Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore

Name of Program: B. Tech (Railway Engineering)

SUBJECT CODE	Category	SUBJECT NAME	TEACHING & EVALUATION SCHEME								
			THEORY			PRACTICAL		Th	T	P	CREDITS
			END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*				
BTEC509	EC	Analog & Digital Communication	60	20	20	30	20	3	1	2	5

Legends: **Th** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based on following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

Course Educational Objectives (CEOs):
To provide the basic fundamentals, principles, concepts of communication systems and various modulation techniques of analog and digital communication systems.

Course Outcomes (COs):
After completion of this course the students are expected to be able to demonstrate following attributes:
1.Ability to analyze signals in the time domain and frequency domains.
2.Ability of demonstrating various analog modulation and demodulation techniques and apply suitable modulation techniques for various applications.
3.Ability of demonstrating various digital modulation and demodulation techniques and apply suitable modulation techniques for various applications.

UNIT-I **[7 Hrs]**

Signals: Classification of signals, Time Domain and Frequency Domain Representation, singularity functions for continuous time.
Spectral Analysis: Fourier series analysis, Fourier Transform and their Properties, Transform of singularity functions and Periodic Signal. Energy and Power Spectral Density of various types of signals.
Systems: Classification of systems, Impulse Response and Convolution integral.

UNIT-II **[7 Hrs]**

Amplitude modulation Techniques
Need of modulation, Amplitude modulation: mathematical representation of AM, modulation index, frequency spectrum, single tone and multi tone AM, generation of AM (square law modulator, switching modulator), Detection of AM (Square law detector, envelope detector), Power distribution, DSB-SC: generation and detection techniques, SSB: generation and detection techniques, VSB.

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UNIT-III [7 Hrs]

Angle modulation Techniques

Frequency and phase modulation, spectrum and bandwidth, Narrowband FM, Wideband FM, FM Modulators: Direct and Indirect method of frequency modulation, FM Detectors: Slope Detector, Foster Seeley Discriminators, Ratio Detectors and PLL detectors.

UNIT-IV [8 Hrs]

Digital conversion of Analog Signals

Sampling theorem, types of sampling, signal reconstruction and reconstruction filters, Pulse Amplitude Modulation (PAM), Pulse Width Modulation (PWM), Pulse Position Modulation (PPM), Quantization, quantization error, Pulse Code Modulation (PCM), Companding, TDM-PCM, Differential PCM, Delta modulation, Adaptive Delta modulation.

UNIT-V [8 Hrs]

Digital Modulation Techniques

Generation and Detection: Amplitude shift keying, Binary Phase shift Keying, differential PSK, Quadrature PSK, M-ary PSK. Frequency shift Keying, M-ary FSK, Quadrature Amplitude Modulation. Bandwidth, spectrum and constellation diagram of various shift keying techniques.

Text Books:

1. B.P. Lathi, Modern Digital and Analog Communication System; TMH, 2014.
2. Simon Haykins, Communication System, John Willy, 2011.
3. Singh & Sapre, Communication System, TMH, sixth reprint, 2016.
4. Taub & Shilling, Communication System, TMH, 2013.

References:

1. P Ramakrishna Rao, "Analog Communication", McGraw Hill Education, 1st Edition, 2011.
2. H P. Hsu: "Schaum's Outline of Signals and Systems", McGraw Hill Education, 3rd Edition, 2014.
3. John G. Proakis, Masoud Salehi, "Fundamental of Communication Systems", Pearson Edition, 2nd Edition, 2014.
4. Wayne Tomasi, "Electronic Communication Systems: Fundamentals Through Advanced", Pearson Edition, 5th Edition, 2008.

List of Experiment:

1. To Understand the Fourier Series Decomposition and Reconstruction for periodic Signals
2. To analyze characteristics of AM modulator & Demodulators.
3. To analyze characteristics of FM modulators& Demodulators.
4. To Study sampling process and signal reconstruction and aliasing.
5. Study of PAM, PPM and PWM.
6. Study of PCM transmitter and receiver.
7. Study of Time division multiplexing (TDM) and De multiplexing.
8. Study of Delta modulation.
9. Study of Adaptive delta modulation.
10. Study of ASK PSK and FSK transmitter and receiver.

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SUBJECT CODE	Category	SUBJECT NAME	TEACHING & EVALUATION SCHEME								
			THEORY			PRAC-TICAL		Th	T	P	CREDITS
			End Sem University Exam	Two Term Exam	Teachers Assessent*	End Sem University Exam	Teachers Assesment*				
BTEE502		Power Electronics	60	20	20	30	20	3	1	2	5

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit;
Q/A – Quiz/Assignment/Attendance, MST Mid Sem Test.
*Teacher Assessment shall be based on following components: Quiz/Assignment/ Project/Participation in class (Given that no component shall be exceed 10 Marks)

Course Educational Objectives (CEOs):
This course aims to equip the students with a basic understanding of modern power semiconductor devices, various important topologies of power converter circuits for specific types of applications. The course also equips students with an ability to understand and analyze non-linear circuits involving power electronic converters.

Course Outcomes (COs): Upon completion of the course, the student will be able to
1. Understand the principle of operation of commonly employed power electronic converters.
2. Analyze non-linear circuits with several power electronic switches.
3. Equipped to take up advanced courses in Power Electronics and its application areas.

Syllabus

UNIT-I **[10 Hrs]**

Power Semiconductor diodes and Transistors: Types of power diodes-General purpose diodes-Fast recovery diodes- Their characteristics and applications, Bipolar junction transistors, Power MOSFETS P-Channel, N-Channel, IGBTs- Basic Structure and working, Steady state and switching characteristics-Comparison of BJT, MOSFET and IGBT-Their applications. SCRs, Static and dynamic characteristics-Two transistor analogy. GTO, DIAC, TRIAC, UJT, IGCT Characteristics.

UNIT-II **[8 Hrs]**

Turn on and turn off mechanism of BJT. Power MOSFET, IGBTs SCR trigger circuits-R, RC and UJT triggering circuits. Triggering circuits for single phase bridge rectifier and Choppers. Driver Circuits of MOSFET IGBT & BJT- Various commutation methods of SCRs- Protection of SCRs.

UNIT-III **[7 Hrs]**

AC-DC Converter: Principles of controlled rectification—Study of single phase and three phase half controlled and full controlled bridge rectifiers with R, RL, RLE loads Effect of source inductances.

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Dual Converters—circulating current mode and Non-circulating current mode, Control Strategies

UNIT-IV **[8 Hrs]**

DC-DC Converter: Classification of Choppers: A, B, C, D & E- Switching mode regulators - Study of Buck, Boost and Buck-Boost regulators.

AC-AC Converter: Principle of operation of Single Phase Bridge type cyclo-converters and their applications. Single phase and Three phase AC Voltage controllers with R & RL load.

UNIT-V **[8 Hrs]**

DC-AC Converter: Principle of operation of Single Phase Inverters-Three phase bridge inverters (180 and 120 Degree modes)-voltage control of invertors—Single Pulse Width Modulation-Multiple pulse width Modulation-Sinusoidal Pulse Width Modulation .Comparison of Voltage Source Inverter and Current Source Inverters- Introduction to Multilevel inverters.

Text Books:

1. Rashid, M.H, 'Power Electronics - Circuits, Devices and Applications', Prentice Hall Publications, 3 rd Edition, 2003.
2. M.D.Singh and K.B.Kanchandhani, 'Power Electronics', Tata McGraw-Hill Publishing Company Limited, 2nd Edition, 2006.

Reference Books:

1. Ned Mohan, Tore M. Undeland, William P. Robbins, 'Power Electronics', John Wiley & Sons Publications, 3rd Edition, 2006.
2. Vedam Subramaniam, 'Power Electronics', New Age International (P) Ltd Publishers, 2001.
3. Philip T. Krein, 'Elements of Power Electronics', Oxford University Press, 1st Edition, 2012.
4. V. R. Moorthi, 'Power Electronics- Devices, Circuits and Industrial Applications', Oxford University Press, 1st Edition, 2005. 4. P.S. Bimbhra, 'Power Electronics', Khanna Publishers, 3rd Edition, 13th Reprint, 2004

LIST OF EXPERIMENTS:

1. Show Static and dynamic characteristics of an SCR.
2. Examine Static and dynamic characteristics of TRAIC.
3. Examine Static and dynamic characteristics of DAIC.
4. Determine Characteristics of MOSFET and IGBT.
5. Analyze Single phase SCR Half controlled converter with R and RL load.
6. Analyze Single phase fully controlled (bridge) converter with R and RL load.
7. Design 3-phase SCR Half Controlled Converter (using simulation platform like MATLAB/Simulink)
8. Design of 3-phase SCR Fully Controlled Converter (using simulation platform like MATLAB /Simulink)
9. Recall of classes of commutation A, B, C, D, E, F.
10. Simulation of Chopper circuit using SCR.

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SUBJECT CODE	Category	SUBJECT NAME	TEACHING & EVALUATION SCHEME								
			THEORY			PRACTICAL		L	T	P	CREDITS
			END SEM UNIVERSITY EXAM	TWO TERM EXAM	TEACHER ASSESSMENT*	END SEM UNIVERSITY EXAM	TEACHER ASSESSMENT*				
BTRW501		Machinery Fault Diagnostics And Signal Processing	60	20	20	30	20	3	1	2	5

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 20 marks.

Course Educational Objectives (CEOs):

To introduction with (A)Machine Faults, (B)Measurement of fault (C) Data acquisition and signal processing techniques, (D) Fault Diagnosis.

Course Outcomes (COs):

After completion of this course the students are expected to be able to demonstrate the following:

1. Student would be able to understand machine faults and its generation modes.
2. Student would be able to measure the parameters of machines to diagnose the health of machine.
3. Students would be able to understand the phenomenon of data acquisition and signal processing.
4. Students will be able to diagnose the machine health by condition monitoring techniques.
5. Student would be able to understand the use of NDT techniques to diagnosis and prognosis the machine health.

Syllabus

Unit - I

Machine Faults: Basics of machine failure, causes of machine fault generation and failure, modes of failures, Fault generation in different components of machine; bearing faults, gear faults, fault in electrical motors, faults in power transmission systems, FMECA,

Unit - II

Measurement of Parameters: Measurement of mechanical and process parameters, Measurement of force, torque, temperature, pressure and flow, Measurement of displacement velocity and acceleration, Measurement of noise and vibration.

Unit – III **Data Acquisition and Signal Processing:** Introduction,sensors, microprocessors and transducers, displacement, position and proximity pickups, characteristics and mounting of transducers, collection of signals, conversion of mechanical signal into electrical signals.

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Signal Processing: Introduction, Signal processing devices and techniques, The Fast Fourier transform (FFT) analysis, time waveform analysis, phase signal analysis, spectral signal processes, wavelet analysis, ANN and fuzzy logic etc.

Unit - IV

Machine Health Diagnostics: Condition monitoring, signature analysis and their significance, machine signatures, temperature, vibration, wear particle and noise monitoring, current signature analysis, acceptable standards, online and offline techniques, performance trending, potential failure (PF) curves.

Unit-V

Non Destructive Testing: Introduction, visual inspection, crack detection techniques; magnetic crack detection & dye penetration, radiography, oil analysis, wear particle analysis, strain gauge technology, ultra-sonic crack detection, thermography etc.

References:

1. *"The vibration analysis handbook" by James I. Tylor; VibrationConsultants, Tampa, Florida, 1999.*
2. *"Vibration Spectrum Analysis" by Steve Goldman; Industrial PressInc., New York, 1994.*
3. *"Mechanical Vibrations" by A H Church; John Wiley & Sons Inc., 2005.*
4. *"Shock and Vibration Handbook" by Cyril M. Harris & Allan G. Piersol; McGraw-Hill Publishing Co.,*
5. *"Journal of Institute of Rail Transport"; Institute of Rail Transport (India).*
6. *"Vibratory Condition Monitoring of Machines" by J. S. Rao; Narosa Publishing House, New Delhi*
7. *"Practical Machinery Vibration Analysis and Predictive Maintenance" by C. Scheffer& Paresh Girdhar; Elsevier.*

List of Experiments

1. To study the different machine faults, its generation and modes.
2. To study the working and mountings of different sensors, microprocessors and transducers.
3. To study the different signal processing devices and techniques.
4. To study different online and offline condition monitoring techniques.
5. To perform vibration signature analysis on machine bearings.
6. To perform electrical motor current signature analysis.
7. To study the different non-destructive testing techniques.
8. To perform a crack detection test on specimen using magnetic/dye penetration technique.
9. To identify the fault in machine by wear particle/oil analysis.

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SUBJECT CODE	Category	SUBJECT NAME	TEACHING &EVALUATION SCHEME								
			THEORY			PRACTICAL		Th	T	P	CREDITS
			End Sem University Exam	Two Term Exam	Teachers Assessment*	End Sem University Exam	Teachers Assessment*				
BTRW502		Electric Traction	60	20	20	-	-	3	1	-	4

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit; Q/A Quiz/Assignment/Attendance, MST Mid Sem Test.

Course Educational Objectives (CEOs):

The course will provide understanding of different traction systems, Locomotives, Track electrification, Comparison between A.C and D.C systems of railway electrification, Types of speed and speed-time curves, Traction motors and their characteristics, Starting and speed control of D.C series ,A.C series and 3-phase induction motors.

Course Outcomes (COs):

After the successful completion of this course students will be able to

1. Distinguish different traction systems and latest trends in traction systems
2. Differentiate services of traction system based on speed time curve
3. Control different types of traction motors
4. Explain the distribution system of a traction system

Syllabus

UNIT-I **[9 hours]**

HISTORY AND PRESENT STATUS OF ELECTRIC TRACTION

Introduction, Third-rail Lines, First Electric Railways Subways and Tunnels, Practical Street Railways, Motor-car Trains Experimental Work, Mountain-grade Lines, Interurban Electric Railways, Railroad Terminals, Competition with Steam Roads, Switching Yards, Private Right-of-Way, Freight Service, Elevated Railways, Electric Locomotives.

Electric systems available for traction

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Direct-current Systems, Three-phase System, Single -phase Systems: Combinations of Electric Systems, Interchangeable or Universal Systems, Relative Advantages of Each System

UNIT-II **[9 hours]**

CHARACTERISTICS OF MODERN STEAM LOCOMOTIVES.

Introduction on Railway Practice, Locomotive Classification, Data Sheets on Proportions, Physical Characteristics , Operating Characteristics, Speed-Torque Characteristics, Compound Locomotives, Mallet Locomotives, Turbine Locomotives, Cost of Operation.

UNIT-III **[8 hours]**

ADVANTAGES OF ELECTRIC TRACTION FOR TRAINS

Physical Advantages, Financial Advantages, Investments decreased or increased, Earning Power and Net Earnings, By-products of Electrification, Advantages in Business Depressions, and in Competition, Social Advantages, Objections to Electric Traction.

UNIT-IV **[8 hours]**

ELECTRIC RAILWAY MOTORS FOR TRAIN SERVICE

Introduction : Direct or Continuous Current Motors, Three -Phase Alternating-Current Motors, Single -Phase Alternating-Current Motors, Comparison of Motors. Rating of Motors: Mechanical and Electrical Data:, Development of Motor Design, Speed -Torque Characteristics of Motors.

UNIT-V **[7 hours]**

ELECTRIC LOCOMOTIVE

Description of DC Electric locomotive, single phase and three phase AC Locomotives. Introduction of DC track electrification, AC track electrification, Major substation equipment.

Text Book

1. Partab H., Modern Electric Traction, Dhanpat Rai and Sons Publication, New Delhi, 2013.
2. Edward P. Burch, Electric Traction for Railway Trains, , Mcgraw-Hill publication,2014.

Reference Books:

1. Sheilah Frey, Railway Electrification Systems & Engineering, White Word Publications, Delhi, 2012.
2. J. Upadhyay & S. N. Mahindra Electric Traction, Allied Publishers Pvt. Ltd., Allied.

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SUBJECT CODE	Category	SUBJECT NAME	TEACHING & EVALUATION SCHEME								
			THEORY			PRAC-TICAL		Th	T	P	CREDITS
			End Sem University Exam	Two Term Exam	Teachers Assessment*	End Sem University Exam	Teachers Assessment*				
BTEE511	Elective	Power Quality	60	20	20	-	-	3	1	-	4

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit;
Q/A – Quiz/Assignment/Attendance, MST Mid Sem Test.
*Teacher Assessment shall be based on following components: Quiz/Assignment/ Project/Participation in class (Given that no component shall be exceed 10 Marks)

Course Educational Objectives (CEOs):
This course aims to study the production of voltages sags, overvoltage and harmonics and methods of control and also study various methods of power quality monitoring.

Course Outcomes (COs): Upon completion of the course, the student will be able to

1. Demonstrate the major power quality problems.
2. Understand equipments that are required to measure the quality of power, as well as techniques available to mitigate power quality problems.

Syllabus

UNIT I **[8 Hrs]**

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.

UNIT II **[8 Hrs]**

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.

UNIT III **[7 Hrs]**

OVERVOLTAGES

Sources of over voltages - Capacitor switching – lightning - ferro resonance. Mitigation of voltage swells - surge arresters - low pass filters - power conditioners. Lightning protection – shielding - line arresters - protection of transformers and cables.

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UNIT IV **[8 Hrs]**

HARMONICS

Harmonic sources from commercial and industrial loads, locating harmonic sources.Power system response characteristics - Harmonics Vs transients. Effect of harmonics - harmonic distortion - voltage and current distortion - harmonic indices - inter harmonics – resonance. Harmonic distortion evaluation - devices for controlling harmonic distortion - passive and active filters. IEEE and IEC standards.

UNIT V **[7 Hrs]**

POWER QUALITY MONITORING

Monitoring considerations - monitoring and diagnostic techniques for various power quality problems - modeling of power quality (harmonics and voltage sag) problems by mathematical simulation tools - power line disturbance analyzer – quality measurement equipment - harmonic / spectrum analyzer - flicker meters - disturbance analyzer. Applications of expert systems for power quality monitoring.

Text Books:

1. R.C. Duggan, "Electrical Power Systems Quality", TMH publication, Third Edition, 2012.
2. C.Sankaran, "Power Quality" by CRC publication, 2001.

Reference Books:

1. J. Vikramarajan, " Enhancement of the Power Quality and Power Factor in Power System" 2014.
2. Chattopadhyay, "Electric Power Quality",springer, 2011

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			THEORY			PRACTICAL		L	T	P	CREDITS
			END SEM UNIVERSITY EXAM	TWO TERM EXAM	TEACHER ASSESSTMENT*	END SEM UNIVERSITY EXAM	TEACHER ASSESSTMENT*				
BTRW512		Project Engineering and Management	60	20	20	0	0	3	1	0	4

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 20 marks.

Course Educational Objectives (CEOs):

To introduction with (A)Project Management Concept in Engineering, (B)Cost Estimation and Risk management, Project Engineering document and drawing, (C)Investment appraisal and quality systems.

Course Outcomes (COs):

After completion of this course the students are expected to be able to demonstrate following knowledge, skills and attitudes

1. Student will be able to understand basic concept of Project Management.
2. Student will be able to understand concept of Cost Estimation.
3. Student will be able to understand concept of Project Interface.
4. Student will be able to understand concept Project engineering documents and drawing.
5. Student will be able to understand concept of Risk Management and quality systems.

Syllabus

Unit-1

Introduction to project management: Definition of project management, purpose & Scope. Basic and detailed engineering: Degree of automation, Project S curves, manpower considerations, inter-department and organization interactions, Multi agency interaction. Types of projects and types of contracts. Project management functions Controlling, responsibility, directing, accountability, project authority and standard communication formats, project reviews. Project planning and scheduling, life project engineering and management cycle phases, the statement of work (SOW), projects specifications, bar charts, milestones, schedules, work breakdown structures.

Unit-2

Cost and estimation: Definition,Preliminary cost estimation, Detailed cost estimation, Final cost estimation, Estimate accuracy, pricing process, salary and other overheads, man-hours,

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materials and support costs. program evaluation and review techniques (PERT) and critical path method (CPM), total PERT/CPM planning crash times, software's used in project management.

Unit-3

Project Interface: Definition, Different project interfaces, Engineering interfaces, construction interfaces, pre-commissioning and commissioning interfaces.

Project Information: Process information, Instrument specifications and standards, Electrical specifications, bid documents, Project procedure, project schedule, Equipment Information.

Stake holder management: Direct stake holder and indirect stake holder.

Unit-4

Project engineering documents and drawing: Mechanical flow sheets, Process flow sheets, Instrument index sheets, loop wiring diagram, panel drawings and specifications, plot plans, installation details, special drawings, purchase requisition.

Design Criteria: Mounting instruments, Selections of units, charts, ranges; Instrument identification, Winterizing, Material of construction, Package equipment systems Electrical safety: NEC code, Purging and pressurization, Enclosures, Intrinsic safety.

Unit-5

Investment appraisal: Project viability, return on investment, net present value, payback, internal rate of return, cost benefit analysis.

Risk Management: Risk awareness, risk identification, risk assessment, risk evaluation, risk management, monitoring, positive risk or opportunity.

Risk Assessment and Mitigation: Definition, Types of project risk, qualitative risk analysis, quantitative risk analysis.

Introduction to International quality systems - ISO 9000 Quality management practices worldwide, certifying agencies. Quality, customers and ISO 9000 ISO 9000- A management overview ISO 9000- Quality system Inspection, Test standards and Calibration

References:

1. *Project Engineering and Management by SubhenduMoulik, Publisher: AuthorHouseUK, ISBN: 9781467890311.*
2. *Project Management planning and control by Albert Lester, Butterworth- Heinemann imprint of Elsevier. ISBN: 978-0-08-1020203. Publisher: Joe Hayton.*
3. *Applied Instrumentation in Process Industries by W.G. Andrew and H.B. Williams, Gulf Professional Publishing, 3rd ed. 2008, ISBN-13: 978-0872010475.*
4. *Project management: A systems approach to planning scheduling and controlling by Harlod Kerzner and Van Nostrand, John Wiley & Sons, 11th ed., 2013, ISBN: 978-1-118-02227-6.*

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			End Sem University Exam	Two Term Exam	Teachers Assessment*	End Sem University Exam	Teachers Assessment*				
BTEE512	Elective	Reliability Engineering	60	20	20	-	-	3	1	-	4

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit; Q/A – Quiz/Assignment/Attendance, MST Mid Sem Test.

*Teacher Assessment shall be based on following components: Quiz/Assignment/Project/Participation in class (Given that no component shall be exceed 10 Marks)

Course Educational Objectives (CEOs):

The overall aim of this course is to provide knowledge of basic reliability evaluation theories with applications for electric power systems. The course gives a thoroughly introduction to reliability theory and generally used models. It aims to arm the students with the concepts of evaluation of generation, transmission and distribution system reliability and their impacts on system planning.

Course Outcomes (COs):

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

1. Understand the concept of probability theory, distribution, network modelling and reliability analysis.
2. Analyze the reliability functions with their relationships and Markov modeling.
3. Evaluate reliability models using frequency and duration techniques and generate various reliability models.
4. Explicate the reliability of composite systems and distribution systems.

Syllabus

UNIT I **[8 hours]**

Probability Theory: Introduction to Probability, Probability distributions: Random variables, density and distribution functions. Mathematical expectation. Binominal distribution, Poisson distribution, normal distribution, exponential distribution, Weibull distribution. Normal Gaussian, Gamma and Beta distribution. Correlation and regression.

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UNIT II **[8 hour]**

Basic Tools and Techniques- Random processes methods & Markov process, Computation of power system reliability measures by using Markov reward models, Evaluation of reliability indices, Universal Generating Function (UGF) Method, Monte Carlo simulation.

UNIT III **[8 hour]**

Generation System Reliability Analysis: Capacity Outage Calculations, Reliability indices using the loss of load probability method, unit commitment and operating constraints, optimal reserve management, single and multi-stage expansion. Interconnected System, Factors affecting interconnection under emergency assistance.

UNIT IV **[6 hour]**

Transmission System Reliability Analysis: Introduction, Objectives of Transmission Planning, Network Reconfiguration, System and Load Point Indices, Data required for Composite System Reliability.

UNIT V **[10 hour]**

Distribution System Reliability Analysis: Radial Networks– Introduction, Network Reconfiguration, Evaluation Techniques, Effects of Lateral Distribution Protection, Bus Bar Failure, Scheduled Maintenance, Temporary and Transient Failure, Weather Effects, Breaker Failure.

Text books:

1. R. Billinton, R.N.Allan, Reliability Evaluation of Power systems, 1996 Plenum Press, New York.
2. Marko Cepin, "Assessment of Power System Reliability- Methods and Applications", Springer-Verlag London Limited 2011.

Reference books:

1. Sharles E.Ebeling. "An Introduction to Reliability and Maintainability Engineering", TMH.
2. J.Endrenyi , "Reliability Modelling in Electric Power Systems", John Wiley & sons, NY.
3. Athanasios Papoulis and S.Unnikrishna Pillai ,"Probability, Random variables and Stochastic Processes, 4th edition, Tata McGraw Hill, 2002.

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SUBJECT CODE	Category	SUBJECT NAME	TEACHING & EVALUATION SCHEME								
			THEORY			PRACTICAL		L	T	P	CREDITS
			END SEM UNIVERSITY EXAM	TWO TERM EXAM	TEACHER ASSESSTMENT*	END SEM UNIVERSITY EXAM	TEACHER ASSESSTMENT*				
BTRW511		Lubrication & Rotor Dynamics	60	20	20	0	0	3	1	0	4

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 20 marks.

Course Educational Objectives (CEOs)

The objective is to understand(A)tribology, lubrication, lubricant chemistry and engineering(B)Lubricant viscosity and its role in the development of Reynolds' equationLubricant types, composition, properties, applications(C)Lubricant handling, use, disposal and recycling(D) vibration in machinery, (E)Rotor-dynamics Analysis, (F) Bearing and its terminology.

Course Outcomes (COs)

Having successfully completed the module, you should be able to demonstrate knowledge and understanding of the following:

1. Lubricant viscosity and its role in the development of Reynolds' equation
2. The main regimes of lubrication and lubricant requirements
3. Lubricant types, composition, properties, applications
4. Lubricant handling, use, disposal and recycling
5. Lubricant condition monitoring and oil analysis
6. Vibration, Vibration in Machinery
7. Rotor Dynamics and bearings

Syllabus

Unit-I

An introduction to the principles of Lubrication. Reynolds Equation, Lubrication regimes: hydrodynamic lubrication, hydrostatic lubrication, elasto-hydrodynamic lubrication, mixed and boundary lubrication, Basic classes of lubricants and the selection of lubricant type based on the specific requirements, problems, particular components and complexities of machine, Properties of the lubricating oils: viscosity, compatibility, corrosion, deterioration, contamination Aqueous lubricants: type, properties, chemistry and applications, Greases: type, properties, chemistry and applications, Solid and gas lubricants: type, properties, chemistry and applications

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Unit-II

Lubricant additives: type, properties, chemistry and applications, Green and nano-lubricants: type, properties, chemistry and applications, Self-lubricating coatings: type, properties, coating techniques and tribological applications, Automotive, aero and marine lubrication and lubricants

Lubricant suppliers: oil, additives, special lubricants, Lubricant testing and specifications: bench tests, specification, Crankcase engine oil tests and specifications, Lubricant condition monitoring and oil analysis, Lubricant use, handling, storage, disposal, recycling, health and safety

Unit - III

The Main Sources of Vibration in Machinery, the Single Degree of Freedom (SDOF), Using Simple Models for Analysis and Diagnostics, Some Observations about Modeling, Unstable Vibration.

Unit – IV

Introduction to Rotor-dynamics Analysis, objectives of Rotor-dynamics Analysis, The Spring–Mass Model, Synchronous and Nonsynchronous Whirl, Analysis of the Jeffcott Rotor, Polar Coordinates, Cartesian Coordinates, Physical Significance of the Solutions, Three Ways to Reduce Synchronous Whirl Amplitudes.

Unit-V

Bearings and Their Effect on Rotor-dynamics, Fluid Film Bearings, Fixed-geometry Sleeve Bearings, Variable-geometry Tilting Pad Bearings, Fluid Film Bearing Dynamic Coefficients and Methods of Obtaining Them, Load Between Pivots Versus Load on Pivot, Influence of Preload on the Dynamic Coefficients in Tilt, Pad Bearings, Influence of the Bearing Length or Pad Length,

References:

1. *Lubricants and Lubrication edited by Theo Mang*
2. *Lubrication for Industry by Kenneth E. Bannister*
3. *Machinery Vibration and Rotor-dynamics by Brian Murphy, Fouad Y. Zeidan, and John M. Vance*
4. *Rotor-dynamics by Agnieszka Muszyńska*

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