Shri Rawatpura Sarkar University, Raipur

Examination Scheme & Syllabus

for

B.Tech.(Electrical Engineering)

Semester-VI

(Effective from the session: 2020-21)

Four Years B.Tech. Programme

Scheme of Teaching and Examination of B.Tech. Six Semester

(Electrical Engineering)

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

(Effective from the Academic Year 2022-2023)

S.No.	Course Code	Course Title	Hours / Week			Credits	Maximum Marks			Sem End Exam Duration (Hrs)
			L	T	P		Continuous Evaluation	Sem End Exam	Total	
1	BENEE601T	Power System Analysis	2	1	-	3	30	70	100	3
2	BENEE601P	Power System Analysis	-	-	2	1	15	35	50	-
3	BENEE602T	Electrical Machines –III	2	1	-	3	30	70	100	3
4	BENEE602P	Electrical Machines -III	-	-	2	1	15	35	50	-
5	BENEE603T	Power Electronics	2	1	-	3	30	70	100	3
6	BENEE603P	Power Electronics	-	-	2	1	15	35	50	-
7	BENEE604T	Smart Grid	2	1	-	3	30	70	100	3
8	BENEE604P	Smart Grid	-	-	2	1	15	35	50	-
9	BENEE605T	Principles of Digital Signal Processing	2	1	-	3	30	70	100	3
10	BENEE606T	Elective III	2	1	-	3	30	70	100	3
						22			800	

Elective III

A. Fiber Optics

B. Simulation and Modeling of Electrical Systems

C. Design of Photovoltaic Systems

D. Process Control

E. System Modeling and Identification

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<table>
<tr><td>Course Title</td><td colspan="5">POWER SYSTEM ANALYSIS</td></tr>
<tr><td>Course Code</td><td colspan="5">BENEE601T</td></tr>
<tr><td rowspan="2">Course Credits</td><td>L</td><td>T</td><td>P</td><td>TC</td><td></td></tr>
<tr><td>2</td><td>1</td><td>-</td><td>3</td><td></td></tr>
<tr><td>Prerequisites</td><td colspan="5">Electrical power system</td></tr>
<tr><td>Course Objectives</td><td colspan="5">• This course is an extension of Electrical Power systems course.
• It deals with basic theory of transmission line modelling and their performance analysis.
• A detailed study of Power System stability, Load flow studies and economic power dispatch his part of the curriculum for students.</td></tr>
<tr><td>Course Contents</td><td colspan="5">UNIT-I
Representation of Power System:
Single line diagram, impedance diagram, reactance diagram, equivalent impedance of three phase transformer, per unit quantities, P.U. impedance of three phase transformer, positive sequence impedance diagram in per unit system, Expression for three phase power in p.u.
UNIT-II
Symmetrical Components:
Expression for positive, negative & zero sequence components, existence of
sequence components of current & voltages for three phase circuit, sequence impedance of alternator &transmission line, Sequence network of unloaded generator, zero sequence network of three phase transformers, phase shift in star-delta transformer.
UNIT-III
Fault Calculations:
Single line to ground fault, Line to line fault, Double line to ground fault on unloaded generator, faults through impedance, open conductor faults, unsymmetrical fault on power system, Three phase short circuit on synchronous machine, Three phase short circuit on power system, Calculation of different current ratings and interrupting capacity of circuit breaker.

UNIT-IV
a) Economic operation of power systems:
Input output curves , criteria for economical distribution of power between generating units in a plant, Expression for transmission line loss in terms of loss formula coefficients, criteria for economical distribution of power</td></tr>
</table>

	between generating plants **b) Load Flow Studies:** Bus admittance matrix, formation of load flow equation, Gauss Siedel method,Newton Raphson method. **UNIT-V** **Power System Stability:** The stability problem, steady-state stability, transient stability, Swing equation, Equal area criterion of stability, application of equal area criterion, critical clearing angle.
Course Outcomes	• Student should be able to make a one line representation of Power System. • Student should be able to evaluate fault currents for different faults at different locations in Power System. • Students should be able to identify cases of stable and unstable Power Systems.
Text Books	1. Elements of power system analysis By W.D.Stevenson(4thEd.McGrawHill) 2. Electrical Power System by Ashfaq Hussain(4thEd.CBSPub.&Dist.)
Reference Books	1 PowerSystemAnalysis andDesignbyB.R.Gupta(3rdEdS.Chand) 2. PowerSystemEngg. ByI.J.Nagrath&Kothari (TataMcGraw Hill) 3. PowerSystemEngg. BYA.Chakrabarti,M.L. Soni,P.V.Gupta,V.S.Bhatnager(6thEdDhanpatRai&Co.)

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<table>
<tr><td>Course Title</td><td colspan="5">ELECTRICAL MACHINE – III</td></tr>
<tr><td>Course Code</td><td colspan="5">BENEE602T</td></tr>
<tr><td rowspan="2">Course Credits</td><td>L</td><td>T</td><td>P</td><td>TC</td><td></td></tr>
<tr><td>2</td><td>1</td><td>-</td><td>3</td><td></td></tr>
<tr><td>Prerequisites</td><td colspan="5">Electrical machine- i & ii</td></tr>
<tr><td>Course Objectives</td><td colspan="5">Tostudytheimportance oftransformationofvariables inthree phaseAC machines.
Tostudytheconstruction andoperationofsinglephaseinductionmotor.
Tostudytheconstructionandoperationofac commutator motors.</td></tr>
<tr><td>Course Contents</td><td colspan="5">UNIT-I
Theory of Ideal Synchronous Machines:
The ideal synchronous machine, synchronous machine inductances,transformation to direct and quadrature axis variables, basic machine relation indq0 variables, steady stateanalysis using dq0, transient analysis, three-phase short circuit, transient power angle characteristics, Effect ofadditional rotorcircuits.
UNIT-II
Theory of Ideal Poly-Phase Induction Machines:
The ideal induction machine, transformation to dqvariables, basic machine relation in dqvariables, steady state analysis using dq variables, electricaltransients ininduction machine, Operation of three phase induction motor on unbalanced supply voltage (single phasing),Power invariance.
UNIT-III
Fractional Horse Power Motor:
Qualitative examination, starting and running performance of single phase induction motor, revolving field theory of single-phase induction motor, starting methods of single phaseinduction motor, Equivalent Circuit for Single phase Induction motors , Maximum starting torque conditions inSingle phase I.M.
UNIT-IV
Two phase & AC Commutator Motors:
Two-phase control motors AC tachometers and servomotor.Unbalanced operation of symmetrical two-phase machine, the symmetrical</td></tr>
</table>

	componentconcept. EMFs inducedincommutateor windings, Torque, action ofcommutate or as frequency converter, Qualitative analysis of singlephaseseries motors, phasor diagrams, Operation under AC and DC supply: Universalmotor, methods forimproving commutation. **UNIT-V** **Special Motors:** Construction, principle of operation and application of Variable Reluctance motor, Steppermotor, Linear Induction motor, Permanent Magnet Brushless DC motor. Permanent Magnet Synchronousmotor.
Course Outcomes	**At the end of this course student will be able to:** • Transformthreephase variables totwo axisvariables. • Analyze theperformanceofsinglephase inductionmotorwiththe helpofitsequivalent circuit. • Understandthe constructionand principlesofoperationofdifferent types ofspecialmotors.
Text Books	1. .“GeneralizedTheoryofElectrical Machines“Dr.P.S.Bimbhra,KhannaPublishers,5th Edition 2. 2.“Performanceand DesignofAC Commutator Machines “byTaylor.
Reference Books	1. ”Electrical Machines ”Fitzerald and Kingseley, 2nd Edition, McGraw Hill. 2. ”Power System Stability”,Vol-3byE.W.Kimbark,JohnWiley&Sons, **3.** Special Electrical Machines ”S. Jaganathan Pearson Publication 1st Edition

Course Title	**POWER ELECTRONICS**					
Course Code	**BENEE603T**					
Course Credits	**L**	**T**	**P**	**T C**		
	2	**1**	**-**	**3**		
Prerequisites	Basicelectronics , analog electronics					
Course Objectives	• To understand the basic concept electronics devices their property, behavior and application. • To understand the concept of waves shaping circuit and constant power supply. • To understand the concept of solid state rectifiers. • To learn the concept of positive and negative feedback in amplifier. • Gain experience in the designing of an electronics circuit					
Course Contents	**UNIT– I** **Power Semiconductor Devices:** Silicon controlled rectifier (SCR), structure, principle of operation, twotransistoranalogy, switching characteristics, trigger requirement , series and parallel operation of SCRs,ratings and protection, Triac structure andprinciple of operation only,Modern semiconductor devices, powerBJT, MOSFET, IGBT structure, static characteristics **UNIT – II** **Phase Controlled Rectifiers:** Principle of phase control, performance parameters, single-phase half wave controlled mid -point full controlled converters and half controlled converters for R,RL and RLE load,comparison of controlled converters with and without freewheeling diode, Effect of source inductance insingle-phase. Single phase dual converter in circulating and non circulating mode, Three-phase half wave andfully controlled bridge converter, three-phase semi-converter. **UNIT – III** **DC To DC Converters:** Forced Commutation Techniques for thyristor: Self commutation, Impulsecommutation, Resonant pulse commutation and Complementary commutation, Principle of chopper operation, controlled strategies, step up chopper, step down chopper, chopper, configurations, Performance parameter					

	ofstep down chopper with R-L-E load for continuous and discontinuous conduction .Working principle ofVoltage commutated ,Current commuted and Load commuted thyristor chopper. **UNIT – IV** **DC to AC Converter: Inverter:** Classification of inverters, voltage source inverter, current source inverter, Series and modified series resonant thyristor inverter. Performance parameters of single phase half bridge andfull bridge inverter for R-L loads, 3-phase inverter-180 degree and 120 degree conduction mode using idealswitches for balanced R load only. Pulse width modulated switching scheme for voltagecontrol, SPWM andmodified SPWM of 1-phase inverters, PWM with Unipolar and Bipolar Voltage Switching. (Elementaryanalysis only) **UNIT – V** **Cyclo-converters & AC Controllers** Basic principle of operation, step-up and step down single-phase tosingle-phase cyclo-converter, Principle of On-off and phase control, AC controller circuit configurations,Performance parameters of Single phase bidirectional controllers for R and RL only.
Course Outcomes	**At the end of this course student will be able to:** • Tointroduce students thebasictheoryofpowersemiconductordevicesand passivecomponents,their practical applicationinpowerelectronics. • TofamiliarizetheoperationprincipleofAC-DC,DC-DC,DC-AC conversioncircuits andtheir applications. • Toprovidethebasisforfurtherstudyofpowerelectronics circuits andsystems.
Text Books	1. .“Powerelectronics Circuits, Devices andApplications”,Muhammad.H.Rashid,PHIpbs.3rd Edition. 2. “PowerElectronics “Dr.P.S.Bhimbra,KhannaPublishers,3rd Edition
Reference Books	1. ”Power Electronics Converters, applications and Design” Mohan, Undeland, Robbins, JohnWiley&Sons,3rd Edition 2. “A text book of power electronics”,S.NSingh,Dhanpat Rai& Co.(P) Ltd. 1st Edition 3. “An Introduction to thyristoranditsapplications”M.Ramamoorty,East-WestPress,2nd Edition

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<tr><td>Course Title</td><td colspan="5">SMART GRID</td></tr>
<tr><td>Course Code</td><td colspan="5">BENEE604T</td></tr>
<tr><td rowspan="2">Course Credits</td><td>L</td><td>T</td><td>P</td><td>TC</td><td></td></tr>
<tr><td>2</td><td>1</td><td>-</td><td>3</td><td></td></tr>
<tr><td>Prerequisites</td><td colspan="5">Basic Electronics , Analog electronics</td></tr>
<tr><td>Course Objectives</td><td colspan="5">• Smart Grid technologies, different smart meters and advanced metering infrastructure.
• The power quality management issues in Smart Grid.
• The high performance computing for Smart Grid applications.</td></tr>
<tr><td>Course Contents</td><td colspan="5">UNIT I
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 & Smart Grid, National and International Initiatives in Smart Grid.

UNIT II
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 and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plugin Hybrid Electric Vehicles(PHEV).
UNIT III
SMART METERS AND ADVANCED METERING INFRASTRUCTURE:
IntroductiontoSmartMeters,AdvancedMeteringinfrastructure(AMI)driversandbenefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU), Intelligent Electronic Devices(IED)&their application for monitoring & protection.</td></tr>
</table>

	UNIT IV **POWER QUALITY MANAGEMENT IN SMART GRID:** Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit. **UNIT V** **HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS:** Local Area Network(LAN),House Area Network(HAN), Wide Area Network(WAN), Broad band over Power line(BPL),IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.
Course Outcomes	• Learners will develop more understanding on the concepts of Smart Grid and its present developments. • Learners will study about different Smart Grid technologies. • Learners will acquire knowledge about different smart meters and advanced metering infrastructure. • Learners will have knowledge on power quality management in Smart Grids. • Learners will develop more understanding on LAN, WAN and Cloud Computing for Smart Grid applications.
Text Books	1.Stuart Borlase "Smart Grid: Infrastructure, Technology and Solutions",CRCPress2012. 2.JanakaEkanayake,NickJenkins,KithsiriLiyanage,JianzhongWu,AkihikoYokoyama, "Smart Grid: TechnologyandApplications",Wiley2012.
Reference Books	1. VehbiC. Güngör ,Dilan Sahin, Taskin Kocak, Salih Ergüt, Concettina Buccella, Carlo Cecati, and Gerhard P. Hancke, "Smart Grid Technologies: Communication Technologies and Standards" IEEE Transactions On Industrial Informatics, Vol.7,No.4, November2011. **2.** Xi Fang, Satyajayant Misra, Guoliang Xue, and DejunYang"SmartGrid –The New and Improved Power Grid: A Survey" ,IEEE Transaction on Smart Grids,vol.14,2012. 3. James Momohe "Smart Grid: Fundamentals of Design and Analysis,", Wiley-IEEE Press , 2012.

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<table>
<tr><td>Course Title</td><td colspan="5">PRINCIPLES OF DIGITAL SIGNAL PROCESSING</td></tr>
<tr><td>Course Code</td><td colspan="5">BENEE605T</td></tr>
<tr><td rowspan="2">Course Credits</td><td>L</td><td>T</td><td>P</td><td>T C</td><td></td></tr>
<tr><td>2</td><td>1</td><td>-</td><td>3</td><td></td></tr>
<tr><td>Prerequisites</td><td colspan="5">Signal &system , communication system</td></tr>
<tr><td>Course Objectives</td><td colspan="5">• Aims toteachthe fundamentalsofdiscrete-time signals andsystems.
• Includesthe conceptandthe classificationofdiscrete-time signal
• Teachesthe representations ofsignals intime,frequency, z-anddiscretefrequencydomains
• Provides therepresentationsand analyses ofsystems
• Developsthetechniques todesign digitalfilters.</td></tr>
<tr><td>Course Contents</td><td colspan="5">UNIT-I
Introduction to digital signal processing:
Introduction, Basic elements of DSP; Classification of signals:continuous and discrete, energy and power; mathematical representation of signals; Classification of systems:Continuous and discrete, linear, causal, stable, dynamic, time variance; Representation of systems; Analog todigital conversion, sampling techniques, Sampling theorem, quantization, quantization error, Nyquist rate,aliasing effect.
UNIT-II
Discrete linear time system analysis:
Introduction, impulse response, convolution sum, interconnection of linear time invariant system; Causal LTI systems, stability of LTI systems, Correlation, Z-transform, inversez-transforms; systems described by difference equations, Solution by z-transform; Impulse Response andFrequency Response.
UNIT- III
Fourier analysis:
Discrete Fourier series, Discrete Fourier transform (DFT), Properties of Discrete FourierTransform, Linear Convolution of sequence using DFT, Frequency domain representation of discrete timesystem, Phase and amplitude spectra, Relation between Discrete- Time Fourier Transform (DTFT) and DFT,Circular convolution, Computation of DFT using Fast Fourier transform (FFT): Radix- 2 decimation in timeand decimation in frequency FFT</td></tr>
</table>

	algorithms, Inverse FFT, Overlap-add and save methods **UNIT- IV** **Infinite Impulse response (IIR) filters:** Introduction, Structures of IIR systems, IIR filter design by ImpulseInvariance, Bilinear transformation, Approximation of derivatives; Design of Butterworth and Chebyshevfilters, Frequency transformation, Realization using direct, cascade and parallel forms. **UNIT- V** **Finite Impulse response (FIR) filters:** Introduction, Structures of FIR systems, Characteristics of FIR digitalfilters, Linear phase FIR filter design using windows, frequency sampling method; designing using PadeApproximation method and Least Squares design methods.
Course Outcomes	**At the end of this course student will be able to:** • Analyze a given signal or system using tools such as Fourier transform and z-transform • Analyze the various characteristics to know the property of a signal or a system • Process signals to make them more useful. • Design a signal processor (digital filter)for a given problem.
Text Books	1. Digital Signal Processing Principles, Algorithms and Applications: John G Proakis and D. G. Manolakis, Pearson, Fourth Edition,2007 2. DigitalSignalProcessing,AComputerBasedapproach:S.K.Mitra,TataMcGrawHill,NewDelhi,2001 3. Signal andsystems, Oppenheim, PHI
Reference Books	1. Discrete TimeSignal Processing:AlanV.Oppenheim, RonaldW.Schafer &Hohn.R., PearsonEducation, 2ndedition, 2005. 2. IntroductiontoDigitalsignal processing:JohnnyR.JohnsonPHIlearningPrivate Ltd,NewDelhi 3. Digital SignalProcessing:S.Salivahanan, A.Vallavraj,C.Gnanapriya,TMH

<table>
<tr><td>Course Title</td><td colspan="5">POWER SYSTEM ANALYSIS LABORATORY</td></tr>
<tr><td>Course Code</td><td colspan="5">BENEE601P</td></tr>
<tr><td rowspan="2">Course Credits</td><td>L</td><td>T</td><td>P</td><td>TC</td><td></td></tr>
<tr><td>-</td><td>-</td><td>2</td><td>1</td><td></td></tr>
<tr><td>Prerequisites</td><td colspan="5">Electrical power system</td></tr>
<tr><td>Course Objectives</td><td colspan="5">• The objective of this course is to learn working of various Vector groups of the transformers their equivalent circuit,
• To learn about phase sequence of the synchronous generator .
• To learn about different types of faults.
• To learn types of transmission lines.</td></tr>
<tr><td>Course Contents</td><td colspan="5">List of Experiments:
(At least Ten experiments are to be performed by each student)
1.1. Determination of the phase sequence of a three phase supply by static method.
2. Determination of vector group (Dy1) of a three phase transformer.
3. Determination of vector group (Dy11) of a three phase transformer.
4. Determination of zero sequence impedance and currents for different connections of a three phase transformer.
5. Determination of the zero sequence reactance of a synchronous generator.
6. Determination of Negative Sequence Reactance of synchronous generator.
7. Study of the effect of load angle · on the stability of synchronous machines.
8. Determination of the fault current in case of three phase fault on a power system.
9. Determination of the fault current in case of line to ground fault on a power system.
10. Determination of the fault current in case of line to line fault on a power system.
11. Determination of the fault current in case of double line to ground fault on a power system.
12. Determination of the change in fault current with the change in the fault location of the power system.
13. Computer Simulation of balanced and unbalanced faults on a power system and observation of the change in system</td></tr>
</table>

	currents and voltages from that of a healthy system. 14. Simulation of Short, Medium & Long transmission line. 15. Computer simulation of a simple system, formation of the bus admittance/ impedance matrix and power flow on the system
Course Outcomes	**At the end of this course student will be able to:** • Understand the fundamentals and working of transformers • Draw the equivalent circuit diagrams of various transformers • Understand the transmission line through simulation.
Text Books	1. Electrical Power System by V.K. Mehta 2. Power System Engg. By I.J. Nagrath& Kothari

Course Title	**ELECTRICAL MACHINE – III LABORATORY**

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Course Code	**BENEE602P**				
Course Credits	**L**	**T**	**P**	**T C**	
	-	**-**	**2**	**1**	
Prerequisites	Electrical machines – i & ii				
Course Objectives	• To understand the basic concept of alternator. • To understand the concept of synchronous motor. • To understand the concept of induction motor. • To understand the concept synchro transmitter.				
Course Contents	**List of experiments:** (At least Ten experiments are to be performed by each student) 11. Determination of negative sequence reactance of alternator by static test. 2. Determination of negative sequence reactance of alternator by line-to-line short circuit test. 3. Determination of zero sequence reactance by synchronous machine. 4. Determination of the Xd&Xq of synchronous machine. 5. Measurement of circuit Constant of 1-phase induction motor. 6. Speed reversal of 1-phase induction motor. 7. Single phasing characteristics of 3-phase induction motor. 8. To study effect of capacitor on starting, running, and performance of induction motor. 9. Output characteristics of Synchro Transmitter. 10. To use Synchro transmitter pair as remote control device. 11. Characteristics of stepper motor. 12. To measure direct axis reactance Xd of synchronous Generator by OCC and SCC test. 13. Study of Linear Induction Motor. 14. To study synchronization of two alternators with each other and effect of change in excitation and speed (frequency) on load sharing. 15. To study speed control of Induction motor by Cascade connection				

Course Outcomes	**At the end of this course student will be able to:** 1. Predict and design rectifiers and filters as per circuit requirement. 2. Learn to design transistor biasing circuit and calculating its stability. 3. Apply the concept of feedback in amplifier circuit. 4. Learn to design oscillator of desired frequency. **5.** Gain experience in the problem finding and trouble shooting in electronics circuits consisting of diodes and transistors.
Text Books	1. “Generalized TheoryofElectrical Machines“Dr.P.S.Bimbhra,KhannaPublishers,5th Edition

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<tr><td>Course Title</td><td colspan="5">POWER ELECTRONICS LABORATORY</td></tr>
<tr><td>Course Code</td><td colspan="5">BENEE603P</td></tr>
<tr><td rowspan="2">Course Credits</td><td>L</td><td>T</td><td>P</td><td>T
C</td><td></td></tr>
<tr><td>-</td><td>-</td><td>2</td><td>1</td><td></td></tr>
<tr><td>Prerequisites</td><td colspan="5">Basic electronics & analog electronics</td></tr>
<tr><td>Course Objectives</td><td colspan="5">• To provide knowledge of Basic Electric Circuit Concepts.
• To provide the concept of conversion of electrical circuits to graphs for determination of current and voltages.
• To provide Knowledge of various electronics circuitsand its applications.
• To give the knowledge of analysis of network reduction and calculation of various parameters.
• To know the basic concepts of coupled circuits and network performance under resonance condition.
• To provide knowledge of three phase balanced and unbalanced Poly phase Circuits and measurement of three phase power.
• To provide the concept of non-sinusoidal waveforms and its impact on electrical circuits</td></tr>
<tr><td>Course Contents</td><td colspan="5">List of experiments:
(At least Ten experiments are to be performed by each student)
1. To study and plot the V-I characteristics of an SCR.
2. To study and plot the drain characteristics of a MOSFET.
3. To study and plot the drain characteristics of a IGBT.
4. To study single-phase half-wave bridge controlled rectifier for R and RL load.
5. To study single-phase full-wave bridge controlled rectifier for R and RL load with and without freewheeling diode.
6. To study of three-phase half-wave controlled rectifier for resistive load.
7. To study of three-phase full-wave controlled rectifier for resistive load.
8. To study step down and step up chopper circuit.
9. To study class A/B/C forced commutation chopper circuits.
10. To study Single Phase series inverter with R and RL loads.
11. To study Single Phase parallel inverter with R and RL loads.
12. To study the bipolar and unipolar switching scheme of a single phase full</td></tr>
</table>

	bridge inverter using MATLAB / PSPICE simulation. 13. To study the three phase VSI for 180/120 mode of conduction using MATLAB / PSPICE simulation. 14. To study Single Phase step down cycloconverter for R and RL loads. 15. To study single-phase AC voltage control by using TRIAC for R and RL loads.
Course Outcomes	**At the end of this course student will be able to:** • Learn about the different types of electrical sources and networks • Converting a electrical circuit into graph and will be able to analyze the circuit graphically. • Analyze circuits with ideal, independent, and controlled voltage and current sources • Understand balanced and unbalanced poly phase circuits. • Analyze the behavior of non-sinusoidal waveforms
Text Books	1. .“PowerElectronics “Dr.P.S.Bhimbra,KhannaPublishers,3rd Edition. 2. .“A text bookofpowerelectronics”,S.NSingh,DhanpatRai&Co.(P)Ltd.1st Edition

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<table>
<tr><td>Course Title</td><td colspan="5">SMART GRID LAB</td></tr>
<tr><td>Course Code</td><td colspan="5">BENEE604P</td></tr>
<tr><td rowspan="2">Course Credits</td><td>L</td><td>T</td><td>P</td><td>TC</td><td></td></tr>
<tr><td>-</td><td>-</td><td>2</td><td>1</td><td></td></tr>
<tr><td>Prerequisites</td><td colspan="5">Electrical measurement & measuring instruments</td></tr>
<tr><td>Course Objectives</td><td colspan="5">• To provide knowledge of Basic Electric Circuit Concepts.</td></tr>
<tr><td>Course Contents</td><td colspan="5">List of experiments:
(At least Ten experiments are to be performed by each student)
1. Measurement of % ratio error and phase angle error of CT.
2. Measurement of current, voltage and power using CT & PT.
3. Measurement of displacement using LVDT.
4. Measurement of force using strain gauge.
5. To Study Piezo-electric transducer.
6. Measurement of temperature using phototransistor demonstration set up.
7. Measurement of displacement using capacitive pickup.
8. To demonstrate the operation of D/A converter.
9. To demonstrate the operation of A/D converter.
10. Measurement of intensity of light.
11. Measurement of angular displacement using capacitor transducer.
12. Industrial automation demonstration through PLC.
13. Measurement of current / voltage using Hall.
14. Measurement of liquid level using capacitive pick-up.
15. Speed control of DC motor using PLC.</td></tr>
<tr><td>Course Outcomes</td><td colspan="5">At the end of this course student will be able to:
• Handle all major tools
• Install ceiling fan and regulator
• Check fluorescent lamp</td></tr>
<tr><td>Text Books</td><td colspan="5">1. Electronic Measurements and Instrumentation: K.Lal Kishore,Pearson.
2. Electronic Instrumentation by H.S.Kalsi, McGrawHill.</td></tr>
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B.Tech. (Electrical Engineering)
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Course Title	**FIBER OPTICS**				
Course Code	**BENEE606TA**				
Course Credits	**L**	**T**	**P**	**T C**	
	2	**1**	**-**	**3**	
Prerequisites	Basic electrical engineering				
Course Objectives	• To provide the students with a broad understanding of predictions of different load demands of the consumers. • Student will understand the layout diagrams of power system by drawing the typical load curves • To provide the students with a broad understanding of electricity generation. • Students will understand the operation and major components of electric generating plants. • Students will have a basic understanding of conversion of coal, oil, gas ,nuclear, hydro, solar, geothermal, etc. energy to electrical energy				
Course Contents	**UNIT- I** Introduction to optical communication, principle of light transmission, optical fiber modes and configuration, mode theory for circular wave guides, single mode fibers, multimode fibers, numerical aperture, mode field diameter, fiber material, fiber fabrication techniques. **UNIT–II** Optical sources, LEDs, LASER diodes, Modal reflection noise, Power launching and coupling, Population inversion, Fiber splicing, Optical connectors, Photo detectors, PIN, Avalanche detectors, Response time, Avalanche multiplication noise. **UNIT – III** Signal degradation in optical fibers, attenuation losses, Signal distortion in optical wave guides, material dispersion, Wave guide dispersion, Chromatic dispersion, Intermodal distortion, Pulse broadening in graded index fiber, mode coupling, Advanced fiber designs: Dispersion shifted, Dispersion flattened, Compensating fibers, Design optimization in single mode fibers. **UNIT – IV** Coherent optical fiber communication, Modulation techniques for homodyne and heterodyne systems, Optical fiber link design, Rise time budget and link power budget, Long haul systems, Bit error rate, Line coding, NRZ,RZ, Block codes, Eye				

	pattern. **UNIT – V** Advanced system techniques, Wavelength division multiplexing, Optical amplification, Semiconductor amplifier, EDFA comparison between semiconductor and optical amplifier, Gain bandwidth, Photonic switching, Optical networks, Optical fiber bus, Ring topology, Star architecture, FDDI and SONET standards
Course Outcomes	**At the end of this course student will be able to:** • Analyze a given optical fibre with different characteristics. • Analyze the various characteristics to know the property of a signal or a system • Know the components materials used for preparation of optical fibre. • Design a economical Optical fibre for communication system.
Text Books	• Optical Fiber Communication", Gerd Keiser, Mc Graw Hill International Ed. • Optical Fiber Communication" A.K. Ghatak & K. Tyagarajan. Optical Fibre Communication: Principals and Techniques", John M. Senior, PHI New Delhi
Reference Books	• Fibre Optics: Principles and Applications", N.S. Kapany, Academic Press, New York. • Fibre Optics System Network Applications", Terry Edwards, John Wiley & Sons. • Fibre Optics Test & Measurements", Dennis Drickson, Prentice Hall PTR, NJ USA. Fibre Optic Communication Technology", D. Jafar, K. Mynbaev & Lowell L. Schenier, Pearson Education, Asia.it's Applications, S.C. Gupta, PHI India.

<table>
<tr><td>Course Title</td><td colspan="5">Simulation and Modelling of Electrical Systems</td></tr>
<tr><td>Course Code</td><td colspan="5">BENEE606TB</td></tr>
<tr><td rowspan="2">Course Credits</td><td>L</td><td>T</td><td>P</td><td>TC</td><td></td></tr>
<tr><td>2</td><td>1</td><td>-</td><td>3</td><td></td></tr>
<tr><td>Prerequisites</td><td colspan="5">Electrical Power System Simulation & Modelling</td></tr>
<tr><td>Course Objectives</td><td colspan="5">To expose student to understand the basics of simulation of electrical energy systems.
To analyze various DC-DC, AC-DC and DC-AC power converters through modeling and simulation.
To develop models for Energy storage systems and power converters with their controls.</td></tr>
<tr><td>Course Contents</td><td colspan="5">UNIT-I
Modelling and simulation of Solar Photovoltaic Systems
Mathematical modeling of PV array, analysis of I-V and P-V characteristics of PV, modeling and simulation of different MPPT algorithm, open loop control and close loop control.
UNIT-II
Review of DC-DC Converters
Steady-state analysis of converter in continuous and discontinuous modes (CCM & DCM), and estimation of converter efficiency, Development of circuit model for simulating dynamic operating conditions in CCM & DCM, Feedback control for converters.
UNIT-III</td></tr>
</table>

	Review of AC/DC and DC/AC converters Design and simulation of AC/DC Converter and DC/AC Converter, open and close loop control. **UNIT-IV** **Battery Interfaces** Mathematical modeling of battery, design of bidirectional dc-dc converter, open loop and close loop control. **UNIT-V** **Modelling of Load Flow & Power system Stability:** Bus admittance matrix, formation of load flow equation, Gauss Siedel method,Newton Raphson method. Swing equation, Equal area criterion of stability, application of equal area criterion
Course Outcomes	1. Understand and illustrate the various aspects related to solar PV system and its operation. 2. Design various types power electronic interface for Renewable Energy Systems. 3. Perform mathematical analysis of power electronic interface related to Electrical Energy Systems. 4. Design and implement forward and feedback control required for desired operations of Electrical Energy Systems.
Text Books	1. R.W. Erickson, Dragan Maksimovic, Fundamentals of Power Electronics (2 e), Springer 2. Advanced Simulation of Alternative Energy, Viktor M. Perelmuter, CRC Press 3. Modeling and Simulation using MATLAB – Simulink, Dr. Shailendra Jain, Wiley
Reference Books	1. Simulation of Power Electronics Converters Using PLECS, FarzinAsadi, Kei Eguchi Academic Press 2. Modeling, Simulation, and Control of a Medium-Scale Power System, Bambaravanage, Tharangika, Rodrigo, Asanka, Kumarawadu and Sisil, Springer 3. Guide to Modeling and Simulation of Systems of Systems, P. Zeigler Bernard, Springer

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<table>
<tr><td>Course Title</td><td colspan="5">DESIGN OF PHTOVOLTAIC SYSTEMS</td></tr>
<tr><td>Course Code</td><td colspan="5">BENEE606TC</td></tr>
<tr><td rowspan="2">Course Credits</td><td>L</td><td>T</td><td>P</td><td>TC</td><td></td></tr>
<tr><td>2</td><td>1</td><td>-</td><td>3</td><td></td></tr>
<tr><td>Prerequisites</td><td colspan="5">Basic Electrical Engineering</td></tr>
<tr><td>Course Objectives</td><td colspan="5">• To understand basic knowledge of solar cell, working principle and its interconnection methods
• To impart modeling of PV system and knowledge of battery storage systems
• To understand concept of maximum power point tracking algorithms in MATLAB.</td></tr>
<tr><td>Course Contents</td><td colspan="5">Unit-I
PV Cell Fundamentals
PV cell characteristics and equivalent circuit, Model of PV cell Short Circuit, Open Circuit and peak power parameters, Datasheet study, Cell efficiency, Effect of temperature, Temperature effect calculation example, Fill factor, PV cell simulation.
Unit-II
Series and Parallel Interconnection of PV modules
Identical cells in series, Load line, Non-identical cells in series, Protecting cells in series, Interconnecting modules in series, Simulation of cells in series, Identical cells in parallel, Non-identical cells in parallel, Protecting cells in</td></tr>
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	parallel, Interconnecting modules, Simulation of cells in parallel, Measuring I-V characteristics. **Unit-III** **Sizing of PV** Sizing PV for applications without batteries, PV sizing examples, Batteries - intro, Capacity, Efficiency, Energy and power densities. **Unit-IV** **Battery Storage** Batteries - Comparison, Battery selection, Other energy storage methods, PV system design- Load profile, selection of PV system design- Battery size and PV array size as per the applications. **Unit-V** **Maximum Power Point Tracking** MPPT concept, MPPT algorithms, Input impedance of DC-DC converters - Boost converter ,Buck converter, Buck Boost converter, PV module in MATLAB, Application in Engineering field.
Course Outcomes	• Illustrate the various aspects of solar PV system and its operation • Design and Analyze interconnected Solar PV systems and its usage in different fields. • Selection of battery storage systems for different PV system • Implement maximum power point tracking PV Systems for various converters used in engineering applications.
Text Books	1. Chenming, H. and White, R. M., Solar Cells from B to Advanced Systems, McGraw Hill Book Co. 2. B. H. Khan, Non-conventional energy resources, McGraw hill. 3. Ruschenbach, H. S., Reinhold, N. Y., Solar Cell Array Design Handbook.
Reference Books	1. Modeling of photovoltaic systems using Matlab: Simplified green codes. Khatib, Tamer, and Wilfried Elmenreich. John Wiley & Sons, 2016. 2. Solar electricity handbook: A simple, practical guide to solar energy-designing and installing photovoltaic solar electric systems. Boxwell, Michael. Greenstream publishing, 2010. 3. Photovoltaic design & installation for DUMMIES. Mayfield, Ryan. John Wiley & Sons.

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<table>
<tr><td>Course Title</td><td colspan="5">PROCESS CONTROL</td></tr>
<tr><td>Course Code</td><td colspan="5">BENEE606TD</td></tr>
<tr><td rowspan="2">Course Credits</td><td>L</td><td>T</td><td>P</td><td>TC</td><td></td></tr>
<tr><td>2</td><td>1</td><td>-</td><td>3</td><td></td></tr>
<tr><td>Prerequisites</td><td colspan="5">Computer Fundamentals</td></tr>
<tr><td>Course Objectives</td><td colspan="5">• To introduce technical terms and nomenclature associated with Process control domain.
• To familiarize the students with characteristics, selection, sizing of control valves. To provide an overview of the features associated with Industrial type PID controller.
• To make the students understand the various PID tuning methods.
• To elaborate different types of control schemes such as cascade control, feed – forward control and Model Based control schemes.</td></tr>
<tr><td>Course Contents</td><td colspan="5">UNIT-I
PROCESS MODELLING AND DYNAMICS:
Need for process control – Mathematical Modeling of Processes: Level, Flow, Pressure and Thermal processes – Continuous and batch processes – Self regulation – Servo and regulatory operations – Lumped and Distributed parameter models – Heat exchanger – CSTR – Linearization of nonlinear systems.
UNIT-II
Final Control Elements:
Actuators: Pneumatic and electric actuators – Control Valve Terminology – Characteristic of Control Valves: Inherent and Installed characteristics – Valve Positioner – Modeling of a Pneumatically Actuated Control Valve – Control Valve Sizing: ISA S 75.01 standard flow equations for sizing Control Valves –</td></tr>
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	Cavitation and flashing –Control Valve selection. **UNIT-III** **Control Actions:** Characteristic of ON-OFF, Proportional, Single speed floating, Integral and Derivative controllers – P+I, P+D and P+I+D control modes – Practical forms of PID Controller – PID Implementation Issues: Bump less, Auto/manual Mode transfer, Anti-reset windup Techniques – Direct/reverse action. **UNIT-IV** **PID CONTROLLER TUNING:** PID Controller Design Specifications: Criteria based on Time Response and Criteria based Frequency Response - PID Controller Tuning: Z-N and Cohen-Coon methods, Continuous cycling method and Damped oscillation method, optimization methods, Auto tuning – Cascade control – Feed-forward control **UNIT-V** **Model Based Control Schemes:** Smith Predictor Control Scheme – Internal Model Controller – IMC PID controller — Three-element Boiler drum level control – Introduction to Multi-loop Control Schemes – Control Schemes for CSTR, and Heat Exchanger - P&ID diagram.
Course Outcomes	• Ability to understand technical terms and nomenclature associated with Process control domain. • Ability to build models using first principles approach as well as analyze models. • Ability to Design, tune and implement PID Controllers to achieve desired performance for various processes • Ability to Analyze Systems and design and implement control Schemes for various Processes. • Ability to Identify, formulate and solve problems in the Process Control Domain.
Text Books	1. .Seborg, D.E.,Edgar,T.F. and Mellichamp, D.A., Process Dynamics and Control, Wiley John and Sons, 2nd Edition, 2003. 2. Bequette, B.W., Process Control Modeling, Design and Simulation, Prentice Hall of India, 2004. 3. Stephanopoulos, G., Chemical Process Control – An Introduction to Theory and Practice, Prentice Hallof India, 2005.
Reference Books	1. Coughanowr,D.R.,ProcessSystemsAnalysisandControl,McGraw-HillInternational Edition,2004. 2. Curtis D. Johnson, Process Control Instrumentation Technology,8th Edition, Pearson, 2006. 3. Considine, D.M., Process Instruments and Controls Handbook, Second Edition, McGraw, 1999. 4. Bela.G.Liptak., Process Control and Optimization., Instrument Engineers Handbook., volume 2, CRC pressand ISA, 2005. 5. Ramesh C. Panda., T.Thyagarajan., An Introduction to Process Modelling Identification and Control for Engineers Narosa Publishing house Pvt. Ltd, 2017.

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Course Title	**SYSTEM MODELLING & IDENTIFICATION**				
Course Code	**BENEE606TE**				
Course Credits	**L**	**T**	**P**	**T C**	
	2	**1**	**-**	**3**	
Prerequisites	Control System Engineering				
Course Objectives	• Exposing the students to techniques for system identification and parameter estimation of dynamical systems				
Course Contents	**Unit I:** **System Modeling** Mathematical modelling of physical systems, Representation of Lumped and Distributed Systems, Transfer Function, State Space Modeling, Black-box modeling. **Unit II:** **Introduction to System Identification** Parameter estimation using input-output data, Least squares algorithm, Generalized, weighted and recursive least squares. Precision of parameter estimates, Instrumental variable method, Autoregressive modelling (linear and nonlinear). Applications of system identification in Electrical Engineering **Unit III:** **Identification in time and frequency domain**				

	Kalman filter, extended Kalman filter, LMS based adaptive filter, Likelihood functions and maximum likelihood estimation (MLE). **Unit IV:** **Identification in time and frequency domain** Singular value decomposition (SVD); Order and structure determination, Yule-Walker equation;Multi-variable system representation, controllability and observability indices **Unit V:** **Nonlinear system identification** Use of optimization techniques in parameter estimation and system identification, Nonlinear system identification using soft computing techniques. Course Materials.
Course Outcomes	• Apply fundamental laws and principles to mathematically model dynamic systems in both time and frequency domain. • Estimate model parameters from the input-output experimental data. • Develop state space equations and transfer function for SISO and MIMO systems. • Identify nonlinear systems using optimization and soft-computing techniques.
Text Books	1. L Ljung, System Identification: Theory for the user, Prentice Hall, 1995. 2. O. Nellles, Nonliner System Identification, From classical approaches to neural networks and fuzzy models, Springer, 2001. 3. R. Pintelon and J. Schoukens, System Identification, A Frequency Domain Approach, Wiley-IEEE press 2012.
Reference Books	