RK UNIVERSITY

DETAIL TEACHING SCHEME

SCHOOL OF ENGINEERING
ACADEMIC YEAR – 2021-22
PROGRAM: B. TECH – ELECTRICAL ENGINEERING
SEMESTER –VII (Batch – 2018-22)
DEFINATION OF CREDIT: **1. Lecture (L):** 1 hour/week/semester, **2. Practical (P)**: 2 hours/week/semester **3. Tutorial(T):** 2 hours/week/semester

TEACHING SCHEME										
Course Code	Course Name	Teaching Hours			SSH	Credits	Audit course	CIE	PSEE	Remarks if any
		Lecture	Tutorial	Practical						
EL712	Advances in Power Systems	3	0	2	2	4	N	Y	Y	-
EL713	Electrical Machine Design	3	2	0	3	4	N	Y	N	-
EL724	Electric Drives	3	0	2	2	4	N	Y	Y	-
EL9XX	Department Elective-II	3	0	0	2/2/2	3	N	Y	N	-
EL710	Commissioning and Testing of Electrical Equipment	3	0	2	2	4	N	Y	Y	-
EL711	Project	-	-	2	5	5*	N	Y	Y	-
EL9XX	Department Elective-III	3	0	2	2/4/2	4	N	Y	Y	-
	Total	**18**	**2**	**10**	**18/20**	**28**				-
	Total Teaching Hours	**30**								-

Department Electives-II

Course Code	Course Name	Teaching Hours			SSH	Credits	Audit course	CIE	PSEE	Remarks if any
		Lecture	Tutorial	Practical						
EL907	HVDC and EHV AC Systems	3	0	0	2	3	N	Y	N	-
EL912	Energy Auditing and Conversation	3	0	0	2	3	N	Y	N	-
EL914	Power System Transients	3	0	0	2	3	N	Y	N	-

HOD **Director**

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DETAIL TEACHING SCHEME

Department Electives-III										
Course Code	Course Name	Teaching Hours			SSH	Credits	Audit course	CIE	PSEE	Remarks if any
		Lecture	Tutorial	Practical						
EL909	Industrial Automation and Control	3	0	2	2	4	N	Y	Y	-
EL908	Digital Signal Processing	3	0	2	2	4	N	Y	Y	-
EL916	Power System Stability and Control	3	0	2	2	4	N	Y	Y	-

N- No
Y – Yes

CIE – Continuous internal evaluation
PSEE – Practical semester end examination including ITD, Dissertation, Industrial project, Industrial training etc.

SSH - Self-study hours per week

Remarks: **Students are expected to work 10 hours/week on project. Two (2) hours shall be allotted in regular teaching for project.*

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RK UNIVERSITY

SYLLABUS

Course Title	**Advances in Power System**
Course Code	**EL712**
Course Credit	Theory :03
	Practical :01
	Tutorial :00
	Credits :04

Course Learning Outcomes:

At the end of the semester students will be able to;

- **Understand** the fundamental structure and element of the smart grid.
- **Analyze** drivers, challenges and benefits to the integration of renewable and distributed generation into large power grids.
- **Describe** the need of state estimation in real time monitoring of power system.
- **Explain** methods for economic dispatch and unit commitment.
- **Understand** the root of the power quality problems in industry and their impact on performance and economics.
- **Learn** to apply appropriate solution techniques for power quality mitigation based on the type of problem.

Detailed Syllabus

Sr. No.	Name of chapter & details	Hours Allotted
	SECTION-I	
1.	**Smart Grid Techniques** Introduction to smart grid- comparison of power grid with smart grid, need of power system enhancement-smart grid applications/ benefits-Smart Grid Functions, Smart Grid architecture, components, Key Challenges to implement the Smart Grid. Distributed generation and Microgrid concept-Distributed generation, integration of distributed generation, Concept of Microgrid- configuration and interconnection, technical and economic advantages of Microgrid Introduction to Indian smart grid.	**08**

2.	**State Estimation Techniques** Data acquisition, Role of a state estimator, Rationale of state estimator, Method of least square and for state estimation, Statistical errors and Bad data recognition.	**06**
3.	**Economic Dispatch and Unit Commitment** Incremental cost curve-co-ordination equations without loss-solution by Lambda iteration method- coordination equations with loss-solution of co-ordination equations using B_{mn} coefficients (no derivation). Unit commitment (UC) problem-constraints in UC-Solution Methods-Priority list methods (Numerical problems).	**07**
	Total	**21**
	SECTION-II	
4.	**Introduction to power quality** Terms and definitions: Overloading - under voltage - over voltage. Concepts of transients - short duration variations such as interruption - long duration variation such as sustained interruption. Sags and swells - voltage sag - voltage swell - voltage imbalance - voltage fluctuation - power frequency variations. International standards of power quality. Computer Business Equipment Manufacturers Associations (CBEMA) curve.	**07**
5.	**Voltage Sags and Interruptions** Sources of sags and interruptions - estimating voltage sag performance. Thevenin's equivalent source - analysis and calculation of various faulted condition. Voltage sag due to induction motor starting. Estimation of the sag severity - mitigation of voltage sags, active series compensators. Static transfer switches and fast transfer switches.	**06**
6.	**Harmonics and power quality measurement** Harmonic sources from commercial and industrial loads. Effect of harmonics – harmonic distortion - voltage and current distortion - harmonic indices-harmonic phasor relationship. Harmonic distortion evaluation - devices for controlling harmonic distortion - passive and active filters. IEEE and IEC standards. Monitoring considerations - monitoring and diagnostic techniques for various power quality problems.	**08**
	Total	**21**

Instructional method and Pedagogy:

- Lectures will be conducted with the aid of multi-media projector, black board, OHP etc.
- Assignments based on course content will be given to the students at the end of each unit/topic and will be evaluated at regular interval.
- Surprise tests/Quizzes/Seminar/ will be conducted

Reference Books:

1. T. K. Nagsarkar & M. S. Sukhija, “Power System Analysis”, Oxford university press, 9th edition.
2. Ekanayake J.B. Liyanage Kithsiri Wu Jianzhong Yokoyama Akihiko &Jenkins Nick, “Smart Grid : Technology and Applications”, Wiley publication, India, New Delhi, ISBN9788126557356.
3. N. V. Ramana, “Power System Operation and Control”, Pearson publication, 2011.
4. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.Wayne Beaty, ‘Electrical Power Systems Quality’ McGraw Hill,2003.
5 Power Generation Operation & Control, John Wiley & Sons, Inc, 1996- A. J.Wood and B. F. Wollenberg.
6 Power quality enhancement using custom power devices, A. Ghosh and G. Ledwich, Kluwer Academic Publication, 2002.
7 Power quality, C. Shankran, CRC Press, 2001.
8 Handbook of power quality, editor: Angelo Baggini, John Wiley & Sons, 2008.
9 Instantaneous power theory and application to power conditioning, H. Akagi et al., IEEE Press, 2007.

Additional Resources

- Power Standards Lab - Tutorials & Standards-Website: www.powerstandards.com/tutor.htm
- A Course on Power Quality in Power Distribution Systems- http://nptel.ac.in/courses/108106025/#
- A Course on Thermodynamics: Fundamentals of Energy –Energy Resources & Technology- http://nptel.ac.in/courses/108105058/
- A Course on Introduction to Non-conventional Energy Systems - http://nptel.ac.in/courses/108108078/
- A Course on Power Electronics & Distributed Generation - http://nptel.ac.in/courses/108108034/
- Sakshat Virtual Lab-Power Quality Experiments-
- http://iitm.vlab.co.in/?sub=46&brch=144&sim=1056&cnt=3256

List of Experiments:	
1.	Familiarization with PSCAD/EMTDC and Understanding of Reactive Power and Power Factor Correction in AC Circuits.
2.	Explain Electromagnetic Transient Phenomenon by simple example using DC Source, Inductor and capacitance.
3.	To obtain the current harmonics drawn by power electronics interface.
4.	To study and simulate load frequency control loop in a single area power system with AGC (automatic generation control) and without AGC (automatic generation control).
5.	Study the dynamic interaction between two control areas using MATLAB (Simulink).
6.	To understand the fundamentals of economic dispatch and solve the problem using classical method without line losses and generating limits with the help of MATLAB program.
7.	To obtain the solution for Economic dispatch by Lambda-iteration method for without transmission losses with the help of MATLAB program.
8	Build a simple ac system to observer the transformer-energizing transient in PSCAD software.
9	To illustrate the effect of shading a single module in a PV array of 11 modules connected in series.
10.	To study and understand the capacitor switching phenomena using PSCAD software.
11.	To study the ferroresonance phenomena in power system and observe the effect of change of load, change the transformer losses on it.
12.	Understand the starting operation of an Induction machine.

Course Title	**Electrical Machine Design**
Course Code	**EL713**
Course Credit	Theory :03
	Practical :00
	Tutorial :01
	Credits :04

Course Learning Outcomes:

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

- **Describe** design factors, limitations, modern trends in design, manufacturing of electrical machines and properties of materials used in the electrical machines.
- **Apply** theoretical concepts in designing conventional electrical machines.
- **Discuss** selection of specific loadings and magnetic circuits of different electrical machines.
- **Sketch** various configurations of AC and DC Armature Windings.
- **Understand** the importance of design of machines based on their applications.

Detailed Syllabus

Sr. No.	Name of chapter & details	Hours Allotted
	SECTION-I	
1.	**Introduction** Principles of electrical machine design - General design considerations - Specifications of machines- Limitation in design- Recent trends in design – CAD – Flow chart methods - Review of properties of materials used in electrical machines - Magnetic circuit calculations- Introduction to Finite element method - mathematical formulation - magnetic field calculations.	**06**

2.	**Armature winding** **AC Windings** No. of phases, Phase spread, concentric winding, Hemitropic winding, Whole coil winding, Mush winding, Integral slot lap and wave winding. Fractional slot lap & wave windings. Examples. **DC Winding:** No. of phases, Phase spread, concentric winding, Hemitropic winding, Whole coil winding, Mush winding, Integral slot lap and wave winding. Fractional slot lap & wave windings. Examples	**08**
3.	**Design of Transformers** Output Equations – Main Dimensions - KVA output for single and three phase transformers –Window space factor – Overall dimensions – Operating characteristics – Regulation – No load current – Temperature rise in Transformers – Design of Tank - Methods of cooling of Transformers.	**07**
	Total	**21**
	SECTION-II	
4.	**Design of DC Machines** Output Equations – Main Dimensions - Magnetic circuit calculations – Carter's Coefficient – Net length of Iron –Real & Apparent flux densities – Selection of number of poles – Design of Armature – Design of commutator and brushes – performance prediction using design values.	**07**
5.	**Design of 3-ϕ Induction Motors** Output equation of Induction motor – Main dimensions – Length of air gap- Rules for selecting rotor slots of squirrel cage machines – Design of rotor bars & slots – Design of end rings – Design of wound rotor -– Magnetic leakage calculations – Leakage reactance of polyphase machines- Magnetizing current - Short circuit current – Circle diagram - Operating characteristics.	**07**
6.	**Design of Synchronous Machines** Output equations – choice of loadings – Design of salient pole machines – Short circuit ratio – shape of pole face – Armature design – Armature parameters – Estimation of air gap length – Design of rotor –Design of damper winding – Determination of full load field mmf – Design of field winding – Design of turbo alternators – Rotor design	**07**
	Total	**21**

Instructional method and Pedagogy:

- Lectures will be conducted with the aid of multi-media projector, black board, OHP etc.
- Assignments based on course content will be given to the students at the end of each unit/topic and will be evaluated at regular interval.
- Surprise tests/Quizzes/Seminar/ will be conducted.

Reference Books:

1. V. N. Mittle*, "Design of Electrical Machine"* TMH publications
2. A.K. Shawney*, "Electrical Machine Design"* Dhanpatrai & sons. Pub.
3. Fitzgerald, A.E. Kingsley, Charles Umans, Stephen "*Electric Machinery*", Tata Mc Graw-Hill Publishing Company Limited New Delhi
4. J.G. Jamnani, *"Elements of Electrical Design*" Mahajan Publication
5. M. N. O. Sadiku*, "Principles of Electromagnetics,* Oxford University Press, 2006
6. *"Electrical Power System Handbook"*, IEEE Press
7. W. H. Hayt*, "Engineering Electromagnetics",* McGraw Hill, 2007
8. N. Ida, *"Engineering Electromagnetics",* Springer, 2004.
9. E. C. Jordan and K. G. Balmain, *"Electromagnetic waves and Radiating systems*" Prentice Hall, 2004.
10. Design Data Handbook, A. Shanmugasundarm, G, Gangadharam, R. Palani, Wiley Eastern Ltd.

Additional Resources

- http://unifiedfieldtheories.com/EMFT_Book.pdf
- http://www.elect.mrt.ac.lk/EE201_em_theory.pdf
- http://web.iitd.ac.in/~hirani/MEL311.pdf

Course Title	**Electrical Drives**
Course Code	**EL724**
Course Credit	Theory :03
	Practical :01
	Tutorial :00
	Credits :04

Course Learning Outcomes:

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

- **Describe** the structure of Electric Drive systems and their role in various applications.
- **Describe** the operation of dc motor drives to satisfy four-quadrant operation to meet mechanical load requirements.
- **Explain** the operation of induction machines in steady state that allows them to be controlled in induction-motor drives.
- **Simulate** torque, speed and position controller of DC, AC-Induction and synchronous motor drives.
- **Model** and analyze electrical motor drives and their sub systems (converters, rotating machines and loads).
- **Use** space vectors presented on a physical basis to describe the operation of an ac machine.

Detailed Syllabus

Sr. No.	Name of chapter & details	Hours Allotted
	SECTION-I	
1.	**Introduction**: Definition of electric drive, type of drives; Speed torque characteristic of driven unit/loads, motors, joint speed-torque characteristic; Classification and components of load torque; Review of power converters used in drives, multi-quadrant operation of electric drive, example of hoist operation in four quadrants. **Estimation of Drive Motor Rating**: Selection of motor power capacity for continuous duty at constant load and variable loads; Selection of motor capacity for short time and intermittent periodic duty, permissible frequency of starting of squirrel cage motor for different duty cycles; Load equalization.	**09**

2.	**DC Drives:** Introduction, Speed-torque relation in dc motor, Methods of speed control, Single-phase half controlled and fully controlled converter fed dc motor drives, Multi-quadrant Operation of a DC Motor , Regenerative Braking, operation of dc drives with continuous armature current; Concept of energy utilization and effect of free-wheeling diode; Operation of drive under discontinuous current, expression for speed-torque characteristic. Separately Excited Dc motor drive, 1phase half controlled drive, 3 phase fully controlled drive, Pulse width modulated drives, Multi-quadrant operation of fully controlled rectifier fed drive, chopper control drive **Closed Loop Control of DC Drives:** Drives with current limit control, single-quadrant closed loop drive with inner current control loop, advantage of inner current control loop in drives, Types of single quadrant closed loop dc drives, Types of closed loop four quadrant dc drives.	**12**
	Total	**21**
	SECTION-II	
3.	**Induction Motor Drive** Variable voltage, rotor resistance and slip power recovery control of induction motors, torque-speed characteristics under different control schemes; Variable frequency control of induction motor, analysis of induction machine under constant V/f operation, constant flux operation and controlled current operation. **Inverter fed AC Drives:** Voltage source inverter fed induction motor drive in open loop, frequency and voltage control in PWM VSI; Operation of closed loop slip-speed controlled VSI fed induction motor drive; Current source inverter, advantage of CSI fed drives, closed loop slip speed-controlled CSI fed drive. **Introduction to space vector control:** Fundamental of direct torque control, vector control and field orient control-reference frame theory, of induction motor drive.	**11**
4.	**Synchronous Motor Drive** Performance Equation for synchronous motor for voltage sources and frequency source, classification of speed control methods, Speed control based of variable frequency control, Variable frequency control on loop motor drive, Types of synchronous motors, Self-Controlled synchronous motor drives, Drives based on load commutation, CSI with load commutation drive, Cycloconverter with load commutation drive, Control requirements for synchronous motor drive, Drives based on converters, VSI based synchronous motor drive, CSI based synchronous motor drive, Applications of synchronous motor drive closed loop operation, Servo Motor Drive with control block diagram and application	**10**

Total	**21**

Instructional method and Pedagogy:

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- Assignments based on course content will be given to the students at the end of each unit/topic and will be evaluated at regular interval.
- Surprise tests/Quizzes/Seminar/ will be conducted.

Reference Books:

1. Dubey G. K., "Fundamentals of Electric Drives", 2nd Ed., Narosa Publishing House, 2007
2. Theodore Wildi, *"Electrical Machines, Drives and Power System"*, Pearson Publication.
3. Dubey G. K., "Power Semiconductor Controlled Drives", Prentice Hall International Edition,1989
4. I.J Nagrath and D.P. Kothari, *"Electric Machines"*, Tata McGraw-Hill Education.
5. Bose B. K., "Power Electronics and Variable Frequency Drives",IEEE Press, Standard Publisher Distributors.
6. Sen P. C., "Thyristor DC Drives", John Wiley and Sons,1991.

Additional Resources

- https://nptel.ac.in/courses/108104011/
- https://nptel.ac.in/courses/108102046/

Course Title	**HVDC and EHV AC Systems**
Course Code	**EL907**
Course Credit	Theory :03
	Practical :00
	Tutorial :00
	Credits :03

Course Learning Outcomes:

At the end of the semester students will be able to-

- **Examine** different issues in EHV AC and UHV AC power transmission lines.
- **Analyze** transient stability of EHV AC lines.
- **Estimate** electrical and mechanical parameters of EHV AC systems**.**
- **Comprehend** various configurations of HVDC lines.
- **Discuss** control topologies of HVDC systems.

Detailed Syllabus

Sr. No.	Name of chapter & details	Hours Allotted
	SECTION-I	
1.	**EHV Transmission** Introduction-Necessity for EHV Transmission, Problems involved in EHV Transmission, Operational Aspects of EHV power transmission, Compensation of EHV systems, Gas insulated EHV lines-Environmental and biological aspects.	**06**
2.	**General Background of EHVAC Transmission Systems** Standard Voltage levels for Transmission lines, Hierarchical levels of Transmission Network, Average values of line parameters, Power handling capacity and line losses, Cost of Transmission line and Equipments, Mechanical consideration in line performance, Comparison of Overhead and Underground lines, Examples of Giant power pools in the world.	**07**
3.	**Aspects of EHVAC Systems** Power Transferability of Ac line, Line Losses-Conductor cost, Transient stability of Ac line, Control of power flow through line Right – of- way(Row)-Corona-Towers(support), Line insulation, Clearance and Creepage distances.	**06**

4	**UHV AC transmission system** Introduction to UHV AC line, applications and issues in Commisiong of UHV AC lines, Development of UHV lines in India and Abroad.	**02**
	Total	**21**
	SECTION-II	
4.	**HVDC Transmission Systems** Choice of HVDC Transmission, Comparison of AC and DC Transmission, Economics of DC power Transmission, Technical Performance and Reliability, Description of HVDC Converter station, Types of HVDC Links, Merits and Limitations of HVDC System, Applications, Modern Trends in HVDC transmission, Case Studies of HVDC links in the world.	**11**
5.	**Converters and HVDC System Control** Pulse number, Choice of Converter Configuration, Simplified analysis of Graetz circuit, Principles of HVDC link Control, DC Breaker, Harmonic Elimination – AC and DC Filter design, Protection Systems in HVDC Substation, HVDC Simulator.	**10**
	Total	**21**

Instructional method and Pedagogy:

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- Assignments based on course content will be given to the students at the end of each unit/topic and will be evaluated at regular interval.
- Surprise tests/Quizzes/Seminar/ will be conducted.

Reference Books:

1. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, Third Edition, New Age International (P) Limited, Publishers, 2009.
2. Sunil S.Rao, “EHV AC, HVDC Transmission and Distribution”, Khanna Publishers, 2004.
3. Padiyar. K.R “HVDC Power Transmission Systems”, New Age International (P) Limited, Publishers, 2009.
4. Prabha Kundur , “Power System Stability and Control”, Mc Graw Hill.
5. S Kamakshaiah and V. Kamaraju, “HVDC Transmission”, Mc Graw Hill.
6. Kimbark E. W. , “Direct Current Transmission Wiley Interscience Vol.I, Wiley, 1971.
7. Power System Analysis and Design, B. R. Gupta, S.Chand and Company (2004).

Additional Resources

- A Course on High-Voltage DC Transmission- http://nptel.ac.in/courses/108104013/

Course Title	Energy Auditing and Conservation
Course Code	EL912
Course Credit	Theory :03
	Practical :00
	Tutorial :00
	Credits :03

Course Learning Outcomes:

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

- **Relate** and **discuss** energy management, audit and conservation.
- **Select** appropriate energy conservation method to reduce the wastage of energy
- **Calculate** the payback period for a given energy conservation equipment
- **Categorize** different electric motor based on requirement and application
- **Select** efficient technology in electric systems.
- **Organize** a structure of an energy audit for a case study.

Detailed Syllabus

Sr. No.	Name of chapter & details	Hours Allotted
	SECTION-I	
1.	**Energy Scenario:** Commercial and Non-Commercial Energy, Primary Energy Resources, Commercial Energy Production, Final Energy Consumption, Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Sector Reforms, Concept of smart grid, Tariff.	**06**
2.	**Energy Conservation Act-2001 and related policies:** Energy Conservation Act-2001 and its features, Notification Under the act, Designated agencies, Schemes of Bureau of Energy Efficiency (BEE)- ECBC, S & L, DSM, BLY, SME's, Designated Consumers, Electricity Act 2003, Integrated Energy Policy.	**07**

3.	**Energy management, Audit and Conservation** Definition and objectives of energy management, Energy Audit: Types and Methodology-Need for energy audit, Type of energy audit, Preliminary energy audit methodology, Detailed energy audit methodology, Energy conservation concept, Identification of Energy Conservation Opportunities, Classification of Energy Conservation Measures. Energy Audit Reporting form, Understanding of Energy costs, Benchmarking and Energy performance, Fuel and Energy Substitution, Energy audit instruments.	**08**
	Total	**21**
	SECTION-II	
4.	**Energy efficiency in thermal utilities** **Cogeneration:** Need for cogeneration, Principle of Cogeneration, Advantages and disadvantages of cogeneration system. **Waste and Heat Recovery system:** Heat losses quantity and quality, Classification and application, Benefits of waste heat recovery, Commercial waste heat recovery devices - Recuperates	**07**
5.	**Energy efficiency and conservation in electric motors** Motor types, Motor characteristics and efficiency, Motor selection, Energy efficient motors, Factors affecting energy efficiency and minimizing motor losses in operation, Technical aspects of energy efficient motors, Rewinding effects on motor efficiency, Motor load survey methodology.	**04**
6.	**Energy efficient technologies in electrical systems** Maximum demand controllers, Automatic power factor controllers (Voltage control, KiloVAR control, Automatic power factor control relay, Intelligent power factor controller), Energy efficient transformers, Electronic ballast (Role of ballast, Conventional Vs. Electronic Ballast), Soft starters, Energy efficient lighting controls (Occupancy Sensors, Time based control: Types and Features, Daylight linked Control, Localized switching).	**07**
7.	**Energy Efficiency and Climate changes:** Energy and environment, Air pollution, Climate change, United Nations Framework Convention on climate change (UNFCCC), Kyoto Protocol, Clean Development Mechanism (CDM), CDM methodology and Procedures.	**03**
	Total	**21**
Instructional method and Pedagogy:		

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- Surprise tests/Quizzes/Seminar/ will be conducted.

Reference Books:

1. Y P Abbi & Shashank Jain, “Handbook on Energy Audit and Environment Management”, TERI, ISBN: 81-7993-092-0, 2006.
2. Giovanni Petrecca, Industrial “Energy Management: Principles and Applications”, The Kluwer international series, ISBN: 978-1-4615-3160-9, 1993.
3. Howard E Jordan, “Energy Efficient Electric motors and their applications”, Springer Publications, 1st edition, 978-1-4899-1465-1, 1994.
4. IEEE Bronze Book, “Recommended Practice for energy conservation and cost-effective planning in industrial facilities”, IEEE Inc, USA, ISBN: 978-0471820376, 2008.

Additional Resources

- Reference books, IEEE, Elsevier- Journals and Conference papers and internet sources.
- www.teriin.org
- www.teriuniversity.ac.in
- www.beeindia.in

Course Title	**Power System Transients**
Course Code	**EL914**
Course Credit	Theory :03
	Practical :00
	Tutorial :00
	Credits :03

Course Learning Outcomes:

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

- **Realize** the concepts of switching operations.
- **Envisage** the consequences of different changes in power system parameters.
- **Predict** the behavior of electrical quantities of network.
- **Put** forward the solutions to transient occurrences and their mitigations.

Detailed Syllabus

Sr. No.	Name of chapter & details	Hours Allotted
	SECTION-I	
1.	**Basic concepts of switching transients** Representation of electric power system as RLC network, Switching of high voltage high frequency: LR Circuit, LC Circuit and RLC Circuit in terms of breaking operations.	**05**
2.	**Transient Analysis of Three-Phase circuits** Symmetrical Components in Three-Phase Systems, Sequence Components for Unbalanced Network, Impedances, The Sequence Networks, The Analysis of Unsymmetrical Three-Phase Fault, The Single Line-to-Ground Fault, The Three-Phase-to-Ground Fault.	**08**
3.	**Travelling Waves on transmission lines** Velocity of Travelling Waves and Characteristic Impedance, Energy Contents of Travelling Waves, Attenuation and Distortion of Electromagnetic Waves, The Lossless Line, The Distortion less Line, Reflection and Refraction of Travelling Waves, The Lattice Diagram.	**08**
	Total	**21**

SECTION-II		
4.	**Effects of Lightning Flashes and Shielding of Transmission lines** Electrostatic field due to Leader stroke, calculation of shielding angle, frequency of occurrence of lightning flashes to transmission line, electric field at earth as a function of leader stroke charge, approximate calculation of area of attraction.	**10**
5.	**Measurement of Fast transients and Damping of Transient occurrences** Measuring current and voltage transients, generalized damping curves, Resistance switching, Load switching, damping and frequency.	**06**
6.	**Protection against transients** Shielded wires, Counter-Poise wires, EHV & UHV surge arrester, calculation of insulation levels at substations with protective zones, standard BILs	**05**
	Total	**21**

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- Assignments based on course content will be given to the students at the end of each unit/topic and will be evaluated at regular interval.
- Surprise tests/Quizzes/Seminar/ will be conducted.

Reference Books:

1. K. Venkata Ratnam, “Special electrical Machines”, University press, 2009, New Delhi.
2. T.J.E. Miller, “Brushless Permanent magnet and reluctance motor drives”, Clarenden press, 1989, Oxford.
3. E. G. Janardhanan, “Special electrical machines”, PHI learning private limited, 2014.
4. Dubey. G .K. “Fundamentals of Electric Drives”, Alpha Science International Limited, Second revised edition, 2008.
5. Cyril G. Veinott, “Fractional and Sub-fractional horse power electric motors”, McGraw Hill International Limited, Fourth edition,1986.
6. Say. M.G “Alternating current Machines”, John Willey & Sons, Fifth edition 1983.
7. Rai. H.M “Electrical Machine Design”, Satya Prakashan Publications, Third edition, 2004.

Course Title	**Commissioning and testing of Electrical Equipment**
Course Code	**EL710**
Course Credit	Theory :03
	Practical :01
	Tutorial :00
	Credits :04

Course Learning Outcomes:

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

- **Recognize** the difference between power transformer and distribution transformer.
- **Identify** various points to be considered while locating transformer and induction machine.
- **Differentiate** and **categorize** different test performed on transformer, induction motor, synchronous machine and protective devices.
- **Demonstrate** various drying out procedures for transformer, induction motor and synchronous machines.
- **Estimate** polarization index for transformer, induction motor and synchronous machine.
- **Plan** maintenance schedule for transformer, induction motor, synchronous machine and switchgear and protective devices.

Detailed Syllabus

Sr. No.	Name of chapter & details	Hours Allotted
	SECTION-I	
1.	**Safety Management:** Objectives, Safety Management during Operation and Maintenance, Clearance and Creepage distances, Electric Shock, need of Earthing, different methods of Earthing, factors affecting the Earth Resistance, methods of measuring the Earth Resistance, Equipment Earthing and System Grounding, Earthing Procedure - Building installation, Domestic appliances, Industrial premises, earthing of substation, generating station and overhead line.	**7**
2.	**Transformer:**	**7**

	Specification of Power and distribution transformers as per BIS. Installation: Location, site, selection, foundation details, polarity & phase sequence (electrical connections), drying of windings and general Inspection.	
3.	**Transformer Commissioning Tests:** Commissioning tests: Volt ratio test, OC & SC Test earth resistance, oil breakdown strength, insulation resistance test, polarizing index, load & temperature rise test, SFRA test. Specific Tests: Determination of performance curves like efficiency, voltage regulation.	**7**
	Total	**21**
	SECTION-II	
4.	**Induction Motor and Commissioning Tests** Specifications for different types of motors, Duty, I.P. protection. Installation: Location of the motors (including the foundation details) & its control apparatus, shaft & alignment for various coupling, fitting of pulleys & coupling, drying of windings. Commissioning Test: Mechanical tests for alignment, air gap symmetry, tests for bearings, vibrations & balancing. Specific Tests: Performance & temperature raise tests, shaft alignment, and Pulleys & couplings, Drying of windings.	**7**
5.	**Synchronous Machines** Specifications As per BIS standards. Installation**:** Physical inspection, Rating nameplate details, Foundation details, Alignments, Excitation systems, Cooling & control gear, drying out. Commissioning Tests: Insulation, Resistance measurement of armature & field wings, Wave from & telephone interference factors, Line charging capacity.	**7**
6.	**Synchronous Machines Performance Tests** Various tests IP estimate the performance for generator & motor operations slip maximum lagging currents, Maximum reluctance power tests, Sudden short circuit tests, transient & sub transient parameters, measurements of sequence impedances, capacitive reactance, Separation of losses, temperature rise tests, and Retardation test. Factory Tests - Gap length, magnetic eccentricity balancing vibration, bearing performance.	**7**
	Total	**21**

Instructional method and Pedagogy:

- Lectures will be conducted with the aid of multi-media projector, black board, OHP etc.
- Assignments based on course content will be given to the students at the end of each unit/topic and will be evaluated at regular interval.

- Surprise tests/Quizzes/Seminar/ will be conducted.

Reference Books:

1. S.Rao, " Testing Commissioning Operation & Maintenance of Electrical Equipments", *Khanna Publishers, 6th Edition, ISBN No: 81-7409-185-8.*
2. R.C.Richardson," *The commissioning of Electrical Plant and Associated Problems",* Chapman and hall Publication.
3. Relevant Bureau of Indian Standards.

List of Experiments:

1	Determination of voltage and current ratio for a single-phase transformer.
2	To measure the insulation resistance of single-phase transformer.
3	To determine the equivalent parameters and different type of losses of a given single phase transformer.
4	To determine the winding resistance and insulation resistance of a 3-phase I.M.
5	To perform no-load and blocked rotor test on a 3-phase I.M.
6	To conduct load test on the 3-phase I.M. and plot the performance characteristics.
7	To Determination Of Xd And Xq Of Salient Pole Synchronous Machine.
8	To obtain the v curve and inverted V curve of synchronous machine
9	To study various procedures and pre-checks for motor installation.
10	To prepare a technical report on trouble shooting and commissioning of induction motor.
11	To measure earth resistance with a dedicated earth tester.
12	To study drying out methods of transformer.

Course Title	PROJECT
Course Code	EL711
Course Credit	Lecture : 00
	Practical : 00
	Tutorial : 00
	Total : 05

Course Learning Outcomes

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

- **Identify, formulate** and **analyse** an engineering problem related to Electrical Engineering.
- **Acquire** the knowledge of techniques, skills, and modern engineering tools necessary for engineering practice.
- **Contribute** in a teamwork to realise the fruit of technical project.
- **Present, discuss**, and constructively **criticize** features of the developed project to the targeted group through written and oral communication.
- **Evaluate** the social, sustainability, and ethical aspects of research and development of the project.
- **Analyze** the outcomes of implemented solution.

Project Guidelines

Project work should be based on one of the following topics:

- To identify the problems in industry and society.
- Perform Literature survey on the specific chosen topic through research papers, Journals, books
  etc. and market survey if required.
- To narrow down the area taking into consideration his/her strength and interest. The nature of
  project can be analytical, simulation, experimental, design and validation.
- To define problem, objectives, scope and its outcomes.
- To design scheme of implementation of project.
- Data collection, simulation, design, hardware if any need to be completed.
- Presentation based on partially completed work.
- Submission of report based on the work carried out.

Instructional Method and Pedagogy:

- The project work should be carried out in one semester.
- One Laboratory per week will be conducted to guide and evaluate student progress. Students need to spend five hours per week to accomplish the interdisciplinary project.
- Preliminary work of the project should be completed in time such as topic selection, literature study, methodology, etc.
- Each student should maintain project progress log book and it should be signed by the guide on regular basis.
- Attendance is compulsory in laboratory. Minimum two internal exams will be conducted and average of two will be considered as a part of overall evaluation.
- Oral examination shall be conducted along with final presentation of the project.
- The project work shall be evaluated on the basis of predefined rubrics.
- Each student must prepare and submit the project report with CD-R which will consists of .doc & .pdf format of the report and .ppt format of presentation at the time of final presentation of the project.
- There will be one departmental copy, one guide copy, and one student copy of the project report.

Report Layout

1. Cover Page & Title Page
2. Declaration
3. Certificate
4. Project work Approval
5. Acknowledgement
6. Abstract
7. Table of Contents
8. List of Table
9. List of Figures
10. List of Symbols, Abbreviations, and Nomenclature
11. Chapters
12. Conclusions
13. Appendices
14. References

Project Report Preparation Guideline

- Paper must be White Royal Executive Bond A4 size and not less than 85 gsm.
- Font size type and margins as per below table.

Details	Font Type	Font size	Spacing
Facing page (cover and first page) - see sample page for details	Times New Roman	14pt bold capitals	Centered (Adjustable spacing)
Chapter headings with chapter number on top	Times New Roman	14pt bold capitals	Centered

Section headings	Times New Roman	12pt bold capitals	Left adjusted
Subsection headings	Times New Roman	12pt. sentence case	Left adjusted
Paragraph headings	Times New Roman	12pt. bold sentence case	Left adjusted
Body of Project report	Times New Roman	12 pt.	Justified and with 1.5 line spacing for text and equations
Margins	Left Margin	1.5 inch	To accommodate binding area
	Right Margin	1.25 inch	
	Top	2.0 inch	On pages on which chapter begins
		1.25 inch	Other pages
	Bottom	1.25 inch	

- References should be as per IEEE citation format.
- Bibliography contains materials that were useful for the preparation of the Project report in a general way and is not directly referred to in the Project report.

Additional Resources:

- E-journal available at library portal.

Course Title	**Industrial Automation and Control**
Course Code	**EL909**
Course Credit	Theory :03
	Practical :01
	Tutorial :00
	Credits :04

Course Learning Outcomes:

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

- **Develop** the knowledge in the field of automation in industries.
- **Describe** different industrial protocol.
- **Discuss** basic knowledge about PLC, SCADA and DSC.

Detailed Syllabus

Sr. No.	Name of chapter & details	Hours Allotted
	SECTION-I	
1.	**Control System and Automation Strategy** Evolution of instrumentation and control, Role of automation in industries, Benefits of automation, Introduction to automation tools PLC, SCADA, DSC, Hybrid DSC/PLC, Automation strategies evaluation, Control system audit, Performance criteria, Safety systems.	**06**
2.	**Programmable Logic Controllers (PLC)** Introduction, Architecture, Definition of discrete state process control, PLC Vs PC, PLC Vs DSC, relay diagram, ladder diagram, ladder diagram examples, Relay sequencers, Timer bar counters, PLC design	**10**
3.	**Advance Applications of PLC and SCADA** PLC programming methods as per IEC 61131, PLC applications for batch process using SFC, Analog control using PLC, PLC interface to SCADA bar DSC using communication link (RS332, RS485) and protocol(Modbus ASCII/RTU).	**05**
	Total	**21**
	SECTION-II	

4.	**Instrumentation Standard Protocols** HART protocol introduction, Frame structure, Programming, Implementation examples, Benefits, Merits and demerits. Foundation fieldbus H1 introduction, Structure, Programming, FDS configuration, Implementation examples, Benefits, Merits and demerits, Comparison with other field bus standard including device net, Profibus, Control net, CAN, Industrial ether net etc.	**08**
5.	**Distributed Control Systems** Introduction, Functions, Advantages and limitations, DSC as an automation tool to support enterprise resource planning, DSC architecture of different makes, Specifications, Configurations and programming functions including database management, Reporting, Alarm management, Communication, third party interface, Control, Display etc. Enhanced functions viz. Advance Process control,	**08**
6.	**Automation for Following Industries** Power, Water and waste water control, Food and beverages, cement, Pharmaceuticals, Automobile and building automation.	**05**
	Total	**21**

Instructional method and Pedagogy:

- Lectures will be conducted with the aid of multi-media projector, black board, OHP etc.
- Assignments based on course content will be given to the students at the end of each unit/topic and will be evaluated at regular interval.
- Surprise tests/Quizzes/Seminar/ will be conducted.

Reference Books:

1. Webband Reis**, "**Programmable Logic Controllers: Principles and Applications**"**, PHI Publications.
2. N.E.Battikha, "The management of Control System: Justification and Technical Auditing**",** ISA Publications.
3. Krishna Kant**, "**Computer Based Process Control**",** PHI Publications.
4. Poppvik Bhatkar**, "**Distributed Computer Control for Industrial Automation", Dekkar Publications.
5. S.K. Singh**, "**Computer Aided Process Control", PHI Publications
6. Garry Dunning**, "**Introduction to Programmable Logic Controllers", Thomas Learning Publications.

List of Experiments:

Sr. No.	Name of Experiments
1.	Use industrial grade sensors and transducer introduction and characteristics like proximity detector, linear encoder, rotary encoder, touch sensor, force sensor, accelerometer, RTDs, load cells and LVDT for measurement
2.	Use Various actuators such as relay, solenoid valve, process control valve and motors for control applications
3.	Simulate analog and digital function blocks
4.	Relay logic diagram and ladder logic diagram
5.	Understand and perform experiments on timers and counters
6.	Logic implementation for traffic Control Application
7	Logic implementation for Bottle Filling Application
8.	Tune PID controller for heat exchanger using DCS
9.	FBD for autoclavable laboratory fermentor
10	Develop graphical user interface for the plant visited by you
11	Mini Project

Course Title	**Digital Signal Processing**
Course Code	**EL908**
Course Credit	Theory :03
	Practical :01
	Tutorial :00
	Credits :04

Course Learning Outcomes:

At the end of the semester students will be able to-

- **Understand** of the digital signals, discrete time systems.
- **Understand** and **apply** frequency domain representation of discrete signals
- **Analysis** of linear time invariant systems with Z-Transforms.
- **Design** structure for discrete time systems and filter design techniques.
- **Understand** DSP processors architecture and programming.

Detailed Syllabus

Sr. No.	Name of chapter & details	Hours Allotted
	SECTION-I	
1.	**Review Discrete Time Systems& Z-transform** Computation of Impulse & response & Transfer function using Z Transform. DTFT Properties and examples - LTI-DT systems -Characterization using difference equation - Block diagram representation - Properties of convolution and the interconnection of LTI Systems - Causality and stability of LTI Systems.	**08**
2.	**Frequency Domain Analysis of Discrete Signals** DFT, Properties, IDF, Linear Filtering Methods Based On DFT, FFT Algorithms, Goertzel Algorithm, Linear Convolution, Circular Convolution. Applications Of FFT, Applications Of DSP to power system.	**07**

3.	**Design of Digital Filters** FIR Filters, Design Of FIR Digital Filters Window Method, Frequency Sampling Methods, FIR Filter Structures - Direct Form Structures, Cascade Form Structures, IIR filter, Design Of IIR Digital Filter Methods Like, Approximation Of Derivatives, Impulse Invariance, Bilinear Transformation, Characteristics Of Butterworth, Chebyshev, Frequency Transformations, IIR Filter Structures Like Direct Form, Parallel Form, Lattice And Lattice – Ladder Structures, Effect Of Finite Register Length In Fir Filter Design.	**09**
	Total	**24**
	SECTION-II	
4.	**Digital Signal Processors** Overview of Digital Signal processors, Selecting Digital Signal Processors, Comparison of some common digital processor, Von Neumann Architecture, Hardvard Architecture, VLIW Architecture, General Purpose DSP: Fixed Point and Floating Point arithmetic, Hardware Multiplier-Accumulator, Special Instructions, On-Chip memory, parallelism, Piplelining.	**06**
5.	**Architecture of TMS320 DSP** Overview. Pins and signals. Internal Architecture. Arithmetic and Logic Unit. Auxiliary Registers, Fixed Point and Floating-Point precision algorithm design, Mathematical, structure and numerical constraints.	**06**
6.	**DSP Programming and Applications of DSP** TMS320 Assembly Language Programming and C Language Programming of DSP, Processor Addressing modes, Instruction set, Programming tools such as DSP Assembler, IDE environments like CCS for DSP chip or visual DSP for Analog DSP chips, programming using DSP processor.	**06**
7.	**Application of DSP in power systems** Measurement of electrical quantities, Power system Protection, State estimation etc. Application of DSP for data compression, array processing and in control System.	**02**
	Total	**21**

Instructional method and Pedagogy:

- Lectures will be conducted with the aid of multi-media projector, black board, OHP etc.
- Assignments based on course content will be given to the students at the end of each unit/topic and will be evaluated at regular interval.
- Surprise tests/Quizzes/Seminar/ will be conducted.

Reference Books:

1. Smith, S. W. The Scientist and Engineer's Guide to Digital Signal Processing
2. J.G.Proakis, D.G.Manolikis, “Digital Signal Processing”, edition II, PHI.
3. Ifeachor, Jervis, “Digital Signal Processing “, edition I, Pearson Education.
4. TI User Manuals TMS320C2x, TMS320LF2407, TMS 320LF2812
5. Website www.ti.com and , www.DSPguide.com
6. Marven, C., Ewers, G. A simple approach to DSP Texas Instr. 1993.

Course Title	**Power System Stability and Control**
Course Code	**EL916**
Course Credit	Theory :03
	Practical :01
	Tutorial :00
	Credits :04

Course Learning Outcomes:

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

- **Explain** methods for dynamic power system analysis, including steady state and transient stability.
- **Know** the construction, modelling and control of FACTS components related to power system stability.
- **Analyze** the stability of simple power systems using linear analysis methods and the equal area method.
- **Apply** computer simulation tools for dynamic and static analysis of large power systems.
- **Derive** the differential equations describing simple one machine infinite bus systems and perform detailed analyses of such systems.
- **Perform** analysis related to frequency control and reserve requirements in a synchronously interconnected power grid.

Detailed Syllabus

Sr. No.	Name of chapter & details	Hours Allotted
	SECTION-I	
1.	**Modeling of Synchronous Machine for Stability Study** Structure of power system, power system control, operating states of power system and control strategies, Modelling of synchronous generator, synchronous generator phasor diagram for different power factors, phasor diagram for salient pole generator, Power factor control and power angle characteristic of cylindrical rotor, Synchronous machine modelling for stability studies with and without saliency.	**03**

2.	**Steady State Power System Stability** Derivation of swing equation, M and H constants, equivalent H constant and examples, Classification of power system stability, Steady state stability, derive the expression for natural frequency of oscillations and damped frequency of oscillations, example, Derivation of synchronizing power coefficient, examples	**06**
3.	**Transient Stability of Power System Stability** Transient stability and factors affecting it, Equal area criteria, Cases of sudden application of mechanical power input, application of three phase fault at the middle of the line or at the end of the line, effect of reclosing on stability, Example based on equal area criteria, Point by point method for the solution of swing equation and examples, Transient stability of multi machine system	**06**
4.	**Small Signal Stability of Single Machine Infinite Bus (SMIB) System** Introduction, eigen value and stability, stability phenomena, types of oscillations, Block diagram representation of SMIB with classical generator model, Block diagram representation of SMIB system with exciter and AVR, effect of AVR on synchronizing and damping torque constant, Power system stabilizer (PSS)	**06**
	Total	**21**
	SECTION-II	
5.	**Voltage Stability (VS) of Power System** Voltage stability, voltage instability and voltage collapse, voltage stability phenomena illustration by radial feeder, active and reactive power transmission by elementary models, difficulties with reactive power transmission, Basic concepts related to VS, transmission system characteristic, PV and QV curve, Derivation of voltage stability limit, examples, Impact of generator characteristic, load characteristic, characteristic of reactive power compensating devices, Voltage stability classification on time frames, voltage collapse scenario, Corrective steps for prevention of voltage collapse, Nature of system response to severe upsets, system responses to islanding condition, system restoration, distinction between mid-term and long-term stability, Power plant responses during severe upsets	**11**

6.	**Methods for Power System Stability Improvement** Different methods for enhancement of transient stability and small signal stability, FACTS controller for stability enhancement: Static Var Compensator (SVC), V-I characteristic of SVC and STATCOM, increase in steady state power transfer capability with SVC, transient stability enhancement with SVC, enhancement of synchronizing torque with SVC, augmentation of power system damping with SVC, TCSC operating principle, enhancement of stability and voltage stability prevention with TCSC	**10**
	Total	**21**

Instructional method and Pedagogy:

- Lectures will be conducted with the aid of multi-media projector, black board, OHP etc.
- Assignments based on course content will be given to the students at the end of each unit/topic and will be evaluated at regular interval.
- Surprise tests/Quizzes/Seminar/ will be conducted.

Reference Books:

1. P. Kundur, "*Power System Stability and Control"*, McGraw Hill, 1994.
2. *"Power System Analysis",* by Hadi Saadat, Tata Mcgraw Hill
3. *"Modern Power* SystemAnalysis", by D.P. Kothari & I. J. Nagrath, Tata Mcgraw Hill
4. *"Power System Analysis and Design",* by B.R. Gupta, S. Chand.
5. C.W. Taylor, "*Power System Voltage Stability"*, McGraw Hill, 1994.
6. *"Power System Analysis"* by Grainger & Stevenson, Tata Mcgraw Hill
7. R. Mohan Mathur and R. K. Varma, *"Thyristor-based FACTS controllers for Electrical Transmission systems"*, IEEE Press, 2002
8. E. Kimbark, *Power System Stability*, Vol. I, II and III, IEEE Press, 1995.

Additional Resources

- A Course on Computer Aided Power System Analysis- http://nptel.ac.in/courses/108107028/
- A Course on Power System Stability Problem- http://nptel.ac.in/courses/108102080/
- A Course on Power System Dynamics & Control Introduction- http://nptel.ac.in/courses/108101004/
- A Course on Nonlinear Dynamical Systems- http://nptel.ac.in/courses/108101002/
- A Course on Introduction to Power System Stability- http://nptel.ac.in/courses/108106026/
- A Course on Modern Power Systems- http://nptel.ac.in/courses/108101040/