi resonant converters and resonant transition converters.

Text Books

1. Robert Ericson, Fundamentals of Power Electronics, Chapman & Hall, 2004.

2. V. Ramanarayanan, Switched Mode Power Conversion, 2007.

Reference Books

1. Umanand.L, Power Electrionics: Essentials and Applications, Wiley India, 2009.

2. B. Jayant Baliga, Power Semiconductor Devices; PWS 1996.

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21EE5212: ADVANCED ELECTRICAL DRIVES

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No:	Course Outcomes(CO)	PO/PSO	Blooms Taxonomy Level (BTL)
1.	Understand the modeling of AC machines	PO2	2
2.	Contrast the speed control performance of 3-Phase induction and synchronous motor drive using vector control methods	PO2	4
3.	Analyze the dynamic behavior of SRM motor drives under various control methods	PSO1	4
4.	Distinguish the performance of BLDC Motor drive using various control techniques	PO2	4

FIELD ORIENTED CONTROL OF INDUCTION MOTOR DRIVES - Field oriented control of induction machines – Theory – DC drive analogy – Direct and Indirect methods – Flux vector estimation - Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy.

SENSORLESS VECTOR CONTROL OF INDUCTION MOTOR: Slip and Speed Estimation at Low performance, Rotor Angle and Flux-linkage Estimation at high performance -rotor Speed Estimation Scheme- estimators using rotor slot harmonics, Model Reference adaptive systems, Extended Kalman Filter.

CONTROL OF SYNCHRONOUS MOTOR DRIVES: Self control margin angle control-torque control-power factor control-Brushless excitation systems - SRM Structure-Stator Excitation-techniques of sensor less operation-convertor topologies-SRM Waveforms-SRM drive design factors-Torque controlled SRM-Torque Ripple-Instantaneous Torque control -using current controllers-flux controllers.

CONTROL OF BLDC MOTOR DRIVES: principle of operation of BLDC Machine, Sensing and logic switching scheme, BLDM as Variable Speed Synchronous motor-methods of reducing Torque pulsations -Three-phase full wave Brushless dc motor -Sinusoidal type of Brushless dc motor - current controlled Brushless dc motor Servo drive.

TEXT BOOKS

1. Electric Motor Drives Modeling, Analysis & control -R. Krishnan- Pearson Education
2. Modern Power Electronics and AC Drives –B. K. Bose-Pearson Publications
3. Sensorless Vector Direct Torque control –Peter Vas, Oxford University Press

REFERENCES BOOKS

1. Modern Power Electronics and AC Drives –B. K. Bose-Pearson Publications-
2. Power Electronics control of AC motors – MD Murphy & FG Turn Bull Pergman Press -1st edition-1998
3. W.Leonhard, "Control of Electrical Drives", Narosa Publishing House, 1992
4. VedamSubramanyam, "Electric Drives – Concepts and Applications", Tata McGraw-Hill publishing company Ltd., New Delhi, 2002

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21EE5213: ELECTRIC VEHICLE TECHNOLOGY

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	Blooms Taxonomy Level (BTL)BTL
CO1	Understand the History, Economics, Environmental issues and power train of Electric Vehicles	PO5	**2**
CO2	Analyze the dynamics of EV	PO7	4
CO3	Select and size the power train for 2W	PO7	3
CO4	Select and size the power train for 4W	PSO2	3

HISTORY, ECONOMIC & ENVIRONMENTAL IMPACT OF ELECTRIC VEHICLE: History of EV, Case studies on Economic and Environment aspects of EV, EV markets – Supply and demand, Economical analysis with case study, Environmental impact analysis with case study. Various Govt. policies, Impact of different transportation technologies on environment and energy supply. Power train components: BEV, HEV, PHEV and FCEV including working of Fuel cell

INTRODUCTION TO EV DYNAMICS: Motion and dynamic equations of electric vehicles, General description of vehicle movement, Vehicle resistance, Dynamic equation, Tire Ground Adhesion and maximum tractive effort, different drive cycles for, Drive cycles for vehicle emission, fuel consumption and performance testing.

2W POWER TRAIN SIZING: Chassis, differential and transmission selection for different drive trains, Battery, converter and motor drive sizing for different 2W drive trains. Analysis on the effect of sizing of different components for different drive cycles

4W POWER TRAIN SIZING: Chassis, differential and transmission selection for different drive trains, Battery, converter and motor drive sizing for different 4W drive trains. Analysis on the effect of sizing of different components for different drive cycles

Text books:

3. "A History of Electric Vehicles" by Nigel Burton, Edition -1, Crowood Publisher.
4. "Electric and Hybrid Vehicles Design Fundamentals, by Iqbal Hussain, CRC Press2nd edition, 2010
5. "*Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*" by M. Ehsani, Second edition, CRC Press, 2009.

Reference books:

2. "Electric Vehicle Technology Explained" by James Larminie and John Lowry.

21EE5214: SMART GRIDTECHNOLOGIES

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the basic concepts of smart grid, terminology, challenges and initiatives.	PO-1	2
CO2	Understand various smart operations of power system structure, components, and monitoring techniques.	PO-4	2
CO3	Apply smart metering and advanced metering infrastructure with monitoring, protection and measuring units.	PSO-2	3
CO4	Apply various communication protocols and cyber-security importance in smart grid.	PO-4	2

INTRODUCTION TO SMART GRID - Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers,functions, opportunities, challenges and benefits, Difference between conventional & SmartGrid, National and International Initiatives in Smart Grid.**SMART GRID TECHNOLOGIES** Technology Drivers, Smart energy resources, Smart substations, Substation Automation,Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring,Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation - service restoration, Outage management, High-Efficiency Distribution Transformers,Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).**SMART METERS AND ADVANCED METERING INFRASTRUCTURE -**

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits,AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor MeasurementUnit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.High Performance Computing for Smart Grid Applications**COMMUNICATION SYSTEMS-**Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUDcomputing to make Smart Grids smarter, Cyber Security for Smart Grid.

TEXT BOOKS

1. Stuart Borlase "Smart Grid: Infrastructure, Technology and Solutions", CRC Press 2017.
2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley 2012.

REFERENCES BOOKS

1. Control and Optimization Methods for Electric Smart Grids, AranyaChakraborthy, Marija D llic Editor, Springer Publications.
2. Smart Grid Fundamentals of Design and Analysis, James Momoh, Wiley IEEE Press, Ed 2012.

21EE51A1: SOFT COMPUTING TECHNIQUES

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the model, learning and training methods of Artificial Neural networks	PO2	2
CO2	Apply Genetic algorithms to engineering problems	PO5	3
CO3	Understand the characteristics of Fuzzy systems	PSO1	2
CO4	Apply Neural networks and fuzzy logic to motor control	PO2	3

INTRODUCTION: Introduction and motivation. Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule-based systems, the AI approaches Knowledge representation. **ARTIFICIAL NEURAL NETWORKS:** Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network. Networks: Hopfield network, Self-organizing network and Recurrent network.

GENETIC ALGORITHM: Genetic Algorithm: Basic concept of Genetic algorithm: Mutation, Reproduction and cross over and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm, genetic algorithm as classifier and engineering applications.

FUZZY SYSTEMS: Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to Fuzzy logic modeling and control of a system.Fuzzification, inference and defuzzification.Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Self-organizing fuzzy logic control.

FUZZY LOGIC & NEURAL NETWORK APPLICATIONS TO DRIVES: Fuzzy logic applications: Design of Fuzzy PI controller for speed control of DC motor- Flux programming efficiency improvement of three phase induction motor-Induction motor speed control. **Neural network applications:**-PWM Controller-Selected harmonic elimination PWM-Space vector PWM.

TEXT BOOKS

1. Neural Networks: A comprehensive Foundation – Simon Haykins, Pearson Edition, 2003.
2. Fuzzy logic with Fuzzy Applications – T.J.Ross – Mc Graw Hill Inc, 1997.
3. Genetic Algorithms- David E Goldberg.
4. Modern Power Electronics and AC Drives –B.K.Bose-Pearson Publications
5. Artificial Intelligent based Electrical Machines and Drives- Peter Vas, Oxford University Press

REFERENCE BOOKS

1. Neural Network Fundamentals with Graphs, Algorithms and Applications, N.K. Bose and P.Liang, Mc-Graw Hill, Inc. 1996.
2. Intelligent System- Modeling, Optimization and Control- Yung C. Shin and ChengyingXu,CRC Press, 2009.
3. Soft computing & Intelligent Systems- Theory & Applications – N.K.Sinha and ModanM Gupta. Indian Edition, Elsevier, 2007.
4. Fuzzy logic Intelligence, Control, and Information- John Yen and Reza Langari, Pearson Education, Indian Edition, 2003.

21EE51A2: DISTRIBUTED GENERATION SYSTEMS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO NO	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understandthe significance of distributed generations and standards.	PO5	2
CO2	Apply various interface system for grid integration with Distributed energy system.	PSO1	3
CO3	Understand technical impacts of DGs integration to ensure power quality issues.	PSO1	2
CO4	Understand economical improvement and control strategyof DG integration.	PO7	2

Need for Distributed Generation– Renewable sources in distributed generation – Current scenario in distributed generation – Planning of DGs – Siting and sizing of DGs – Optimal placement of DG sources in distribution systems. Standards for interconnecting Distributed resources to electric power systems: IEEE 1547.

Grid integration of DG– Different types of interfaces – Inverter based DG and rotating machine based interfaces – Aggregation of multiple DG units – Energy storage elements – Batteries, ultra capacitors, flywheels. Requirements for grid interconnection, limits on operational parameters: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues.

Technical impacts of DGs –Transmission systems, Distribution systems, De-regulation – Impact of DGs upon protective relaying – Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

Economic and control aspects of DGs– Market facts, issues and challenges – Limitations of DGs – Voltage control techniques, Reactive power control, Harmonics, Power quality issues – Reliability of DG based systems – Steady state and Dynamic analysis. DG installation classes, security issues in DG implementations.

TEXT BOOKS:

1. H. Lee Willis, Walter G. Scott , 'Distributed Power Generation – Planning and Evaluation', Marcel Decker Press, 2000.
2. M.GodoySimoes, Felix A.Farret, 'Renewable Energy Systems – Design and Analysis with Induction Generators', CRC press.

REF BOOKS:

1. F. Katiraei, M.R. Iravani, 'Transients of a Micro-Grid System with Multiple Distributed Energy Resources', International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, 2005.
2. John Twidell and Tony Weir, "Renewable Energy Resources", Taylor and Francis Publications, Second Edition, 2006.

21EE51S3: FLOATING SOLAR & OFF- SHORE WIND TECHNOLOGIES

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO. No	Course Outcome	PO	BTL
1	understand the selection of floating solar power plant	PO-3	2
2	understand different layouts and selection of converters	PO-4	2
3	understand the operation of off shore wind power plants	PO-4	2
4	Analyze the operation of floating solar and off shore power system	PO-3	4

Concept of Floating Solar PV System – **Selection of Floating Solar PV Plant**: Site Survey of Floating Solar PV Plant, Dam Dimension calculations, Environment factor assessment, Power evacuation level, pontoon angle, Magnetic North & True North with variation of azimuth angle, Temperature factor - **Selection of floating pontoon:** Types of Pontoon, Specification of main Pontoons, Selection criteria for PV module pontoons, etc,. – **Preparation of Floating Solar PV Plant**: Overall plant layout, DC blocking layout, Earthing Layout for Floating solar Power Plant, Connection of Leap frog method for string connection – PV Modules & Sizing – Inverter Selection & Sizing – HT Switch & Sizing.

Overview of offshore wind technology - Energy Conversion Systems for Offshore Wind Turbines - Modelling and Analysis of Drivetrains in Offshore Wind Turbines - Fixed and Floating Offshore Wind Turbine Support Structures – **Offshore Wind Turbine Controls** - Operation and Maintenance Modelling - Supervisory Wind Farm Control - Offshore Transmission Technology - Grid Integration and Control for Power System Operation Support.

Text Books:

3. Marco Rosa-Clot Giuseppe Marco Tina, "Submerged and Floating Photovoltaic Systems", Springer Publishers, ISBN: 9780128121498
4. Olimpo Anaya-Lara, John Olav Tande, KjetilUhlen, Karl Merz, "Offshore Wind Energy Technology", Wiley Publishers, ISBN: 978-1-119-09780-8

21EE51B1: GREEN BUILDING AND ENERGY SYSTEMS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Apply energy audit for energy management in buildings	PO5	3
CO2	Understand energy conservation opportunities in electrical systems	PO7	2
CO3	Apply energy management strategies for energy efficiency	PSO1	3
CO4	Apply practices for energy efficiency green buildings	PO2	3

Syllabus

Energy Management: Definition and Objective of Energy Management, General Principles, Energy Management Strategy, Energy Balance sheet and Management Information System (MIS), Energy Modelling and Optimization, Demand Side management (DSM), Peak Demand control- Methodologies

Green Building Practices: Energy efficiency-life cycle perspective, Environmental product declaration, Building information model, choice of heat insulation materials, high thermal mass materials, phase change materials, Green building certifications

Energy Audit: Need, types, methodology and approach, Instruments for energy audit, Energy Management Approach, Understanding Energy Costs, Bench marking, Energy performance, matching energy usage to requirements, maximizing system efficiency, Return of Investment

Energy conservation opportunities: Energy conservation in HVAC, Refrigeration and Air Conditioning, Pumping Systems, lighting control, lighting control, Energy Conservation Building Code, Energy Conservation opportunities in Transformers and cables, Transmission lines

Text books

3. Industrial Energy Management: Principles and Applications by Giovanni and Petrecca, The Kluwer international series-207 (1999)
4. Guide to Electric Load Management by Anthony J.Pansini, Kenneth D.Smalling, Pennwell pub (1988)
5. Energy Management: W.R.Murphy, G.Mckay (Butterworths)

Reference books

6. Energy Management Hand book by Turner, Wayne C, Lilburn, The Fairmont press, 2001
7. Handbook of Energy Audits by Albert Thumann, Fairmont Pr; 5th edition (1998).
8. Recommended practice for Energy Conservation and cost effective planning in Industrial facilities by IEEE Bronze book, IEEE Inc, USA.
9. Energy Management Principles: C.B. Smith (Pergamon Press)
10. Bureau of Energy Efficiency Publications-Rating System, Teri Publications – Griha Rating System, Leeds Publications.

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21EE51B2: DIGITAL SIGNAL PROCESSORS AND APPLICATIONS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand components of digital signal processing	PO-2	2
CO2	Understand Architecture of TMS320C5X, TMS320C6X and ADSP-21XXprocessors	PSO-1	2
CO3	Understand programming of functional units of TMS320C5X, TMS320C6X and ADSP-21XX	PO-2	2
CO4	Apply Signal conditioning and PWM applications with TMS320C5X, TMS320C6X and ADSP-21XX processors	PSO-2	3

FUNDAMENTALS OF DIGITAL SIGNAL PROCESSING: Review of DSP fundamentals. Issues involved in DSP processor design - speed, cost, accuracy, pipelining, parallelism, quantization error, etc. Key DSP hardware elements - Multiplier, ALU, Shifter, Address Generator, etc.**TMS320C5X PROCESSOR 9 Architecture**: Assembly language syntax - Addressing modes – Assembly language Instructions - Pipeline structure, Operation – Block Diagram of DSP starter kit – Application Programs for processing real time signals.**TMS320C6X PROCESSOR 9 Architecture:** of the C6x Processor - Instruction Set - DSP Development System: Introduction– DSP Starter Kit Support Tools- Code Composer Studio - Support Files - Programming Examples to Test the DSK Tools – Application Programs for processing real time signals. **ADSP PROCESSORS 9 Architecture of ADSP-21XX:** and ADSP-210XX series of DSP processors- Addressing modes and assembly language instructions –**Software development tools:** assembler, linker and simulator. Applications using DSP Processor - spectral analysis, FIR/IIR filter, linear-predictive coding, etc.

TEXT BOOKS:1. Avtar Singh and S. Srinivasan, Digital Signal Processing – Implementations using DSP Microprocessors with Examples from TMS320C54xx, cengage Learning India PrivateLimited, Delhi 2012

2. B.Venkataramani and M.Bhaskar, "Digital Signal Processors – Architecture", TATA McGraw-Hill Education, 2002.

REFERENCES:1. Programming and Applications" – Tata McGraw – Hill Publishing Company Limited. NewDelhi, 2003.

2. RulphChassaing, Digital Signal Processing and Applications with the C6713 and C6416DSK, A JOHN WILEY & SONS, INC., PUBLICATION, 2005 5. User guides Texas Instrumentation, Analog Devices, Motorola.

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21EE51B3: OPTIMIZATION TECHNIQUES

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No:	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand classical optimization techniques, describe clearly the problems with and without constraints, identify its parts and analyze the individual functions, Feasibility study for solving an optimization problem.	PO-6	2
CO2	Apply mathematical translation of the verbal formulation of an optimization problem and design algorithms of linear programming problems, the repetitive use of which will lead reliably to finding an approximate solution.	PSO-2	3
CO3	Analyze and measure the performance of an algorithm of different methods to solve non-linear programming problems, study and solve optimization problems.	P-11	4
CO4	Analyze optimization techniques using algorithms. Investigate study, develop, organize and promote innovative solutions for various applications.	PO-12	4

Classical Optimization Techniques: Single variable optimization, multi-variable optimization with no constraints, with equality and inequality constraints, Karush- Kuhn- Tucker constraints.

Linear Programming (LP): Geometry of LP problem, graphical solution, simplex algorithm, two-phases of simplex algorithm, duality, dual simplex method, quadratic programming.

Non-Linear Programming: One-dimensional optimization – Fibonacci method, golden section method, quadratic and cubic interpolation methods, Newton's method.Unconstrained optimization - Steepest descent method, conjugate gradient method, Davidon-Fletcher-Powell method.Constrained Optimization - Augmented Legrangian multiplier method, Branch and bound method

Non-traditional Optimization Methods and Applications: Genetic algorithms (G A), G A Operators, G A for constrained optimization.Particle swarm optimization (PSO).

Text Books:

1. S.S. Rao, 'Engineering Optimization : Theory andPractice.III Edition, New Age International (p) Limited Publications

2. Kalyanmoy Deb, 'Optimization for Engineering Design', PHI Learning Private Limited.

Reference Books:

1. PurnachandraBiswal, ' Optimization in Engineering', Scitech Publications (India) PVT Ltd.

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21EE52C1: FACTS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

Co.No:	Course Outcomes	PO/PSO	BTL
CO 1	Understand theimportance of FACTS devices and their applications to the Power Systems.	PO-8	2
CO 2	Analyzethe static shunt compensation and operation of devices under this category.	PO-9	4
CO 3	Analyze thestatic series compensation and operation of devices under this category.	PO-8	4
CO 4	Analyze the operation and applications of devices like UPFC and IPFC.	PO-9	4

FACTS CONCEPT AND GENERAL SYSTEM CONSIDERATIONS: Transmission interconnections, Power Flow in AC system, Dynamic stability Considerations and the importance of the controllable parameters, Introduction to Facts devices, Basic types of FACTS Controllers, benefits from FACTS controllers.**STATIC SHUNT COMPENSATION:** Objectives of shunt compensation, Methods of controllable VAR generation, variable impedance type static VAR generators (SVC): TCR, TSR, TSC, FC-TCR, TSC-TCR, switching converter type VAR generators: STATCOM, Comparison between SVC and STATCOM, STATCOM for transient and dynamic stability enhancement.**STATIC SERIES COMPENSATION: Objectives** of series compensation, variable impedance type static series controllers: GCSC, TSSC, TCSC, switching converter type controller: SSSC, Operation and Control External system Control for series Compensator SSR and its damping – Static Voltage and Phase angle Regulators - TCVR and TCPAR – Operation and Control.**UPFC AND IPFC:**The unified power flow Controller – Operation –Comparison with other FACTS devices – control of P and Q – dynamic performance – special Purpose FACTS controllers – Interline Power flow Controller – Operation and Control- Application and HVDC controlled link.

TEXT BOOKS:

4. FACTS: Modelling and Simulation in Power Networks, By Enrique Acha, Claudio R. Fuerte-Esquivel, Hugo Ambriz-Pérez, César Angeles-Camacho WILEY
5. K.R.Padiyar "FACTS Controller in power Transmission and Distribution" New Age Int Publisher,2007
6. Flexible AC Transmission Systems: Modelling and Control, By Xiao-Ping Zhang, Christian Rehtanz, Bikash Pal

REFERENCE BOOKS:

4. N.G Hingorani&L.Gyugyi " Understanding FACTS: Concepts and Technology of Flexible AC Transmission System" , IEEE Press,2000
5. Ned Mohan et.al "Power Electronics" John wiley& Sons,2 nd edition ,2002
6. T.J.E Miller, "Reactive power control in electric Systems" John willey& sons,1982.

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21EE52N2: ENERGY STORAGE SYSTEMS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO NO	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand different energy storage system conversions.	PO5	2
CO2	Illustrate various electrochemical storage system operations.	PSO1	2
CO3	Understand electrode properties and energy conversion of super capacitor.	PSO1	2
CO4	Outline fuel cell energy conversion concepts and different type's chemistries.	PO7	2

Need of Energy Storage; Different Modes of Energy Storage: Potential energy: Pumped hydro storage; KE and Compressed gas system: Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors, electromagnets; Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical, electro-chemical, fossil fuels and synthetic fuels.

Electrochemical Energy Storage Systems: Batteries: Primary, Secondary batteries; chemistries of primary batteries such as Zinc-Carbon, Alkaline and secondary batteries such as Lead acid, Nickel Cadmium, Metal hydrides, lithium ion, lithium phosphate and high temperature batteries-sodium-sulphur. Advantages, disadvantages, limitations and application each above mentioned batteries.

Super capacitors: Types of electrodes and some electrolytes, Electrode materials - high surface area activated carbons, metal oxide, and conducting polymers, Electrolyte - aqueous or organic,

Disadvantages and advantages of super capacitors - compared to battery systems, applications -

transport vehicles, private vehicles, and consumer electronics - energy density, power density, price, and market.

Fuel Cell Basics: Fuel cell definition, Difference between batteries and fuel cells, fuel cell history, components - principle of working -Fuel cell thermodynamics -efficiency, Electrochemical kinetics, Butler-Volmer equation-Types of fuel cells and its chemistries – AFC, PAFC, PEMFC,MCFC and SOFC – merits and demerits.

References:

J Larminie and A Dicks, Fuel Cell Systems Explained", 2nd Edition, Wiley, 2003

Johannes Jensen Bent Squrensen, Fundamentals of Energy Storage, John Wiley, NY, 1984.

P.D.Dunn, Renewable Energies. First Edition, Peter Peregrinus Ltd, London, United Kingdom, 1986

S Srinivasan, Fuel Cells: From Fundamentals to Applications, Springer 2006

R. M. Dell, D.A.J. Rand, 'Understanding Batteries', RSC Publications, 2001.

James Larminie, Andrew Dick, 'Fuel Cell System Explained', J. Wiley, 2003.

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21EE52N3: GRID INTEGRATION OF RENEWABLE ENERGY SYSTEMS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO NO	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand Control Algorithms of Various Electric Vehicle Charging Modes	PO5	2
CO2	Apply Power Electronic Converters for Electric Vehicle Charging	PSO1	3
CO3	Apply Charging Station Infrastructure	PSO1	3
CO4	Understand Installation and site assessment of Charging Station	PO7	2

Introduction to renewable energy systems, environmental aspects of electric energy

conversion, impacts of renewable energy generation on environment, Need of integrating large renewable energy sources, issues related to integration of large renewable energy sources.

Power Electronic Converters: need of power electronic equipment's in grid integration, converter, inverter, chopper, ac regulator and cycloconverters for AC/DC conversion.

Solar-Photovoltaic (PV) cells-characteristics, variability, energy conversion principles, electrical modelling, optimal power extraction, shading effect, Stand-alone PV system, Grid connected PV system, Design of PV system-load calculation, array sizing, selection of converter/inverter, battery sizing.

Wind: variability, principles of wind energy extraction, electromechanical energy conversion, characteristics of wind turbines, voltage regulation

Grid operation and Control :Scheduling and dispatch, Forecasting, reactive power and voltage control, frequency control, operating reserve, storage systems, electric vehicles, CERC and CEA orders (technical and safety standards)

Text Books

1. Integration of Alternative sources of Energy, Felix A. Farret and M. Godoy Simoes, IEEE Press – Wiley-Interscience publication, 2006.
2. Grid integration of solar photovoltaic systems, Majid Jamil, M. Rizwan, D.P.Kothari, CRC Press (Taylor & Francis group), 2017

Reference Books

1. Renewable Energy Grid Integration, Marco H. Balderas, Nova Science Publishers, New York, 2009.
2. Wind Power Integration connection and system operational aspects, B. Fox, D. Flynn L. Bryans, N. Jenkins, M. O' Malley, R. Watson and D. Milborrow, IET Power and Energy Series 50 (IET digital library), 2007
3. Power Generation, Operation, and Control, Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheblé, John Wiley & Sons, New York, 2013 (3rd edition)

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21EE52E1: CHARGING TECHNOLOGY FOR ELECTRIC VEHICLES

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO NO	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand Control Algorithms for Various Electric Vehicle Charging Modes	PO5	2
CO2	Apply Power Electronic Converters for Electric Vehicle Charging	PSO1	3
CO3	Apply Charging Station Infrastructure	PSO1	3
CO4	Understand Installation and site assessment of Charging Station	PO7	2

Charger Topologies : Charging time and charging speed, Defining power levels- Normal charging, Semi-fast charging, Overview of power levels ,DC conductive charging, AC conductive charging, Low power Charger, Automotive standard charger, High power topologies, Multi-port Charger.

Power Electronics for EV Battery Charging: Forward/ Flyback Converters, Half-Bridge DC–DC Converter, Full-Bridge DC–DC Converter, Power Factor Correction, Bidirectional Battery Chargers, Dual active bridge dc-dc converter. Charging Modes: Constant-current charging, Constant-voltage charging, Pulse Charging, Reflex charging, Float charge, Trickle Charge.

Charging Infrastructure: Charger - Existing National & International Charger Architecture Standards - SAE J1773, VDE-AR-E 2623-2-2, JEVS G105-1993 (CHAdeMO), CCS, Type-1 AC, Type-2 AC, Bharat DC-001, Bharat AC-001, Cords and Cables, Earthing, Fault Protection, Testing, Charging Safety, Protection against electric shock Digital Communication between EV and Charging Station.

Installation: Govt. of India guideline on Public Charging Stations, IEC Standards- 60068-2(1, 2, 14, 30), 61683, 60227, 60502, 60947 part I,II, III and 61215 Site assessment, EVSE Typical Site Plans, Design Guidelines and Site Drawings, Planning Considerations, Station Configuration, Selection and erection of electrical equipment - Isolation, switching and control, Load management at charging station and peak load management.

Text Books:

1.Power Electronics by Daniel W.Hart.

2.Power Electronics for Renewable Energy Systems, Transportation and industrial Applications by Haitham Abu-Rub, Mariusz Malinwoski, Kamal Al-Haddad.

Reference Books :1. AIS-138 Part 1 and Part2

1. Electric Vehicle Charging Stations Technical Installation Guide, 2 nd Edition, Hydro Quebec.

21EE52E2: BATTERY MANAGEMENT SYSTEMS FOR ELECTRIC VEHICLE

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the specifications and Li-ion chemistry	PO1	2
CO2	Understand the key functions of Battery management systems	PO5	2
CO3	Develop Enhanced Self Correcting (ESC) Model of battery	PO7	4
CO4	Develop Algorithms for SOC estimation of battery	PSO2	4

Syllabus:

Battery specifications and Li-on chemistry

Battery specifications, cell-module-pack formation and specification calculation, working principle of Li-ion cell, materials used for various components of Li-ion cell, different li-ion chemistries and there specification comparison

Functions of battery-management systems

BMS architecture, BMS functionality: Sensing and High Voltage Control, Protection-isolation,overvoltage, overcurrent protection, Performance-Battery pack energy and power calculations using HPPC, Balancing- passive and active cell balancing, Interface, and Diagnostics

Battery Modelling

Simple OCV model, Rint model, Thevinenins model, Hysteresis effect and ESC model of battery cell.Charge, discharge tests to determine battery cell parameters,

SOC estimation

Stoichiometry for SOC estimation, Look-table method and Coulomb counting methods and their limitation for accurate state estimation. Linear and nonlinear Kalman filter based estimation techniques

Text books:

1. Battery management systems: Battery Modeling, Gregory L.Plett, Artech house, 2015.
2. Battery management systems: Equivalent circuit methods, Gregory L.Plett, Artech house, 2015.

Reference books:

1. Hybrid Electric vehicles-Principles and Applications with practical perspectives, Chris Mi, M. AbdulMasrur and David Wenzhong Gao, Wiley Publications,*1* edition 2011

2. Electric and Hybrid Vehicles power sources, models, sustainability, infrastructure and the market, Edited by Gianfranco Pistoia, Elsevier 1 edition 2010.

3. Electric and Hybrid Vehicles Design Fundamentals, by Iqbal Hussain, CRC Press2nd edition, 2010.

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21EE52D2: POWER QUALITY

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand basic power quality issues	PO-1	2
CO2	Understand conventional loop control for voltage and current balance	PSO-1	2
CO3	Apply DSTATCOM for power quality restoration	PO-2	3
CO4	Apply combined compensation techniques for power quality restoration and fault ride through.	PSO-2	3

INTRODUCTION- Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non linear and unbalanced loads, DC offset in loads, Notching in load voltage,

Disturbance in supply voltage – Power quality standards. Low Voltage Ride Through, High Voltage Ride Through.

CONVENTIONAL LOAD COMPENSATION METHODS -Principle of Load compensation and Voltage regulation – Classical load balancing problem: Open loop balancing – Closed loop balancing, Current balancing – Harmonic reduction andvoltage sag reduction – Analysis of unbalance – instantaneous real and reactive powers –Extraction of fundamental sequence component.

LOAD COMPENSATION USING DSTATCOM - Compensating single phase loads – Ideal three phase shunt compensator structure –Generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced –Realization and control of DSTATCOM – DSTATCOM in Voltage control mode. SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM-Rectifier supported Dynamic Voltage Restorer – DC Capacitor supported DVR – DVR Structure – voltage Restoration – Series Active Filter – Unified Power Quality Conditioner- Wind power interconnection requirement - Fault ride through techniques.

TEXT BOOKS:

1. ArindamGhosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002
2. R.C. Duggan, Mark.F.McGranaghan,SuryaSantoas and H.WayneBeaty, "Electrical Power System Quality", McGraw-Hill, 2004.
3. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publication, 1994.
4. Math H J Bollen, "Understanding Power Quality Problems: voltage sags and interruptions", iley-IEEE Press, 2000. Indian Reprint – 2013

REFERENCE BOOKS:

1 Jos Arrillaga and Neville R. Watson ," Power system harmonics",Wiley,2003.
2. Derek A. Paice , "Power Electronics Converter Harmonics :Multipulse Methods for CleanPower",Wiley,1999.
3. Ewald Fuchs, Mohammad A. S. Masoum Power Quality in Power Systems and Electrical Machines, Elseveir academic press publications, 2011.

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Annexure IV

List of Certificate Courses to be offered by Department of EEE for AY 2021-2022

Y18 & Y19 Admitted Batches

Level -1 and 2 certifications

Stream 1: L1- BEVT & Power train sizing; L2-Li-ion Cell testing & BMS Stream 2: L1- IoT and data Science for Smart Grid; L2: Advanced IoT & Machine Learning

Stream 3: L1: HCIA- AI-1; HCIA- Routing & Switching

Stream 4: L1- AI Engineer-1; L-2 AI Engineer-2

Level-3 Certificate courses to be offered in 2021-22

S1: L3- Electric Vehicle Design

S2 & S4: L3- Internet of Things from APSSDC Y20 admitted Batch Level-1

Certificate Courses to be offered in 2021-22

S1: BEVT & Power train sizing

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Annexure V
MOOC Courses in A.Y 2021-2022

Sl	Title	platform
1	First step Korean-YONSEI University	COURSERA
2	SPANISH Vocabulary Course	Udemy

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KONERU LAKSHMAIAH EDUCATION FOUNDATION
Pre-Ph.D. Examination

SMART METERS AND SMART CITIES

SYLLABUS

SMART METERING: Introduction, Smart metering, Evolution of electricity metering, Key components of smart metering, Smart meters: An overview of the hardware used Signal acquisition, Signal conditioning, Analogue to digital conversion, Computation, Input/output, Communication.

COMMUNICATIONS INFRASTRUCTURE AND PROTOCOLS FOR SMART METERING: Home-area network, Neighbourhood area network, Data concentrator, Meter data management system, Protocols for communications, Demand-side integration, Services provided by DSI, Implementations of DSI, Hardware support to DSI implementations, Flexibility delivered by prosumers from the demand side, System support from DSI. Smart Appliances, Automatic Meter Reading (AMR).

SMART CITY: Vision and goals of smart city, concept of smart city and its features, issues and challenges of urbanization in India, international scenario, issues and probable solutions, need for smarter approaches process of selection of smart cities, developing and demonstrating new technologies, smart city strategies, digital and information technologies, urban planning best practices.

SMART TRANSPORTATION: Importance and significance of mobility, data collections, smart sensors, role of geographic information system, integration of GIS and ITS, related air quality; accidents and safety analysis; advanced traffic management systems, commercial vehicle operations, advanced transportation systems, advanced vehicle control systems, case studies, public transportation management; electronic payment, connected vehicle technology and application, mobile applications.

Text books:

1. Janaka Ekanayake, N. Jenkins, K. Liyanage, J. Wu, Akihiko Yokoyama, *Smart Grid: Technology and Applications*, Wiley.
2. Bob Williams, *Intelligent Transport Systems Standards*, Artech House Publishers, 2008
3. Austroads, *The Implication of Intelligent Transport Systems for Road Safety*, Austroads Incorporated, 1999.

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KONERU LAKSHMAIAH EDUCATION FOUNDATION
Pre-Ph.D. Examination

CHARGING STATION FOR ELECTRIC VEHICLE
SYLLABUS

CHARGER TOPOLOGIES: Charging time and charging speed, Defining power levels- Normal charging, Semi-fast charging, Overview of power levels ,DC conductive charging, AC conductive charging, Low power Charger, Automotive standard charger, High power topologies, Multi-port Charger

POWER ELECTRONICS FOR EV BATTERY CHARGING: Forward/ Flyback Converters, Half-Bridge DC–DC Converter, Full-Bridge DC–DC Converter, Power Factor Correction, Bidirectional Battery Chargers, Dual active bridge dc-dc converter

CHARGING MODES: Constant-current charging, Constant-voltage charging, Pulse Charging, Reflex charging, Float charge, Trickle Charge

CHARGING INFRASTRUCTURE: Charger - Existing National & International Charger Architecture Standards - SAE J1773, VDE-AR-E 2623-2-2, JEVS G105-1993 (CHAdeMO), CCS, Type-1 AC, Type-2 AC, Bharat DC-001, Bharat AC-001, Cords and Cables, Earthing, Fault Protection, Testing, Charging Safety, Protection against electric shock. Digital Communication between EV and Charging Station

INSTALLATION; Govt. of India guideline on Public Charging Stations, IEC Standards- 60068-2(1, 2, 14, 30), 61683, 60227, 60502, 60947 part I,II, III and 61215, Site assessment, EVSE Typical Site Plans, Design Guidelines and Site Drawings, Planning Considerations, Station Configuration, Selection and erection of electrical equipment - Isolation, switching and control, Load management at charging station and peak load management

Text books:

1. Daniel W.Hart, *Power Electronics*, McGraw-Hil, 2010.
2. Haitham Abu-Rub, MariuszMalinwoski, Kamal Al-Haddad, *Power Electronics for Renewable Energy Systems, Transportation and industrial Applications*, John Wiley & Sons, Ltd, 2014.

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KONERU LAKSHMAIAH EDUCATION FOUNDATION
Pre-Ph.D. Examination

FACTS DEVICES
SYLLABUS

FACTS CONCEPT AND GENERAL SYSTEM CONSIDERATIONS: Transmission interconnections, Power Flow in AC system, Dynamic stability Considerations and the importance of the controllable parameters, Introduction to Facts devices, Basic types of FACTS Controllers, benefits from FACTS controllers.

STATIC SHUNT COMPENSATION: Objectives of shunt compensation, Methods of controllable VAR generation, variable impedance type static VAR generators (SVC): TCR, TSR, TSC, FC-TCR, TSC-TCR, switching converter type VAR generators: STATCOM, Comparison between SVC and STATCOM, STATCOM for transient and dynamic stability enhancement.

STATIC SERIES COMPENSATION: Objectives of series compensation, variable impedance type static series controllers: GCSC, TSSC, TCSC, switching converter type controller: SSSC, Operation and Control External system Control for series Compensator SSR and its damping – Static Voltage and Phase angle Regulators - TCVR and TCPAR – Operation and Control.

UPFC AND IPFC: The unified power flow Controller – Operation –Comparison with other FACTS devices – control of P and Q – dynamic performance – special Purpose FACTS controllers – Interline Power flow Controller – Operation and Control.

Text Books:

1. Enrique Acha, Claudio R. Fuerte-Esquivel, Hugo Ambriz-Pérez, César Angeles-Camacho, *FACTS: Modelling and Simulation in Power Networks*, WILEY.
2. K.R.Padiyar, *FACTS Controller in power Transmission and Distribution*, New Age Int Publisher, 2007.
3. Xiao-Ping Zhang, Christian Rehtanz, Bikash Pal, *Flexible AC Transmission Systems: Modelling and Control*, Springer.

Reference Books:

1. N.G Hingorani&L.Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission System*, IEEE Press,2000
2. Ned Mohan et.al, *Power Electronics*, John wiley& Sons,2 nd edition ,2002
3. T.J.E Miller, *Reactive power control in electric Systems*, John willey& sons,1982.

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KONERU LAKSHMAIAH EDUCATION FOUNDATION
Pre-Ph.D. Examination

REAL TIME CONTROL OF POWER SYSTEMS
SYLLABUS

SYSTEM OPTIMIZATION: Strategy for two generator systems-generalized strategies-effect of transmission losses-Sensitivity of the objective function-Formulation of optimal power flow-solution by Gradient method-Newton's method - Unit Commitment, Hydro-Thermal Coordination.

LOAD FREQUENCY CONTROL: AGC multi area system, static and dynamic response, Load frequency control of 2-area system,

SECURITY CONTROL: Security analysis and monitoring, generator and line outages by linear sensitivity factors,

STATE ESTIMATION: Power system state estimation, Weighted least square state estimation, state estimation of AC network, Treatment of bad data – network observability and pseudo measurements.

TEXT BOOKS:

1. Allen J. Wood and Bruce F. Wollenberg, *Power Generation, Operation & Control*, 2nd edition, John Wiley and Sons, 1996.
2. I.J. Nagarath& D. P. Kothari , *Modern power system analysis*, 3rd Edition, TMH, New Delhi, 2003.

REFERENCE BOOKS:

1. I. Elgard , *Electric Energy Systems Theory – An Introduction*, TMH, 1983.
2. Abhijit Chakrabarti&SunitaHalder, *Power System Analysis operation and Control*, 1st edition, PHI, 2006.
3. Mahalanabis A.K., Kothari D.P. and Ahson S.I., *Computer aided power system analysis and control*, 4th Edition, 2011, TMH.
4. J.J.Grainger, W.D.Stevenson JR, *Power system analysis*, Tata McGraw Hill N.D. 2007.
5. A. Handschin and E. Petroiaenu, *Energy Management Systems, Operations and Control of Electric Energy Transmission Systems*, Springer-Verlag, Berlin, Heidelberg, 1991.

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KONERU LAKSHMAIAH EDUCATION FOUNDATION
Pre-Ph.D. Examination

RENEWABLE ENERGY SOURCES AND INTEGRATION
SYLLABUS

SOLAR ENERGY: Generic Photovoltaic Cell, Equivalent Circuits, Cells to Modules to Arrays, I –V Curve, Impacts of Temperature and Insolation, Shading impacts on I–V curves, I–V Curves for different loads, MPPT, System sizing, System Performance, Economics. Modelling of Solar PV system components: Mathematical models -PV cell, PV Array, Battery pack, dc-dc converter, P&O MPPT technique, DC bus voltage regulation

WIND ENERGY: Components of WECS, Power obtained from the wind, Simple momentum theory, Power coefficient, Aerodynamics of WT, Betz's Limit, Blade Element Theory, Blade Design, Control Strategies: Power Regulation, yaw control, Pitch control, stall control, Schemes for Maximum Power Extraction. Wind Turbine Technology & Generators: HAWT, VAWT, Constant Speed constant frequency, Variable speed variable frequency, Modeling of DFIG, PMSG. Grid Connected Systems:

GEOTHERMAL ENERGY: Introduction to geothermal energy, structure of the earth interior, geothermal gradients, geothermal resources, geothermal power generation – liquid dominated and vapour dominated geothermal electric power plants. **TIDAL ENERGY:** Introduction to tidal energy, tidal characteristics, tidal range, tidal energy estimation, types of tidal power plants – single basin single effect plant, single basin double effect plant, double basin double effect plants.

INTEGRATION OF ALTERNATE SOURCES OF ENERGY: Introduction, principles of power injection: converting technologies, power flow; instantaneous active and reactive power control approach; integrating multiple renewable energy sources; DC link integration; AC link integration; HFAC link integration; islanding and interconnection.

Text books

1.Kalogirou .S.A., *Solar Energy Engineering: Processes and Systems*, Academic Press, 2009.
2.G. D. Rai, *Non-Conventional Energy Sources*, Khanna Publishers, First edition
3.H.P. Garg & J. Prakash, *Solar Energy - Fundamentals and Applications*, Indian Edition - First Revised Edition, Mc Graw Hill Education.
4. Felix A. Farret and M. Godoy Simoes, *Integration of Alternative sources of Energy*, IEEE Press – Wiley-Interscience publication, 2006.

Reference books

1. Roger H.Charlier, Charles W., *Ocean Energy- Tide and Tidal Power,* ISBN: Library of Congress Control Number: 2008929624_c Springer-VerlagBrerlin Heidelberg 2009.
2. John Twidell& Toney Weir: E&F.N. Spon, *Renewable Energy Sources*, Taylor &Francis New York, 2nd edition.

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KONERU LAKSHMAIAH EDUCATION FOUNDATION
Pre-Ph.D. Examination

IOT FOR INDUSTRIAL AUTOMATION

SYLLABUS

INTRODUCTION & ARCHITECTURE: What is IIoT and connected world? the difference between IoT and IIoT, Architecture of IIoT, IOT node, Challenges of IIOT. IIOT Components-Fundamentals of Control System, introductions, components, closed loop & open loop system. Introduction to Sensors (Description and Working principle): What is sensor? Types of sensors, working principle of basic Sensors -Ultrasonic Sensor, IR sensor, MQ2, Temperature and Humidity Sensors (DHT-11).Digital switch, Electro Mechanical switches.

COMMUNICATION TECHNOLOGIES OF IIOT: Communication Protocols: IEEE 802.15.4, ZigBee, Z Wave, Bluetooth, BLE, NFC, RFID Industry standards communication technology (LoRAWAN, OPC UA, MQTT), connecting into existing Modbus and Profibus technology, wireless network communication.

VISUALIZATION AND DATA TYPES OF IIOT: Front-end EDGE devices, Enterprise data for IIoT, Emerging descriptive data standards for IIoT, Cloud data base, Could computing, Fog or Edge computing. Connecting an Arduino/Raspberry pi to the Web: Introduction, setting up the Arduino/Raspberry pi development environment, Options for Internet connectivity with Arduino, Configuring your Arduino/Raspberry pi board for the IoT. Retrieving Data - Extraction from Web: Grabbing the content from a web page, Sending data on the web, Troubleshooting basic Arduino issues, Types of IoT interaction, Machine to Machine interaction (M2M).

CONTROL & SUPERVISORY LEVEL OF AUTOMATION: Programmable logic controller (PLC), Real-time control system, Supervisory Control & Data Acquisition (SCADA). HMI in an automation process, ERP & MES. Application of IIOT - Case study: Health monitoring, Iot smart city, Smart irrigation, Robot surveillance.

Text Books

1. Mahmood, Zaigham, *The Internet of Things in the Industrial Sector*, Springer Publication.
2. Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat , *Industrial Internet of Things: Cyber manufacturing System*, Springer Publication.
3. Ismail Butun, *Industrial IoT Challenges, Design Principles, Applications, and Security.*

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KONERU LAKSHMAIAH EDUCATION FOUNDATION
Pre-Ph.D. Examination

ADVANCED POWER CONVERTERS
SYLLABUS

RESONANT DC-DC CONVERTERS: Switching loss, hard switching, and basic principles of soft switching- classification of resonant converters- load resonant converters – series and parallel – resonant switch converters – operation and analysis of ZVS, ZCS converters comparison of ZCS/ZVS Introduction to ZVT/ZCT PWM converters - Numerical problems.

SPECIAL INVERTER TOPOLOGIES: Series Inverters -Switched Mode Rectifier - Single phase and three phase boost type APFC and control -Three phase utility inter phases and control Push-Pull and Forward Converter Topologies - Voltage Mode Control Half and Full Bridge Converters - Flyback Converter.

SOFT SWITCHING CONVERTERS: Resonant (Pulsating) DC Link Inverter -Active-clamped Resonant DC Link Inverter- Quasi-resonant Soft-switched Inverter - Numerical problems.

MULTILEVEL INVERTERS- MULTILEVEL & BOOST INVERTERS: Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters -Comparison of multilevel inverters - application of multilevel inverters – PWM techniques for MLI – Single phase & Three phase Impedance source inverters -Introduction-Matrix converter circuit-Control strategies.

TEXT BOOKS:

1. N.Mohan, T.M.Undeland, W.P Robbins, *Power Electronics, Converters, Applications & Design*", Wiley India Pvt. Ltd.-2013
2. William Shepherd and Li Zhang, *Power Converter Circuits* , CRC press ,Taylor & Francis -2004

REFERENCE BOOKS:

1. Gyugyi, L., B. R. Pelly, *Static Power Frequency Changers*, Wiley, New York.
2. Rashid M.H., *Power Electronics Circuits, Devices and Applications*, Prentice Hall India, Third Edition, New Delhi, 2004
3. Ali Emadi, AlirezaKhaligh, ZhongNie, Young Joo Lee, *Integrated Power Electronic Converters and Digital Control*", CRC press
4. Simon Ang, Alejandro Oliva, *Power-Switching Converters*, Second Edition, CRC Press, Taylor & Francis Group, 2010
5. Marian.K.Kazimierczuk and DariuszCzarkowski, *Resonant Power Converter*, John Wiley & Sons limited, 2011

KONERU LAKSHMAIAH EDUCATION FOUNDATION
Pre-Ph.D. Examination

SMART GRID TECHNOLOGIES
SYLLABUS

THE SMART GRID: Introduction – Necessity of smart grid – Definition – Early smart grid initiatives – overview of the technologies required for the smart grid-Information and communication technologies, Sensing measurement, control and automation technologies, Power electronics and energy storage.
DATA COMMUNICATION: Introduction – dedicated and shared communication channels – switching techniques – communication channels- layered architecture and protocols; Communication technologies for the smart grid: Introduction –communication technologies – standards for information exchange.
INFORMATION SECURITY FOR THE SMART GRID: Introduction – Encryption and Decryption: Symmetric Key encryption, Public key encryption - Authentication – Digital signature: Secret key signature, Public key signature, Message digest – cyber security standards.
SMART METERING AND DEMAND SIDE INTEGRATION: Introduction – smart metering – smart meters – Communication infra structure and protocols for smart metering - Demand side integration.
INTRODUCTION TO SMART GRID APPLICATIONS: Introduction – voltage and VAR control and optimization – fault detection, isolation and restoration (FDIR) – Demand response (DR) – Distributed energy resources (DERs) – wide area monitoring, control and protection (WAMCP).

Text Books:
1. JanakaEkanayake ,KithsiriLiyanage , Jianzhong Wu , Nick Jenkins, *Smart Grid: Technology and Applications,* first Edition, John Wiley & sons Limited (2012).
2. Lars T. Berger and Krzysztof Iniewski, *Smart Grid: Applications, communication and security,* first Edition ,John Wiley & sons Limited;(2012).

Reference Books:
James Momoh, *Smart grid: Fundamental of Design and analysis*, John Wiley & sons Limited IEEE Press (2012).

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KONERU LAKSHMAIAH EDUCATION FOUNDATION
Pre-Ph.D. Examination

BATERY MANAGEMENT SYSTEM FOR ELECTRIC VEHICLES
SYLLABUS

COMPONENTS OF BATTERY MANAGEMENT SYSTEMS: Lithium-ion cellterminology, major functions provided by a battery-management system and their purpose - Identify the major components of a lithium-ion cell and their purpose - Understand how a battery-management system "measures" current, temperature, and isolation.

FUNCTIONS OF BATTERY MANAGEMENT SYSTEMS: Identify electronic components that can provide protection and specify a minimum set of protections needed - Compute stored energy in a battery pack - List the manufacturing steps of different types of lithium-ion cells and possible failure modes.

STATIC MODELLING OF BATTERY: Static modelling of battery: static model parameters of the battery, lab test to determine the parameters of battery model, static equivalent circuit determination.

DYNAMIC MODELLING OF BATTERY: Dynamic modelling of battery, parameters affecting the dynamic model, lab test to determine the dynamic model parameters, dynamic equivalent circuit determination.

Text books:

1. L.Plett , Gregory, *Battery management systems: Battery Modeling*, Artech house, 2015.
2. Gregory L.Plett, *Battery management systems: Equivalent circuit methods*, Artech house, 2015.

Reference books:

1. Chris Mi, M. AbdulMasrur and David Wenzhong Gao, *Hybrid Electric vehicles-Principles and Applications with practical perspectives*, Wiley Publications,*1* edition 2011
2. Gianfranco Pistoia, *Electric and Hybrid Vehicles power sources, models, sustainability, infrastructure and the market,* Elsevier 1 edition 2010.
3. Iqbal Hussain, *Electric and Hybrid Vehicles Design Fundamentals,* CRC Press2nd edition, 2010.

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KONERU LAKSHMAIAH EDUCATION FOUNDATION
Pre-Ph.D. Examination

POWER QUALITY
SYLLABUS

INTRODUCTION: Power or voltage quality, terms and definitions: short duration voltage variations, Interruptions – Voltage sag – Swell – Surges – Harmonics – Voltage fluctuations. Long duration voltage variations: Over voltage – Under voltage – Sustained interruptions, Transients: Impulse transients – Oscillatory transient, Power quality terms.

LONG INTERRUPTIONS: Definition – Interruptions – Causes of long interruptions – Origin of interruptions – Limits for the interruptions frequency – Limits for the interruption duration.

SHORT INTERRUPTIONS: Definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems. Multiple events, single phase tripping – voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions.

VOLTAGE SAG ANALYSIS: Voltage sag magnitude – Monitoring - Theoretical calculations – Examples - Sag magnitude in non-radial systems, Voltage calculation in meshed systems, Voltage sag duration, Fault clearing time – Magnitude duration plots- Measurement of sag duration, Magnitude and Phase angle jumps for three phase unbalanced sags – Phase to phase fault – Single phase faults – Two phase to ground faults – High impedance fault – Meshed systems.

MITIGATION OF INTERRUPTIONS AND VOLTAGE SAGS: Overview of mitigation methods – From fault to trip, Reducing the number of faults, Reducing the fault clearing time changing the power system, Installing mitigation equipment, Improving equipment immunity, Different events and mitigation methods. System equipment interface – Voltage source converter, series voltage controller, Shunt voltage controller, combined shunt and series controller. Typical wiring and grounding problems.

Text books:

1. Math H J Bollen, *Understanding Power Quality Problems: voltage sags and interruptions*, Wiley-IEEE Press, 1999.
2. Roger C Dugan, Surya Santoso, Mark F. Mc Granaghan, H. Wayne Beaty, *Electrical power system squality*, Third edition, 2012, TMH.

Reference Books:

1. Angelo Baggini, *Hand book of power quality*, Wiley publications, 2008.
2. Edward F Fuchr, Mohammad A S Masoum, *Power Quality in Power System and Electrical Machine,* 1st Edition, Elsevier,2008

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KONERU LAKSHMAIAH EDUCATION FOUNDATION
Pre-Ph.D. Examination

ADAPTIVE CONTROL SYSTEMS
SYLLABUS

ELEMENTS OF PROBABILITY THEORY: definition of probability and random variable, probability functions, expected value, mean and covariance, independence and correlation, Gaussian distribution and its properties. **STOCHASTIC PROCESSES AND SYSTEM MODELS:** Elements of the theory of stochastic processes, mean value function and covariance kernel, independent and correlated stochastic processes, stationery and non sequence model, Gaussian white process.

NON PARAMETRIC METHODS & PARAMETRIC METHODS: Nonparametric methods: Transient analysis-frequency analysis-Correlation analysis-Spectral analysis.Liner Regression: The Lease square estimate-best liner unbiased estimation under linear constraints-Prediction error methods: Description of Prediction error methods-Optimal Prediction –relationships between Prediction error methods and other identification methods theoretical analysis.

ADAPTIVE CONTROL SCHEMES: Introduction – users- Definitions-auto tuning-types of adaptive control-gain scheduling controller-model reference adaptive control schemes – self tuning controller. MRAC and STC: Approaches – The Gradient approach – Lyapunov functions – Passivity theory – pole placement method Minimum variance control – Predictive control.

ADAPTIVE CONTROL AND APPLICATION: Stability – Convergence – Robustness – Application of adaptive control, direct model reference adaptive control. Introduction: Basic approaches to adaptive control. Applications of adaptive control. Identification: Error formulations linear in the parameters. Direct adaptive control: Linear error equations with dynamics. Gradient and pseudo-gradient algorithms. Strictly positive real transfer functions. Kalman-Yacubovitch-Popov lemma.Passivity theory.

TEXT BOOKS:

1. Dan Simon, *Optimal State Estimation*, Wiley Intersience, 2006.
2. S. Sastry and M. Bodson, *Adaptive Control: Stability, Convergence, and Robustness*, Prentice-Hall, 1989.

REFERENCE BOOKS:

1. K.J. Astrom and B. Wittenmark, *Adaptive Control*, Addison-Wesley, 2nd edition, 1995.
2. I.D. Landau, R. Lozano, and M. M'Saad, *Adaptive Control*, Springer Verlag, London, 1998.
3. Meditch, *Stochastic Optimal Linear Estimation and Control,* Mc-Graw Hill Company, 1969.
4. K.S. Narendra and A.M. Annaswamy, *Stable Adaptive Systems*, Prentice-Hall, 1989.
5. P.E. Wellstead& M.B. Zarrop, *Self-Tuning Systems: Control and Signal Processing*, J. Wiley & Sons, Chichester, England, 1991

KONERU LAKSHMAIAH EDUCATION FOUNDATION
Pre-Ph.D. Examination

DIGITAL PROTECTION OF POWER SYSTEMS
SYLLABUS

PROTECTION OF POWER SYSTEM EQUIPMENT: summation transformer, phase-sequence current segregating network.Load shedding and frequency relays; Out of step relaying; Re-closing and synchronizing - adaptive protection – integrated protection and control.

DIGITAL PROTECTION: Developments in computer relaying – mathematical basis for protective relaying algorithms, Fourier Transforms – Discrete Fourier transforms –Walsh - Hadamard, Haar - wavelet transforms, digital relaying algorithms,.

MICROPROCESSOR BASED PROTECTION RELAYS: Working principles of μP based over current, directional, distance, current differential relays and frequency relays - microprocessor implementation of digital distance relaying algorithms.

MODERN TRENDS IN PROTECTION: New developments in relaying principles –travelling wave propagation – types of travelling wave relays- AI based numerical protection – FPGA based relays.

TEXT BOOKS:

1. Badri Ram & DN Viswakarma, *Power System Protection & Switch Gear*, Tata McGraw Hill Publishing Company Limited, New Delhi (1995).

REFERENCE BOOKS:

1. T.S.MadhavaRao, *Power System Protection – Static relays*, TMH, 2010.
2. A.T.Johns and S.K.Salman, *Digital Protection for Power Systems,* 1995.
3. A.G.Phake, James S.Thorp, *Computer Relaying for power Systems*, John Wiley and sons
4. J.Lewis Blackburn, *Protective relaying principles and applications*, Marcel & Dekker

KONERU LAKSHMAIAH EDUCATION FOUNDATION
Pre-Ph.D. Examination

AI TECHNIQUES IN POWER SYSTEMS
SYLLABUS

ARTIFICIAL NEURAL NETWORKS: Introduction Models of Neuron Network – Architectures –Hebbian learning –Supervised learning – Unsupervised learning – Reinforcement learning.
ANN PARADIGMS: Multi – layer perceptron using Back propagation Algorithm (BPA) –Radial Basis Function Network –Hopfield Network – Application to Load forecasting.
FUZZY LOGIC: Introduction – Fuzzy versus crisp – Fuzzy sets – Membership function – Basic Fuzzy set operations –Fuzzy Inference – Fuzzy Rule based system–Defuzzification methods – Application to Load Frequency Control.
GENETIC ALGORITHMS: Introduction–Encoding – Fitness Function–Reproduction operators–Genetic Modeling – Genetic operators–Cross over – Single site cross over – Two point cross over – Multi point cross over – Uniform cross over –Mutation operator – Elitism - Generational cycle – convergence of Genetic Algorithm – Application to economic dispatch.

Text Books:
1. S.Rajasekaran and G.A.V.Pai Neural Networks, *Fuzzy Logic & Genetic Algorithms*, PHI, New Delhi, 2003.
2. Rober J. Schalkoff, *Artificial Neural Networks,* Tata McGraw Hill Edition, 2011

Reference Books:
1. James A freeman, David M Skapura, *Neural Networks*, Addison – Wesley, an imprint of Pearson Education, II Edition , 2000
2. S N Sivanandam, S sumathi, S. N deepa, *Introduction to Neural Networks using Matlab 6.0*, Tata Mc Graw Hill Publishing Company Private Limited, 2006
3. K Sundareswaran, *Fuzzy Logic Systems*, Jaico Publishing House, 2005

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KONERU LAKSHMAIAH EDUCATION FOUNDATION
Pre-Ph.D. Examination

ADVANCED ELECTRICAL DRIVES
SYLLABUS

FIELD ORIENTED CONTROL OF INDUCTION MOTOR DRIVES: Field oriented control of induction machines – Theory – DC drive analogy – Direct and Indirect methods – Flux vector estimation - Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy.

SENSORLESS VECTOR CONTROL OF INDUCTION MOTOR: Slip and Speed Estimation at Low performance, Rotor Angle and Flux-linkage Estimation at high performance -rotor Speed Estimation Scheme- estimators using rotor slot harmonics, Model Reference adaptive systems, Extended Kalman Filter.

CONTROL OF SYNCHRONOUS MOTOR DRIVES: Self control-margin angle control-torque control-power factor control-Brushless excitation systems - SRM Structure-Stator Excitation-techniques of sensor less operation-convertor topologies-SRM Waveforms-SRM drive design factors-Torque controlled SRM-Torque Ripple-Instantaneous Torque control -using current controllers-flux controllers.

CONTROL OF BLDC MOTOR DRIVES: principle of operation of BLDC Machine, Sensing and logic switching scheme, BLDM as Variable Speed Synchronous motor-methods of reducing Torque pulsations -Three-phase full wave Brushless dc motor -Sinusoidal type of Brushless dc motor - current controlled Brushless dc motor Servo drive.

Text Books:

1. R. Krishnan, *Electric Motor Drives Modeling, Analysis & control,* - Pearson Education
2. B. K. Bose, *Modern Power Electronics and AC Drives*, Pearson Publications
3. Peter Vas, *Sensorless Vector Direct Torque control*, Oxford University Press

References books:

1. B. K. Bose , *Modern Power Electronics and AC Drives*, Pearson Publications-
2. MD Murphy & FG Turn Bull, *Power Electronics control of AC motors,* Pergman Press -1st edition-1998
3. W.Leonhard, *Control of Electrical Drives*, Narosa Publishing House, 1992
4. VedamSubramanyam, *Electric Drives – Concepts and Applications*, Tata McGraw-Hill publishing company Ltd., New Delhi, 2002

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