Course Curriculum for B. Tech.

In

Electrical Engineering

(For students admitted in 2019-20 onwards)

National Institute of Technology Arunachal Pradesh

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1.0 Semester wise Credit point distribution

Sl. No.	Year	Credit Point	
		ODD	EVEN
1	First	18.5	20.5
2	Second	23	21
3	Third	21	21
4	Fourth	15	20
Total Credit Point		**77.5**	**82.5**
		160	

2.0 Subject Category wise Credit point Distribution

Course Category	Sem-I	Sem-II	Sem-III	Sem-IV	Sem-V	Sem-VI	Sem-VII	Sem-VIII	Total Credit Point
Core (Basic Science)	**7**	**10**	**4**	**3**	**--**	**--**	**--**	**--**	**24**
Core (Engineering Science)	**6**	**3**	**--**	**--**	**--**	**--**	**--**	**--**	**9**
Core (Professional)	**--**	**--**	**12**	**12**	**15**	**15**	**9**	**6**	**69**
Core (Humanities)	**3**	**3**	**3**	**3**	**--**	**3**	**--**	**--**	**15**
Elective (Professional)	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**0**
Open Elective	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**0**
Elective (online course)	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**0**
Lab (Basic Science)	**1**	**1**	**--**	**--**	**--**	**--**	**--**	**--**	**2**
Lab (Engineering Science)	**1.5**	**3.5**	**--**	**--**	**--**	**--**	**--**	**--**	**5**
Lab (Humanities)	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**0**
Lab (Professional)	**--**	**--**	**4**	**3**	**5**	**2**	**1**	**--**	**15**
Internship	**--**	**--**	**--**	**--**	**1**	**1**	**1**	**--**	**3**
Academic Project	**--**	**--**	**--**	**--**	**--**	**--**	**4**	**10**	**14**
Audit (NSS/NCC)	**0**	**0**	**--**	**--**	**--**	**--**	**--**	**--**	**0**
Grand Viva	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**4**	**4**
Total Credit Point	**18.5**	**20.5**	**23**	**21**	**21**	**21**	**15**	**20**	**160**

3.0 Elective-II & III

- These two courses will be chosen from NPTEL (https://nptel.ac.in/) / SWAYAM portal (https://swayam.gov.in).
- Student can enrol in 4th year (7th & 8th semester). However, the courses will be credited in 8th semester only.
- Courses will be of completely student's choice and should be of at least of 12 weeks including tutorials which will be considered as 3 credit courses.
- The choice of courses should be from outside the core and electives offered / opted.

4.0 Internship

- Internship - I: Student will go for internship during summer vacation (after 4th semester) for a period of 4 weeks. The assessment will be done on 5th semester
- Internship - II: Student will go for internship during winter vacation (after 5th semester) for a period of 4 weeks. The assessment will be done on 6th semester
- Internship - III: Student will go for internship during summer vacation (after 6th semester) for a period of 4 weeks. The assessment will be done on 7th semester
- At least one internship has to be done in Industry preferably during Internship - III.

❖ INSTITUTE VISION

To transform into an acclaimed institution of higher learning with creation of an impact on the north eastern region in terms of innovation and entrepreneurship

❖ INSTITUTE MISSION

- ❖ *To generate new knowledge through state-of-the-art academic program and research in multidisciplinary field*
- ❖ *To identify regional, Indian and global need to serve the society better.*
- ❖ *To create an ambience to flourish new ideas, research and academic excellence to produce new leaders and innovators*
- ❖ *To collaborate with other academic, research institutes and industries for wholistic growth of the students*
- ❖ *Utilization of available big resources to encourage entrepreneurship through formation of startups*

❖ Vision of the Department

Mould generations of Electrical Engineers on global standards with multidisciplinary perspective to meet evolving societal needs for the north eastern region.

❖ Mission of the Department

M1: *Empower students with knowledge in electrical and allied engineering facilitated in innovative class rooms and state-of-the art laboratories.*

M2: *Inculcate technical competence and promote research through industry interactions, field exposures and global collaborations.*

M3: *Promote professional ethics and selfless service.*

❖ Programme Outcome

PO1: Engineering Knowledge
PO2: Problem Analysis
PO3: Design/Development of Solutions
PO4: Conduct Investigations of complex problems
PO5: Modern tools usage
PO6: Engineer and Society
PO7: Environment and Sustainability
PO8: Ethics
PO9: Individual & Team work
PO10: Communication
PO11: Project management & Finance
PO12: Lifelong learning

❖ Programme Specific Outcome

PSO1: Future Technology.
PSO2: Research and Innovation.

COURSE STRUCTURE

3rd Semester

Sl. No.	Course Code	Course Name	L	T	P	Cr.
1	EE 201	Electrical Circuit Analysis	3	0	0	3
2	EE 202	Electrical Circuit Analysis Laboratory	0	0	2	1
3	EE 203	Electrical and Electronics Measurement	3	0	0	3
4	EE 204	Electrical and Electronics Measurement Laboratory	0	0	2	1
5	EC 201	Analog Circuits – I	3	0	0	3
6	EC 203	Analog Circuits-I Laboratory	0	0	2	1
7	EC 202	Digital Logic Design	3	0	0	3
8	EC 204	Digital Logic Design Laboratory	0	0	2	1
9	MA 201	Probability and Statistics	3	1	0	4
10	MH 201	Introduction to Human Values and Ethics	3	0	0	3
		TOTAL SEMESTER VALUES	**18**	**1**	**8**	**23**

4th Semester

Sl. No.	Course Code	Course Name	L	T	P	Cr.
1	EE 221	Electrical Machines – I	3	0	0	3
2	EE 222	Electrical Machines - I Laboratory	0	0	2	1
3	EE 223	Power System – I	3	0	0	3
4	EE 224	Power System - I Laboratory	0	0	2	1
5	EE 225	Electromagnetic Field Theory	3	0	0	3
6	EE 226	Signals and Systems	3	0	0	3
7	EE 227	Signals and Systems Laboratory	0	0	2	1
8	MA 203	Numerical Methods	3	0	0	3
9	MH 206	Entrepreneurship	3	0	0	3
		TOTAL SEMESTER VALUES	**18**	**0**	**6**	**21**

5th Semester

Sl. No.	Course Code	Course Name	L	T	P	Cr.
1	EE 301	Electrical Machines - II	3	0	0	3
2	EE 302	Electrical Machines - II Laboratory	0	0	2	1
3	EE 303	Power System - II	3	0	0	3
4	EE 304	Power System - II Laboratory	0	0	2	1
5	EE 305	Linear Control Systems	3	0	0	3
6	EE 306	Linear Control Systems Laboratory	0	0	2	1
7	EC 303	Microprocessor and Interfacing	3	0	0	3
8	EC 307	Microprocessor and Interfacing Laboratory	0	0	2	1
9	EE 307	Power Electronics	3	0	0	3
10	EE 308	Power Electronics Lab.	0	0	2	1
11	EE 390	Summer Internship I	0	0	2	1
		TOTAL SEMESTER VALUES	**15**	**0**	**12**	**21**

6th Semester

Sl. No.	Course Code	Course Name	L	T	P	Cr.

1	EE 321	Switchgear and Protection	3	0	0	3
2	EE 322	Power System Operation and Control	3	0	0	3
3	EE 323	Electrical Drives	3	0	0	3
4	EE 324	Electrical Drives Laboratory	0	0	2	1
5	EE 325	Electrical Machine Design	3	0	0	3
6	EE 326	Electrical Machine Design Laboratory	0	0	2	1
7	EE 327	Utilization of Electrical Power	3	0	0	3
8	MH 306	Professional Communication	3	0	0	3
9	EE 391	Summer Internship II	0	0	2	1
		TOTAL SEMESTER VALUES	**18**	**0**	**6**	**21**

7th Semester

Sl. No.	Course Code	Course Name	L	T	P	Cr.
1	EE 401	Renewable Energy Sources (Open Elective)	3	0	0	3
2	EE 402	Renewable Energy Sources Laboratory	0	0	2	1
3	EE 403	ELECTIVE I	3	0	0	3
		403A: High Voltage Engineering				
		403B: Advanced Control System				
		403C: Special Electrical Machines				
4	EE 404	ELECTIVE II	3	0	0	3
		404A: Flexible AC Transmission Systems (FACTs)				
		404B: Advanced Power Electronics				
		404C: Electrical Estimation and Costing				
5	EE 490	Summer Internship III	0	0	2	1
6	EE 491	Project Phase I and Dissertation	0	0	8	4
		TOTAL SEMESTER VALUES	9	0	12	15

8th Semester

Sl. No.	Course Code	Course Name	L	T	P	Cr.
1	EE 421	ELECTIVE III (from SWAYAM)	3	0	0	3
2	EE 422	ELECTIVE IV (from SWAYAM)	3	0	0	3
3	EE 491	Grand Viva	0	0	8	4
4	EE 499	Final Project Dissertation	0	0	20	10
		TOTAL SEMESTER VALUES	6	0	28	20

Syllabus for B. Tech in Electrical Engineering, NIT Arunachal Pradesh

EE 201: Electrical Circuit Analysis

L	T	P	Credit
3	0	0	3

Course Objective:

The course has been designed to make students:

1. understand the calculations of electrical circuits / networks.
2. work with electrical circuits in cascaded form and implementation in real world.

Course Content:

INTRODUCTION: Basic Concepts of Electrical Circuits, Circuit Concepts – R-L-C parameters – Voltage and Current sources – Independent and dependent sources-Source transformation – Voltage – Current relationship for passive elements (for different input signals-square, ramp, saw tooth, triangular); Kirchhoff's laws – network reduction techniques – series, parallel, series parallel, star-to-delta or delta-to-star transformation, Nodal analysis, Mesh analysis, Super node and Super mesh for D.C. Excitations

Single Phase A.C Circuits: R.M.S and Average values and form factor for different periodic wave forms,– Concept of Reactance, Impedance, Susceptance and Admittance – Phase and Phase difference – concept of power factor, Real and Reactive powers – J-notation, Complex and Polar forms of representation, Complex power. Steady state analysis of R, L and C (in series, parallel and series parallel combinations) with sinusoidal excitation; Transient analysis of different electrical circuits with and without initial conditions; Solution using Laplace Transforms, Fourier analysis of different types of input signals

Locus Diagrams and Resonance: Locus diagrams – series R-L, R-C, R-L-C and parallel combination with variation of various parameters – Resonance – series, parallel circuits, concept of band width and Q factor.

Magnetic Circuits: Magnetic Circuits – Faraday's laws of electromagnetic induction – concept of self and mutual inductance – dot convention – coefficient of coupling – composite magnetic circuit - Analysis of series and parallel magnetic circuits

Network Topology: Definitions – Graph – Tree, Basic cutest and Basic Tie-set matrices for planar networks – Loop and Nodal methods of analysis of Networks with independent voltage and current sources - Duality and Dual networks.

Network Theorems:

Tellegen's, Superposition, Reciprocity, Thevenin's, Norton's, Maximum Power Transfer, Millman's and Compensation theorems for D.C. and A.C. excitations. Three phase unbalanced circuits

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: apply network theorems for the analysis of electrical circuits.

CO2: obtain the transient and steady-state response of electrical circuits.

CO3: analyse circuits in the sinusoidal steady-state (single-phase and three-phase).

CO4: analyse two port circuit behaviour.

Text Books:

1. M. E. Van Valkenburg, "Network Analysis", Prentice Hall, 2006.

2. D. Roy Choudhury, "Networks and Systems", New Age International Publications,1998.

Reference Books:

1. W. H. Hayt and J. E. Kemmerly, "Engineering Circuit Analysis", McGraw HillEducation, 2013.

2. C. K. Alexander and M. N. O. Sadiku, "Electric Circuits", McGraw Hill Education,2004.

3. K. V. V. Murthy and M. S. Kamath, "Basic Circuit Analysis", Jaico Publishers, 1999.

EE 202: Electrical Circuit Analysis Laboratory

L	T	P	Credit
0	0	2	1

Course Objective:

The course has been designed to make students:

1. work with electrical circuits in laboratory and apply theoretical knowledge of networks into practice.
2. familiar with devices used in electrical circuit analysis.

List of Practical:

1. Verification of KVL and KCL (Simulation using MATLAB and Hardware)
2. Mesh Analysis (Simulation using MATLAB and Hardware)
3. Nodal Analysis (Simulation using MATLAB and Hardware)
4. Verification of Superposition Theorem (Simulation using MATLAB and Hardware)
5. Verification of Reciprocity Theorem (Simulation using MATLAB and Hardware)
6. Verification of Maximum Power Transfer Theorem (Simulation using MATLAB and Hardware)
7. Verification of Thevenin's Theorem (Simulation using MATLAB and Hardware)
8. Verification of Norton's Theorem (Simulation using MATLAB and Hardware)
9. Verification of Compensation Theorem (Simulation using MATLAB and Hardware)
10. Verification of Millman's Theorem (Simulation using MATLAB and Hardware)
11. Verification of Series and Parallel Resonance (Simulation using MATLAB and Hardware)
12. Determination of Self, Mutual Inductance and Coefficient of Coupling

Course Outcome:

1. At the end of this course, students will demonstrate the ability to:
2. CO1: apply fundamental laws to electric circuits.
3. CO2: select suitable instrument for measurement of electrical quantities.
4. CO3: verify basic network theorems to solve complex circuits.
5. CO4: demonstrate performance improvement by power factor correction.
6. CO5: compare resonance characteristics of series and parallel RLC circuits and determine resonant frequency.
7. CO6: design of filter to reduce ripple in rectifier circuits

EE 203: Electrical and Electronics Measurement

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is designed to:

1. provide a methodical approach to problem solving.
2. learn a number of powerful engineering circuit analysis techniques such as nodal analysis.
3. introduce mesh analysis, theorems, source transformation and several methods of simplifying networks.
4. understand the concept of graphical solution to electrical network

Course Content:

Basics of Measurements: Accuracy, Precision, resolution, reliability, repeatability, validity, Errors and their analysis, Standards of measurement, calibration of instruments.

Bridge Measurements: AC bridges: Applications and conditions for balance, Maxwell's bridge, Hay's bridge, Schering bridge, Wien's bridge, De Sauty's bridge, Insulation testing, Ground resistance measurement, Varley and Murray loop test.

Electromechanical Indicating Instruments: PMMC galvanometer, Ohmmeter, Electrodynamometer, Moving iron meter, Rectifier and thermo-instruments, Comparison of various types of indicating instruments.

Power and Energy Measurement: Electrodynamometer type of wattmeter and power factor meter, Power in poly phase system: two wattmeter method, Single-phase induction and Electronic energy meters.

Instrument Transformers: Current and Voltage transformers, Constructional features, Ratio and Phase angle errors.

Oscilloscopes: - Cathode Ray Tube, Vertical and Horizontal Deflection Systems, Delay lines, Probes and Transducers, Specification of an Oscilloscope. Oscilloscope measurement Techniques, Special Oscilloscopes, Storage Oscilloscope, Sampling Oscilloscope.

Electronic Instruments: Electronic multimeter, Digital voltmeters, General characteristics ramp type voltmeter, Quantization error, Digital frequency meter/Timer, Q meter and its applications, Distortion meter, Wavemeter and Spectrum Analyser.

Display Devices: - LED, LCD, Power quality analyzer, Applications of expert systems for power quality monitoring, Net Metering and data logger.

Digital Data Acquisition System: Interfacing transducers to Electronics Control and Measuring System. Instrumentation Amplifier, Isolation Amplifier. An Introduction to Computer-Controlled Test Systems.IEEE-488 GPIB Bus

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: understand the concept of measurement different electrical and non-electrical parameters.

CO2: select a suitable measuring instrument for field specific applications.

CO3: compare different measuring instruments and analyse their errors in measurement of a specific quantity.

CO4: discuss the concepts in digital measurement and data acquisition system.

Text Books:

1. E. W. Golding and F. C. Widdis, "Electrical Measurements and Measuring Instruments", Pitman (2003).
2. A. D. Helfrick and W. D. Cooper, "Modern Electronic Instrumentation and Measurement Techniques", Prentice Hall of India (2007).

Reference Books:

1. A. K. Shawney, "Electrical and Electronic Measurements and Instrumentation", Dhanpat Rai and Sons.
2. H. S. Kalsi, "Electronic Instrumentation", Tata McGraw Hill (2007).
3. B. C. Nakra and K.K. Chaudhary, "Instrumentation Measurement and Analysis", Tata McGraw Hill (2003).

EE 204: Electrical and Electronics Measurement Laboratory

L	T	P	Credit
0	0	2	1

Course Objectives:

The course is designed to:

1. provide a methodical approach to problem solving.
2. learn a number of powerful engineering circuit analysis techniques such as nodal analysis.
3. introduce mesh analysis, theorems, source transformation and several methods of simplifying networks.
4. understand the concept of graphical solution to electrical network

List of Practical:

1. Measurement of low resistance by Kelvin's Double Bridge method.
2. Study of Galvanometer and determination of sensitivity and galvanometer constants.
3. Measurement of capacitance and loss angle of capacitor using Schering bridge.
4. Measurement of unknown inductance by Maxwell's inductance and capacitance bridge.
5. Measurement of inductance and Q-factor using Owen bridge.
6. Measurement of ratio and phase angle errors of instrument transformers
7. Calibration of voltmeters and ammeters using potentiometer.
8. Measurement of power and power factor in a three phase AC circuit by two-wattmeter method.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: extend the range and calibrate electro mechanical instruments

CO2: verify the characteristics of Active and Passive Transducers.

CO3: determine R, L and C parameters using bridge circuits and perform basic signal conversion

CO4: simulate and verify measurement and Instrumentation systems using Software.

EC 201: Analog Circuits I

L	T	P	Credit
3	0	0	3

Course Objectives:

The objective of the course is:

1. To make the students understand the fundamentals of electronic devices.
2. To train them to apply these devices in mostly used and important applications

Course Content:

Introduction to Semiconductor: Review of quantum mechanics, Electrons in periodic lattices, E-k diagrams, Quasi particles in semiconductors, Evolution and uniqueness of semiconductor technology, Equilibrium carrier concentration, Thermal equilibrium and wave particle duality, Bond and band models of Intrinsic and Extrinsic semiconductors.

Carrier transport: Random motion drift and diffusion, Excess carriers, Injection level lifetime direct and indirect semiconductors, Procedure for analyzing semiconductor devices, Basic equations and approximations.

P-N Junction: Device structure and fabrication, Equilibrium picture, DC forward and reverse characteristics, Small-signal equivalent circuit, Switching characteristics, Schottky, Homo and hetero-junction band diagrams, I-V characteristics and small signal switching models.

Bipolar Junction Transistor: History, Device structures and fabrication, Transistor action and amplification, Common emitter DC characteristics, Small-signal equivalent circuit, Ebers-Moll model and SPICE model.

Transistor Biasing and Thermal Stabilization: Graphical analysis of transistor circuits, Bypass capacitor, Coupling capacitors, Need for biasing, Operating point, Load line analysis, BJT biasing methods, Stabilization against V_{BE}, Ic, and β, Stability factors, (S, S', S"), Bias compensation, Thermal runaway, Thermal stability, FET biasing methods and analysis.

Transistor Amplifiers: BJT and FET amplifier circuits, Small signal analysis, Hybrid parameters, CE, CB, CS and CD Configuration, Impedance, reflections, Phase splitter

Frequency Response: Low frequency and high frequency response of CE / CS amplifiers, Miller's theorem, High frequency response of CG and cascade amplifiers.

Course Outcome:

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

CO1: apply the knowledge of basic semiconductor material physics.

CO2: characterize semiconductors, diodes, transistors and amplifiers.

CO3: analyze the characteristics of various electronic devices like diode, transistor etc.

CO4: design simple analog circuits.

Text Books:

1. B. Streetman and S. Banerjee “Solid State Electronic Devices”, Pearson Education, 2015
2. D.L. Schilling and C. Belove, “Electronic Circuits: Discrete and Integrated”, McGraw Hill, 2002.

Reference Books:

1. S.M. Sze, “Physics of Semiconductor Devices”, Wiley Eastern, 2008
2. Kevin F Brennan, “The Physics of Semiconductors" Cambridge Univ. Press., 1999.
3. J. Millman, “Microelectronics”, McGraw Hill, 2017.
4. A.S. Sedra and K.C. Smith, “Microelectronic Circuits”, Oxford, 2017.

EC 203: Analog Circuits I Laboratory

L	T	P	Credit
3	0	0	3

Course Objectives:

The objective of the course is:

1. To make the students understand the fundamentals of electronic devices.
2. To train them to apply these devices in mostly used and important applications

List of Practical:

1. Study of V-I characteristics of PN junction and Zener diodes.
2. Study and design of Half wave and Full wave rectifier circuits.
3. Study of BJT characteristic.
4. Study of BJT biasing methods.
5. Study of FET characteristics.
6. Study of FET biasing methods.
7. Study of MOSFET inverter.
8. Study of BJT and FET amplifier circuits

Course Outcome:

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

CO1: plot the characteristics of electronic devices to understand their behavior.
CO2: characterize and classify diodes and transistors
CO3: analyze the characteristics of various electronic devices like diode, transistor etc
CO4: design simple analog circuits

EC 202: Digital Logic Design

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is designed to meet the objectives of:

1. To make the students to build a solid foundation about Boolean algebra
2. To make the students to study Digital Logic Gates and Circuits
3. To provide a clear foundation of Modern Digital System

Course Content:

Number systems: Decimal, Binary, Octal and Hexadecimal systems, Conversion of a number from one base to another, Introduction to logic gates.

Boolean algebra: Theorems and operations, Boolean expressions and truth tables, Duality and inversion, Multiplying out and factoring expressions, Exclusive-OR and equivalence operations, Positive and negative logic. Combinational logic design using truth table: Minterms and maxterms expressions.

Minimization techniques: Algebraic method, Karnaugh maps (including 5 and 6 variables), Quine-McCluskey method, Multi-output circuits, Multi-level circuits, Design of circuits with universal gates.

Codes: BCD, Excess- 3, Gray, ASCII, EBCDIC.Combinational circuits: Arithmetic circuits: adders and subtractor-ripple carry adders, Carry look ahead adders, adder cum subtractor, BCD Adder and Subtractor, Comparator, Decoder, Encoder, Priority encoder, MUX/DEMUX and their structures.

Combinational logic design using ROM array, Applications of MSI designs.

Sequential circuits: Latches and Flip-Flops: SR latch, SR Flip-Flop, JK Flip-Flop, D Flip-Flop, T Flip-Flop, Flip-Flops with preset and clear inputs, Triggering methods and their circuits, Conversion of one type of flip flop to another, Excitation table, Applications of Flip Flops. Difference between synchronous and asynchronous circuits.

Shift Registers: Right shift, left shift, bidirectional, SISO, SIPO, PISO, PIPO, universal shift registers.

Counters: Operation; up counter, down counter, up/down counter, mod n counters, Other types of Counters: Ring counter, Johnson counter, BCD counter.

Finite State Machines: Mealy and Moore types, Basic design steps, Design of counters using sequential circuit approach.

Asynchronous sequential circuits: Analysis and synthesis, State reduction and state assignment, Hazards.

Introduction to digital logic families: Characteristics, Basic working of TTL NAND gate, ECL gate and CMOS logic gate, Memory Devices: types of memories, RAM BJT cell and MOS RAM cells, organization of a RAM. Introduction to HDL

Course Outcome:

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

CO1: design and analyse combinational and sequential logic circuits.

CO2: optimize combinational and sequential logic circuits

CO3: analyse a memory cell and apply for organizing larger memories

Text Books:

1. A. Malvino and D. Leach, “Digital Principles and Applications”, Tata McGraw Hill, 2010.
2. M. Morris Mano, “Digital Logic Design”, Prentice Hall, 2018.

Reference Books:

1. C. H. Roth (Jr.), “Fundamentals of Logic design”, Cengage Engineering, 2013.
2. R L Morris and J R Miller, “Designing with TTL integrated circuits”, McGraw Hill, 1971.

3. R. P. Jain, “Modern Digital Electronics”, Tata McGraw Hill, 2009.
4. Anand Kumar, “Fundamentals of Digital Circuits”, Prentice Hall, 2014.
5. J Crowe and B. Hayes-Gill, “Introduction to Digital Electronics”, Butterworth-Heinemann, 1998.

EC 204: Digital Logic Design Laboratory

L	T	P	Credit
0	0	2	1

Course Objectives:

The course is designed to meet the objectives of:

1. To make the students to build a solid foundation about Boolean algebra
2. To make the students to study Digital Logic Gates and Circuits
3. To provide a clear foundation of Modern Digital System

List of Practical:

1. Verification of truth tables of logic gates -OR, AND, NOT, NAND, NOR and Ex-OR. Verification of NAND and NOR as universal gates.
2. Design and verification of the truth tables of half and Full adder circuit using universal gates only.
3. Design and verification of the truth tables of Half and Full subtractor circuits using universal gates only.
4. Minimize the following logic system with SOP/POS by tabular technique and implement the circuit.
   SOP: f(A,B,C,D) = m0 + m1+ m2+ m3+ m5+ m6+ m10+ m13+ m15
   POS: f(X,Y,Z) = M0.M1.M3.M7
5. Design Gray to Binary and Binary to Gray code Converter and test the circuit.
6. Design and verify BCD to Excess-3 code converter using logic gates.
7. Design and test of SR flip-flop using NOR/NAND gates.
8. Verification of the truth table of the Multiplexer using IC 74150
9. Verification of the truth table of the Demultiplexer using IC 74154.
10. Basic GATEs implementation in HDL

Course Outcome:

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

CO1: design and analyse combinational and sequential logic circuits.

CO2: optimize combinational and sequential logic circuits

MA 201: Probability and Statistics

L	T	P	Credit
3	1	0	4

Course Objectives:

The course is designed to meet with the objectives of:

1. providing high quality education in pure and applied mathematics in order to prepare students for graduate studies or professional careers in mathematical sciences and related fields,
2. imparting theoretical knowledge and to develop computing skill to the students in the area of Science and Technology,
3. providing teaching and learning to make the students competent to their calculating ability, logical ability and decision making ability,
4. giving students theoretical knowledge of Calculus, Algebra and their practical applications in the various fields of Science and Engineering,
5. apply their knowledge in modern industry or teaching, or secure acceptance in high-quality graduate programs in Mathematics and other fields such as the field of quantitative/Mathematical finance, Mathematical computing, statistics and actuarial science.

Course Content:

Probability: Random Experiment, Sample space; Events; Probability of events, Frequency Definition of probability; Axiomatic definition of probability; Finite sample spaces, Probability of Non-disjoint events (Theorems). Conditional probability; General Multiplication Theorem; Independent events; Bayes' theorem and related problems.

Random variables: Probability mass function; Probability density function and distribution function. Distributions: Binomial, Poisson, Uniform, Exponential, Normal, t and $\chi 2$. Expectation and Variance (t and $\chi 2$ excluded); Moment generating function; Transformation of random variables (One variable); Central limit theorem (Statement only).

Basic Statistics: Measures of Central tendency: Moments, skewness and Kurtosis - Probability distributions: Binomial, Poisson and Normal - evaluation of statistical parameters for these three distributions, Correlation and regression – Rank correlation.

Statistics: Population; Sample; Statistic; Estimation of parameters (consistent and unbiased); Sampling distribution of sample mean and sample variance (proof not required).

Estimation: Maximum likelihood estimate of statistical parameters (Binomial, Poisson and Normal distribution). Interval estimation (Normal distribution). Testing of Hypothesis and $\chi 2$ goodness of fit. Curve fitting: Linear and non-linear.

Course Outcome:

Upon Completion of the subjects:

CO1: students will add new interactive activities to fill gaps that we have identified by analysing student log data and by gathering input from other college professors on where students typically have difficulties,

CO2: students will add new simulation-style activities to the course in Inference and Probability,

CO3: students will be substantially prepared to take up prospective research assignments.

Text Books:

1. V. K. Rohatgi and A. K. Md Ehsanes Saleh, "An Introduction to Probability and Statistics", Willy, 2^{nd} edition, 2008.
2. S. C. Gupta and V. K. Kapoor, "Fundamental of Mathematical Statistics", Sultan Chand and Sons, 2014.

Reference Books:

1. Sheldon M Ross, "Introduction to Probability Models" , Academic Press; 14th edition, 2014.

2. Harald Cramer, "Random Variables and Probability Distributions", Cambridge University Press; Revised ed., 2014.
3. Murray R. Spiegel, "Probability and Statistics", McGraw-Hill, McGraw Hill Education; 3rd edition, 2017.
4. P. L. Mayer, "Introductory Probability and Statistical Applications", Oxford and IBH, 2nd, 1970.
5. W. Feller, "An Introduction to Probability Theory and Its applications", Vol I, Jon Willy and Sons, 3rd edition, 2008.
6. K.L. Chung, "A course of Probability Theory", Academic Press, 3rd edition, 2000.

MH 201: Introduction to Human Values and Ethics

L	T	P	Credit
3	1	0	4

Course Objectives:

The course is designed to meet with the objectives of:

1. Enabling students to acquire and cultivate ethical practices in terms of business, engineering and life in general.
2. Developing a sense of moral responsibility in business and enterprise.
3. Emphasizing the importance of values and ethics in modern life.

Course Content:

Universal Human values

Getting to Know Your Students: Aspirations and family expenditures, Purpose of the Course, Gratitude, Competitions and Co-operation: The Full story of Tortoise and Rabbit), Competition and Excellence, Self and Body, Peer Pressure, Self Confidence, *Identity and Assumptions,* Prosperity, Peer pressure –English, Relationships- Seven Relations, Relationship Vs Transaction, Mulya in Relationships: Trust, Mulya in Relationships: Respect, Anger *(if time permits,* Nature – Four Orders*),* NIRMAN: *Youth for Purposeful Life,* Gandhi Film, Gandhi Film- Points to ponder

Ethics of Profession

Engineering profession: Ethical issues in Engineering practice, Conflicts between business demands and professional ideals. Social and ethical responsibilities of Technologists. Codes of professional ethics. Whistle blowing and beyond, Case studies.

Profession and Human Values

Values Crisis in contemporary society, Nature of values: Value Spectrum of a good life, Psychological values: Integrated personality; mental health, Societal values: The modern search for a good society, justice, democracy, secularism, rule of law, values in Indian Constitution.

Aesthetic values: Perception and enjoyment of beauty, simplicity, clarity, Moral and ethical values: Nature of moral judgements; canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility.

Course Outcome:

Upon Completion of the subjects:

CO1: understand the importance of values and ethics in business and work places

CO2: understand the benefits of managing ethics at work place.

Text Books:

1. S. Blackburn, "Being Good: A Short Introduction to Ethics", Oxford University Press, 2001
2. P. Singer, "The Most Good You Can Do: How Effective Altruism Is Changing Ideas About Living Ethically", Yale University Press 2015

Reference Books:

1. S. Dinesh Babu, "Professional Ethics and Human Values", Firewall Media, 2007
2. R. S. Nagarajan, "A Textbook on Professional Ethics and Human Values", New Age International, 2007.

EE 221: Electrical Machines I

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is designed to:

1. acquire knowledge about the fundamental principles and classification of electromagnetic machines.
2. acquire knowledge about the constructional details and principle of operation of dc machines.
3. acquire knowledge about the working of dc machines as generators and motors.
4. acquire knowledge about the constructional details, principle of operation, testing and applications of transformers.

Course Content:

Magnetic fields and magnetic circuitsReview of magnetic circuits - MMF, flux, reluctance, inductance; review of Ampere Law andBiot Savart Law; Visualization of magnetic fields produced by a bar magnet and a currentcarrying coil - through air and through a combination of iron and air; influence of highly permeable materials on the magnetic flux lines.

Electromagnetic force and torque: B-H curve of magnetic materials; flux-linkage vs current characteristic of magnetic circuits;linear and nonlinear magnetic circuits; energy stored in the magnetic circuit; force as a partialderivative of stored energy with respect to position of a moving element; torque as a partialderivative of stored energy with respect to angular position of a rotating element. Examples -galvanometer coil, relay contact, lifting magnet, rotating element with eccentricity or saliency.

DC machines: Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core, visualization of magnetic field produced by the fieldwinding excitation with armature winding open, air gap flux density distribution, flux perpole, induced EMF in an armature coil. Armature winding and commutation – Elementaryarmature coil and commutator, lap and wave windings, construction of commutator, linearcommutation Derivation of back EMF equation, armature MMF wave, derivation of torqueequation, armature reaction, air gap flux density distribution with armature reaction.

DC machine - motoring and generation: Armature circuit equation for motoring and generation, Types of field excitations – separately excited, shunt and series. Open circuit characteristic of separately excited DC generator, backEMF with armature reaction, voltage build-up in a shunt generator, critical field resistance and critical speed. V-I characteristics and torque-speed characteristics of separately excited, shunt and series motors. Speed control through armature voltage. Losses, load testing andback-to-back testing of DC machines

Transformers: Principle, construction and operation of single-phase transformers, equivalent circuit, phasor diagram, voltage regulation, losses and efficiency Testing - open circuit and short circuit tests,polarity test, back-to-back test, separation of hysteresis and eddy current losses Three-phasetransformer - construction, types of connection and their comparative features, Paralleloperation of single-phase and three-phase transformers, Autotransformers - construction,principle, applications and comparison with two winding transformer, Magnetizing current,effect of nonlinear B-H curve of magnetic core material, harmonics in magnetization current,Phase conversion - Scott connection, three-phase to six-phase conversion, Tap-changingtransformers - No-load and on-load tap-changing of transformers, Three-windingtransformers. Cooling of transformers.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: understand the concepts of magnetic circuits.

CO2: understand the operation of dc machines.

CO3: analyse the differences in operation of different dc machine configurations.

CO4 analyse single phase and three phase transformers circuits.

Text Books:

1. E. Fitzgerald and C. Kingsley, "Electric Machinery”, New York, McGraw HillEducation, 2013.

2. A. E. Clayton and N. N. Hancock, “Performance and design of DC machines”, CBS Publishers, 2004.

Reference Books:

1. M. G. Say, “Performance and design of AC machines”, CBS Publishers, 2002.
2. P. S. Bimbhra, “Electrical Machinery”, Khanna Publishers, 2011.
3. I. J. Nagrath and D. P. Kothari, “Electric Machines”, McGraw Hill Education, 2010.

EE 222: Electrical Machines I Laboratory

L	T	P	Credit
0	0	2	1

Course Objectives:

The course is designed to:

1. acquire knowledge about the fundamental principles and classification of electromagnetic machines.
2. acquire knowledge about the constructional details and principle of operation of dc machines.
3. acquire knowledge about the working of dc machines as generators and motors.
4. acquire knowledge about the constructional details, principle of operation, testing and applications of transformers.

List of Practical:

1. Open Circuit Characteristics of a DC Shunt Generator.
2. Characteristics of a separately excited D.C Generator.
3. Characteristics of a D.C shunt motor
4. Speed control of a D.C motor.
5. Characteristics of a compound D.C generator (short shunt).
6. Measurement of the speed of a D.C series motor as a function of load torque.
7. Equivalent circuit of a single-phase transformer.
8. Predetermination of efficiency of a DC motor (Swinburn's test)
9. Testing the efficiency of a DC motor |(Hopkinson's test)
10. Retardation (Run-Down) test on a DC shunt motor (to find the stray losses)
11. Separation of Core Losses

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: construct the equivalent circuit of transformers and predetermine the characteristics

CO2: analyse the performance characteristics of DC machines and Transformers

CO3: implement speed control of DC Machines

CO4: realize three phase transformer connections

EE 223: Power System I

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is designed to:

1. impart the knowledge of generation of electricity based on conventional and non-conventional sources
2. enable the students to do analysis of different types of distribution systems and its design
3. make students capable of analysis of mechanical and electrical design aspects of transmission system

Course Content:

Generation of Electric Power: Brief description of Thermal, Hydro, Nuclear and brief description of non-conventional power plants. Merits, Demerits and site selections of the above power plants.

Transmissions and distribution of power three-wire four-wire system and service connections.

Calculation of inductance: Inductors, inductance of single phase and three phase unsymmetrically spaced transmission lines. Transposition of power lines, concept of GMD and self-GMD. Bundle conductor, Skin and proximity effect.

Calculation of Capacitance: Two infinite lines of charge, Capacitance of single-phase transmission line, Capacitance of a three-phase unsymmetrically spaced transmission line. Effect of earth on capacitance of conductors.

Mechanical design Transmission Lines and Cables: Introduction, the catenary curve, Sag calculation, Types of insulators, Potential distribution over a string of suspension insulators, Methods of equalising the potential. Calculations of capacity of cables, charging current, stress, grading, heating of cables, Capacitance of a single core cable and three-core cable.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: understand structure of electric power system and operation of various generating, transmission and distribution system.

CO2: determine transmission line /cable parameters for various conductor configurations.

CO3: analyze transmission line performance using various models.

CO4: examine the mechanical design of overhead transmission lines.

Text Books:

1. J. Graingerand W. D. Stevenson, “Power System Analysis”, McGraw Hill, 1994.
2. Harder Edwin, “Fundamentals of Energy Production”, John Wiley and Sons, 1982.

Reference Books:

1. M. V. Deshpande, “Elements of Electric Power Station Design”, A.H. Wheeler and Company, 1979.
2. J. Burke, “Power Distribution Engineering; Fundamentals and Applications”, MarcelDekk.,1996.
3. C. L. Wadhwa, “Electric Power Systems”, Second Edition, Wiley Eastern Limited,1985.
4. I. J. Nagrath and D. P. Kothari, “Power System Engineering”, Tata McGraw Hill, 1995

EE 224: Power System I Laboratory

L	T	P	Credit
0	0	2	1

Course Objectives:

The course is designed to:

1. impart the knowledge of generation of electricity based on conventional and non-conventional sources
2. enable the students to do analysis of different types of distribution systems and its design
3. make students capable of analysis of mechanical and electrical design aspects of transmission system

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: understand structure of Transmission line and line simulator.

CO2: determine transmission line parameters for various conductor configurations using TLS

CO3: analyze transmission line parameters for Ferranti effect with PI model.

CO4: examine the Transmission regulation and efficiency with various loading.

List of Practical:

1. Introduction to TLS (Transmission Line Simulator) and its components
2. To calibrate the TLS into a particular transmission line considering three different conductors
3. To simulate the TLS into a particular transmission line considering twin Moose with resistive load.
4. To verify the Ferranti effect simulation for an un-loaded transmission line.
5. To verify the findings of Ferranti effect experiments (Exp-no.4) using MATLAB simulation for an un-loaded transmission line.
6. To determine the surge impedance of the given transmission line
7. To determine the loading capability of the line and voltage regulation at given power factor.
8. To determine the shunt capacitive compensation to improve the receiving end voltage and power factor

Syllabus for B. Tech in Electrical Engineering, NIT Arunachal Pradesh

EE 225: Electromagnetic Field Theory

L	T	P	Credit
3	0	0	3

Course Objectives:

This course is design to meet the objectives of:

1. imparting theoretical & practical knowledge to students in the area of Electromagnetic Field Theory,
2. providing teaching and learning to make students acquainting with modern state-of –art of Electromagnetic propagation,
3. injecting the future scope and the research direction in the field of Electromagnetisms,
4. making students competent to design & development of Electromagnetisms.

Course Content:

Review of vector algebra- Rectangular, cylindrical and spherical, Curvilinear coordinates, Line, surface and volume integrals, Gradient, Divergence, Curl, Divergence theorem, Stoke's theorem.

Coulomb's Law – Electric flux and flux density, Gauss's law and applications. Poisson's and Laplace equations and their solutions. Electric Current: Charge conservation and continuity equation–conductivity and Ohm's law.

Lorentz force, magnetic field intensity (H) – Biot–Savart's Law - Ampere's Circuit Law – H due to straight conductors, circular loop, infinite sheet of current, Magnetic flux density (B) – B in free space, conductor, magnetic materials – Magnetization, Magnetic field in multiple media –Boundary conditions, scalar and vector potential, Poisson's Equation, Magnetic force, Torque, Inductance, Energy density, Applications.

Faraday's law – Displacement current.

Maxwell's equations (differential and integral form) – Relation between field theory and circuit theory, wave equation, Wave parameters; velocity, intrinsic impedance, propagation constant – Waves in free space, lossy, lossless dielectrics and conductors- skin depth, Flow of energy and Poynting vector, Plane wave reflection and refraction: linear, elliptic and circular polarization, reflection coefficient and standing wave ratio, Brewster's angle.

Transmission Lines; Concept of Lumped parameters and Distributed parameters. Line Parameters, Transmission line equations and solutions, Physical significance of the solutions, Propagation constant, Characteristic Impedance; Wavelength; Velocity of Propagation; Distortion-less, lossy, lossless Line, Reflection and Transmission coefficients; Standing Waves, VSWR, Input Impedance, Smith Chart - Applications; Load Matching Techniques / Quarter wave Matching.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: understand calculations of electric and magnetic fields in space in some selected geometries with boundary conditions.

CO2: perform calculations of stationery and time-dependent electrical currents in selected circuits containing resistors, capacitors, and inductors.

CO3: analyse for the operational principles of common electrical devices.

Text Books:

1. Mathew N. O. Sadiku, 'Principles of Electromagnetics', 6th Edition, Oxford University Press Inc. Asian edition, 2015.
2. William H. Hayt and John A. Buck, 'Engineering Electromagnetics', McGraw Hill Special Indian edition, 2014.

Reference Books:

1. Kraus and Fleish, 'Electromagnetics with Applications', McGraw Hill International Editions, Fifth Edition, 2010.
2. V. V. Sarwate, 'Electromagnetic fields and waves', First Edition, Newage Publishers, 1993.

3. J.P. Tewari, ‘Engineering Electromagnetics - Theory, Problems and Applications’, Second Edition, Khanna Publishers.
4. S. P. Ghosh, Lipika Datta, ‘Electromagnetic Field Theory’, First Edition, McGraw Hill, Education(India) Private Limited, 2012.

Syllabus for B. Tech in Electrical Engineering, NIT Arunachal Pradesh

EE 226: Signals and Systems

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is design to:

1. imparting knowledge to the students for classification of networks and systems based on different criteria and their analysis using network theorems,
2. applicability of Fourier and Laplace transforms in circuit analysis,
3. making familiar with SPICE modelling,
4. use of MATLAB for circuit solving procedures.

Course Content:

Standard signals- Step, Ramp, Pulse, Impulse, Real and complex exponentials and Sinusoids_ Classification of signals – Continuous time (CT) and Discrete Time (DT) signals, Periodic and Aperiodic signals, Deterministic and Random signals, Energy and Power signals – Classification of systems- CT systems and DT systems- – Linear and Nonlinear, Time-variant and Time-invariant, Causal and Non-causal, Stable and Unstable.

Fourier series for periodic signals, Fourier Transform and Inverse Transform – properties,

Z-transform (ZT) and Inverse Z-transform (IZT)- properties. Region of convergence in Z-Transform. Laplace Transform and Inverse Transform-properties

Impulse response – convolution integrals for continuous signals - convolution for discrete signals. Correlation and Spectral Density. Differential Equation- Fourier and Laplace transforms in Analysis of CT systems – Systems connected in series / parallel. Baseband signal Sampling – Fourier Transform of discrete time signals (DTFT) – Properties of DTFT, Inverse Fourier Transform of discrete signals (IDFT). Fast Fourier Transform (FFT)-Inverse Fast Fourier Transform (IFFT).

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: understand the different kind of systems

CO2: determine the frequency components present in a deterministic signal

CO3: characterizing LTI systems in the time domain and frequency domain

CO4: compute the output of an LTI system in the time and frequency domains

Text Books:

1. Allan V. Oppenheim, S. Wilsky and S. H. Nawab, “Signals and Systems‖”, Pearson, 2015.
2. B. P. Lathi, “Principles of Linear Systems and Signals‖, Second Edition”, Oxford, 2009.

Reference Books:

1. A. Anand Kumar, “Signals and Systems‖”, PHI Learning, 2012.
2. Tarun Kumar Rawat, “Signals and Systems”, Oxford University Press, India.
3. Charles Phillips, “Signals, Systems and Transforms”, 3rd Edition, Pearson Education.
4. R. E. Zeimer, W. H. Tranter and R. D. Fannin, ―Signals and Systems – Continuous and Discrete‖, Pearson, 2007.

EE 227: Signals and Systems Laboratory

L	T	P	Credit
0	0	2	1

Course Objectives:

The course is design to:

1. imparting knowledge to the students for classification of networks and systems based on different criteria and their analysis using network theorems,
2. applicability of Fourier and Laplace transforms in circuit analysis,
3. making familiar with SPICE modelling,
4. use of MATLAB for circuit solving procedures.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: familiarity with discrete and continuous signals and systems.

CO2: understand the concepts of sampling of any continuous signals

CO3: analyse the Spectrum of any kind of signals.

CO4: acquire skills of using MATLAB software for discrete and continuous systems

List of Practical:

1. Program for autocorrelation and cross correlation of two signals
2. Program for Convolution two signals
3. Frequency response of discrete time system using D.T.F.T.
4. Program for calculating Inverse z-transform
5. Verification of sampling theorem.
6. Spectrum observation of any real signal using FFT and reconstruct the original signal using IFFT.
7. Synthesis of signals using Fourier Series
8. Study of Laplace Transforms using MATLAB

MA 203: Numerical Methods

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is designed to meet the objectives of:

1. Introducing the basic concepts of round off error, truncation error, numerical stability and condition, Taylor polynomial approximations; to derive and apply some fundamental algorithms for solving scientific and engineering problems: roots of nonlinear equations, systems of linear equations, polynomial and spline interpolation, numerical differentiation and integration, numerical solution of ordinary differential equations.
2. Application of computer oriented numerical methods which has become an integral part of the life of all the modern engineers and scientists. The advent of powerful small computers and workstation tremendously increased the speed, power and flexibility of numerical computing.
3. Injecting future scope and the research directions in the field of numerical methods.

Course Content:

Errors in computation: Overflow and underflow; Approximate numbers, significant digits, Approximation in numerical computation; Sources of errors (Truncation, chopping round off etc) Propagation and control of round off errors; Pitfalls (hazards) in numerical computations (ill conditioned and well conditioned problems).

Algebraic and Transcendental Equations: Bisection method; Regula-Falsi Method; Fixed point iteration method, Newton-Raphson Method, Secant Method; Order of convergence of Newton Raphson method.

Interpolation: Lagrange's Interpolation, Newton's forward and backward Interpolation Formula, Newton's Divided Difference Formula; Error statement only.

Numerical Differentiation: Use of Newton's forward and backward interpolation formula only.

Numerical Integration: trapezoidal formula (composite); Simpson's $1/3^{rd}$ and $3/8^{th}$formula (composite); Weddle's method, Error statement.

System of Linear Equations: Gauss elimination method; Gauss-Jordan Method; Matrix Inversion; Operations Count; LU Factorization Methods ; Gauss Jacobi, Gauss-Seidel Method; SOR (Formula only).

First Order Ordinary Differential Equations: Picard Method, Taylor's Series Method; Euler's Method; Modified Euler's Method, Runge-Kutta Method (up to 4th order); Error formula only.

Partial differential equations: Finite difference method for partial derivative, Implicit and explicit methods for one dimensional heat equation (FTCS and Crank-Nicholson methods), Finite difference explicit method for wave equation.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: Students will be skilled to do Numerical Analysis, which is the study of algorithms for solving problems of continuous mathematics.

CO2: Students will know numerical methods, algorithms and their implementation in Cfor solving scientific problems.

CO3: Students will be substantially prepared to take up prospective research assignments

Text Books:

1. K. E. Atkinson, "An Introduction to Numerical Analysis", John Wiley and Sons; 2nd edition, 1989.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, "Numerical method for Scientific and Engineering Computation", New Age International Pvt Ltd Publishers; 3rd edition, 1996.

Reference Books:

1. Santanu Saha Ray, Numerical Analysis with Algorithm and Programming, Chapman and Hall/CRC; 1 edition, 2018.
2. D. Kincaid and W. Cheney, "Numerical Analysis: Mathematics of Scientific Computing", 3rd Ed., AMS, 2002.
3. S. D. Conte and C. de Boor, "Elementary Numerical Analysis - An Algorithmic Approach", SIAM-Society for Industrial and Applied Mathematics, 2017.

4. C.M. Bender and S.A. Orszag, "Advanced Mathematical Methods for Scientists and Engineers", Springer; Softcover reprint of hardcover 1st edition, 1999.
5. John H. Mathews, "Numerical Methods for Mathematics Sciences and Engineering", Laxmi Publications, 2011.
6. V Rajaraman, "Computer Oriented Numerical Methods", PHI Learning Private Limited; 4th edition, 2018
7. Steven C. Chapra, "Numerical Methods for Engineers", McGraw-Hill Education; 6th edition, 2010.
8. Brian Bradie, "A Friendly Introduction to Numerical Analysis", Pearson Education; 1 edition, 2007.
9. R. L Burden and J.D. Faires, Numerical Analysis, Brooks/Cole; 3rd edition, 2002

MH 206: Entrepreneurship

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is designed to meet the objectives of:

1. To involve themselves in the business activities
2. Starting innovative practices in their entrepreneurial activities.
3. Developing their skills on the traits that they want to carry forward.
4. Starting activities on Forest based Technology.

Course Content:

Introduction to Entrepreneurship

Meaning, Role of Entrepreneur, Entrepreneur Process: different approaches, Motivation for becoming an Entrepreneur. SME Concept, its role, status, prospects and policies for promotion of SMEs. Importance of Entrepreneurship: innovations, Qualities of successful Entrepreneur, Functions of an Entrepreneur, Types of Entrepreneur, Issues and Problems Entrepreneurial Practices.

Importance of Entrepreneurship

Entrepreneurship and Innovations, Converting Innovation to Economic Value which includes, Growth Strategies, value position, Market Segments, Value Chain Structure, Revenue Model, Qualities of successful Entrepreneur, Functions of an Entrepreneur, Types of Entrepreneur, Issues and Problems Entrepreneurial Practices. Contribution of Entrepreneurs: Towards R and D, creates Wealth of Nation and Self prospect with Challenge. Entrepreneur Carrier: Different Stages, Entrepreneur Development Programmers (EDPs).

Characteristics of Entrepreneurship

Risk taker, Perceptive, Curious, Imaginative, Persistent, Goal setting, and Hardworking, Research and Management Skill, Organizing and Controlling, Soft skills and Feasibility. Women Entrepreneurship: Opportunities, promotion Hurdles and Prospects of women Entrepreneurs, Factors and Models of Entrepreneurial Development. Social Entrepreneurial Initiative: Solving social problems through opportunity identification, idea generation techniques, Business plan, Strategic Plan etc.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: start their venture more scientifically.

CO2: start their venture by linking with the financial institutions.

Text Books:

1. V. Desai, "Small-Scale Industries and Entrepreneurship", Himalaya Publishing House, Delhi. 2008
2. A. Kaulgud, "Entrepreneurship Management", Vikas Publishing House, Delhi.

Reference Books:

1. L. G. Cynthia, "Entrepreneurship Ideas in Action", Thomson Asia Pvt. Ltd., Singapore.
2. A. J. Timmons and S. Spinelli, Stephen, "New Venture Creation: Entrepreneurship for the 21st Century", 8th Edition, Boston, MA: Irwin McGraw-Hill
3. B. Barringer, "Entrepreneurship: Successfully Launching New Ventures", Pearson Education Publishing 2015
4. L. Hisrich, "Entrepreneurship", Tata McGraw Hill, New Delhi, 2001.
5. Donald F. Kuratko, "Entrepreneurship: Theory, Process, Practice", Cengage Learning 2017.

EE 301: Electrical Machines II

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is designed to:

1. study construction and operation of AC Electrical Machines,
2. calculation of machine parameters and modelling,
3. brief study of special electrical motors (PMBL), etc.,
4. introduce theory of machine control and practical applications.

Course Content:

Fundamentals of AC machine windings: Physical arrangement of windings in stator and cylindrical rotor; slots for windings; singleturncoil - active portion and overhang; full-pitch coils, concentrated winding, distributed winding, winding axis, 3D visualization of the above winding types, Air-gap MMFdistribution with fixed current through winding - concentrated and distributed, Sinusoidallydistributed winding, winding distribution factor

Pulsating and revolving magnetic fields: Constant magnetic field, pulsating magnetic field - alternating current in windings withspatial displacement, Magnetic field produced by a single winding - fixed current and alternating currentPulsating fields produced by spatially displaced windings, Windings spatially shifted by 90degrees, Addition of pulsating magnetic fields, three windings spatially shifted by 120degrees (carrying three-phase balanced currents), revolving magnetic field.

Induction Machines: Construction, Types (squirrel cage and slip-ring), Torque Slip Characteristics, Starting andMaximum Torque. Equivalent circuit. Phasor Diagram, Losses and Efficiency. Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency). Methods of starting, braking and speed control for induction motors. Generator operation. Self-excitation. Doubly-Fed Induction Machines.

Single-phase induction motors: Constructional features, double revolving field theory, equivalent circuit, determination ofparameters. Split-phase starting methods and applications

Synchronous machines: Constructional features, cylindrical rotor synchronous machine - generated EMF, equivalentcircuit and phasor diagram, armature reaction, synchronous impedance, voltage regulation. Operating characteristics of synchronous machines, V-curves. Salient pole machine – tworeaction theory, analysis of phasor diagram, power angle characteristics. Parallel operation ofalternators - synchronization and load division.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: understand the concepts of rotating magnetic fields.

CO2: understand the operation of ac machines.

CO3: analyse performance characteristics of ac machines.

Text Books:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", McGraw Hill Education, 2013.
2. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.

Reference Books:

1. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
2. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.
3. A. S. Langsdorf, "Alternating current machines", McGraw Hill Education, 1984.
4. P. C. Sen, "Principles of Electric Machines and Power Electronics", John Wiley and Sons, 2007.

EE 302: Electrical Machines II Laboratory

L	T	P	Credit
0	0	2	1

Course Objectives:

The course is designed to:

1. study construction and operation of AC Electrical Machines,
2. calculation of machine parameters and modelling,
3. brief study of special electrical motors (PMBL), etc.,
4. introduce theory of machine control and practical applications.

List of Practical:

1. Different methods of starting of 3 phase squirrel cage Induction motor and their comparison [D.O.L, Auto transformer and Star-Delta].
2. Speed control of 3 phase squirrel cage induction motor by different methods and their comparison [voltage control and frequency control].
3. Speed control of three phase slip ring Induction motor by rotor resistance control.
4. Determination of regulation of Synchronous machine by Potier reactance method.
5. Determination of regulation of an Alternator by Synchronous Impedance method.
6. Determination of equivalent circuit parameters of a single-phase Induction motor.
7. Load test on single phase slip ring induction motor to obtain the performance characteristics
8. Determination of direct axis reactance [X_d] and quadrature axis reactance [X_q] of three phase synchronous machine by slip test.
9. Performance characteristics of wound rotor induction motor by direct loading.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: construct the equivalent circuit of induction motors and predetermine the characteristics

CO2: analyze the performance characteristics of synchronous and asynchronous machines.

CO3: control asynchronous motors

CO4: demonstrate the connection of synchronous and asynchronous machines to infinite bus bar.

EE 303: Power System II

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is designed to:

1. introduce students to the concepts of performance of power system under various faults, like LG, LLG, LLL, LLLG etc. and their effects on power system, Single line diagram for fault analysis, tools for analyzing faults in power system, Symmetrical components, Unsymmetrical faults, PU system, Positive, Negative and Zero sequences components, Z bus formation,
2. analysis the power system under various faults. And to solve this power system constraint which are the tools to make use of. Solving faults problems has become a new challenged to power Engineers,
3. introduce the advent of powerful symmetrical components has become very useful tools to solve these constrains. Recognizing the importance of concepts of fault analysis in power system, this module is can be introduced in the Electrical Engineering curriculum.

Course Content:

Performance of transmission line. Introduction, short, medium and long transmission line,'Pi' and 'Tee' representation of medium transmission line with ABCD constants, Ferranti effect, transposition.Impedance or reactance diagram. Per unit system, Equivalent circuit diagram of transmission line.

Symmetrical components: Introduction, operator, sequence impedance and sequence networks on power system, Transmission line, Transformers, Synchronous machine. Positive, Negative and zero sequences in power system.

Symmetrical Fault Analysis: Symmetrical faults in Transmission line, Transients in transmission line, Short circuit synchronous machine on load and on no load condition. Algorithm for short circuit studies. Formation and implementation of ZBUS in solving faults.

Unsymmetrical Fault Analysis: Unsymmetrical faults in transmission line, Symmetrical components analysis of unsymmetrical faults. Single – line to ground (LG) fault, Line to line (LL) fault, Double line to ground (LLG) faults, Open Conductor faults. Bus impedance matrix methods for analysing of unsymmetrical faults.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: understand the various representations of transmission lines.

CO2: know the tools for faults calculation in transmission line.

CO3: analyze the transient in transmission line, transformers and in synchronous machine.

CO4: evaluation of fault current in symmetrical and unsymmetrical faults in transmission lines.

Text Books:

1. J. Graingerand W. D. Stevenson, "Power System Analysis", McGraw Hill, 1994.
2. Harder Edwin, "Fundamentals of Energy Production", John Wiley and Sons, 1982.

Reference Books:

1. M. V. Deshpande, "Elements of Electric Power Station Design", A.H. Wheeler and Company, 1979.
2. J. Burke, "Power Distribution Engineering; Fundamentals and Applications", MarcelDekk.,1996.
3. C. L. Wadhwa, "Electric Power Systems", Second Edition, Wiley Eastern Limited,1985.
4. I. J. Nagrath and D. P. Kothari, "Power System Engineering", Tata McGraw Hill, 1995

EE 304: Power System II Laboratory

L	T	P	Credit
0	0	2	1

Course Objectives:

The course is designed to:

1. introduce students to the concepts of performance of power system under various faults, like LG, LLG, LLL, LLLG etc. and their effects on power system, Single line diagram for fault analysis, tools for analyzing faults in power system, Symmetrical components, Unsymmetrical faults, PU system, Positive, Negative and Zero sequences components, Z bus formation,
2. analysis the power system under various faults. And to solve this power system constraint which are the tools to make use of. Solving faults problems has become a new challenged to power Engineers,
3. introduce the advent of powerful symmetrical components has become very useful tools to solve these constrains. Recognizing the importance of concepts of fault analysis in power system, this module is can be introduced in the Electrical Engineering curriculum.

List of Practical:

1. To study of various tools for solving faults in transmission line.
2. To study faults analysis using Bus impedance matrix in MATLAB.
3. To model transmission line using MATLAB programming.
4. To create ZBUILD and SYMFAULT programs for fault analysis
5. To study Single line to Ground (LG) fault using program/Simulink model.
6. To study Double line to Ground (LLG) fault using program/Simulink model.
7. To Study Single line to Ground (LLL) fault using program/Simulink model.
8. To study Line to line (LL) fault using program/Simulink model.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: understand structure of Transmission line and line simulator.

CO2: determine transmission line parameters for various conductor configurations using TLS

CO3: analyze transmission line parameters for Ferranti effect with PI model.

CO4: examine the Transmission regulation and efficiency with various loading.

Syllabus for B. Tech in Electrical Engineering, NIT Arunachal Pradesh

EE 305: Linear Control Systems

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is designed to:

1. impart theoretical and practical knowledge to the students in the area of process control engineering,
2. introduce basic characteristics of feedback control systems,
3. familiarize students with FRA and State Variable Analysis,

Course Content:

Industrial Control examples. Mathematical models of physical systems. Control hardware and their models. Transfer function models of linear time-invariant systems.

Feedback Control: Open-Loop and Closed-loop systems. Benefits of Feedback. Block diagram algebra.

Standard test signals. Time response of first and second order systems for standard test inputs. Application of initial and final value theorem. Design specifications for second-order systems based on the time-response.

Concept of Stability. Routh-Hurwitz Criteria. Relative Stability analysis. Root-Locus technique. Construction of Root-loci.

Relationship between time and frequency response, Polar plots, Bode plots. Nyquist stability criterion. Relative stability using Nyquist criterion – gain and phase margin. Closed-loop frequency response. Stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness of control systems.

Root-loci method of feedback controller design. Design specifications in frequency-domain. Frequency-domain methods of design. Application of Proportional, Integral and Derivative Controllers, Lead and Lag compensation in designs.

Analog and Digital implementation of controllers. Concepts of state variables. State space model. Diagonalization of State Matrix. Solution of state equations. Eigenvalues and Stability Analysis. Concept of controllability and observability.

Pole-placement by state feedback. Discrete-time systems. Difference Equations. State-space models of linear discrete-time systems. Stability of linear discrete-time systems. Performance Indices. Regulator problem, Tracking Problem. Nonlinear system–Basic concepts and analysis.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: understand the modellingof linear-time-invariant systems using transfer function and state-space representations.

CO2: understandthe concept of stability and its assessment for linear-time invariant systems.

CO3: design simple feedback controllers.

Text Books:

1. M. Gopal, “Control Systems: Principles and Design”, McGraw Hill Education, 1997.
2. B. C. Kuo, “Automatic Control System”, Prentice Hall, 1995.

Reference Books:

1. K. Ogata, “Modern Control Engineering”, Prentice Hall, 1991.
2. I. J. Nagrath and M. Gopal, “Control Systems Engineering”, New Age International, 2009
3. B. S. Manke, “Linear Control Systems with MATLAB applications”, Khanna Publishers, 12th Edition, 1986.

EE 306: Linear Control Systems Laboratory

L	T	P	Credit
0	0	2	1

Course Objectives:

The course is designed to:

1. impart theoretical and practical knowledge to the students in the area of process control engineering,
2. introduce basic characteristics of feedback control systems,
3. familiarize students with FRA and State Variable Analysis,

List of Practical:

1. Familiarization with MATLAB- control system tool box, MATLAB- Simulink tool box.
2. Determination of step response for first order and second order system with unity feedback and calculations of control system specifications like time constant, % peak overshoot, settling time etc., from the response.
3. Simulation of step response and impulse response for Type-0, Type-1 and Type –2 system with unity feedback using MATLAB and Pspice.
4. Determination of root locus, Bode- Plot, Nyquist Plot Using MATLAB- control system toolbox for 2nd order system and determination of different control system specifications from the plot.
5. Determination of PI, PD and PID controller action of first order simulated process.
6. Determination of approximate transfer function experimentally from bode plot.
7. Evaluation of steady state error, setting time, percentage peak overshoot, gain margin, phase margin with addition of lead.
8. Compensator and by compensator in forward path transfer function for unity feedback control system using Pspice or otherwise.
9. A practical position control system and determination of control system specifications for variation of system parameters.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: understand the behavior of different processes and parameters in process control.

CO2: identify the required instrumentation in process control.

CO3: develop dynamic model of processes.

CO4: design of process controllers.

CO5: application of computer-controlled systems.

EC 303: Microprocessor and Interfacing

L	T	P	Credit
3	0	0	3

Course Objectives

The course has been designed:

1. to introduce students to basic concepts of microprocessor
2. to give a knowledge on assembly level language.
3. to introduce interfacing of peripheral with microprocessor.

Course Content:

Introduction: Microcomputer structure and operation, 8086 microprocessor family, Overview, Architecture of processor 8085 and 8086.

Assembly Language Programming: Programming development steps, Constructing machine development codes for 8085 and 8086 instructions, Assembly language program development tools.

Strings, Procedure and Macros: String instructions, Writing and using procedures, Writing and using assembler macros

Instruction Description and Assembler Directives: Instruction descriptions, Assembler directives systems connections, Timing and troubleshooting: Basic 8086 microcomputer systems connections, Logic analyzer to observe microprocessor bus signals, Troubleshooting simple 8086-based microcomputer

Peripheral Interfacing Applications: Basic interfacing concepts, Memory / IO interfacing, Non-programmable peripheral interface, 8255 programmable peripheral interface, Interfacing display, keyboards, 8279 programmable keyboard / display interface, 8253/54 programmable timer, DMA controller, Interrupt controller, ADC and DAC interfacing, 8086 interrupts and types, 8259A priority interrupt controller, Software interrupt applications.

Memories, Coprocessors and EDA Tools: 8086 maximum mode and DMA data transfer, Interfacing and refreshing dynamic RAMs, Coprocessor - 8087 Math coprocessor, Computer based design and development tools.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: students will have the thorough understanding of the evolution of microprocessor

CO2: students will get to know the interfacing knowledge to get a kick start in embedded world

CO3: students will get the idea of doing lively embedded design projects

Text Books:

1. Sunil Mathur, “Microprocessor 8085 and its Interfacing”, PHI, 2007.
2. Sunil Mathur, “Microprocessor 8086: Architecture, Programming and Interfacing”, PHI, 1998.

Reference Books:

1. R. S. Gaonkar, “Microprocessor Architecture, Programming and Applications with 8085”, Penram International, 2000.
2. B. Ram, “Fundamental of Microprocessor and Microcomputers”, Dhanpat Rai Publications, 2007.
3. Leventhal Lance, “Introduction to Microprocessor - Software, Hardware and Programming”, PHI, 1996.
4. A. P. Mathur, “Introduction to Microprocessor”, Tata McGraw-Hill, 1994.
5. K. L. Short, “Microprocessor and Programming Logic”, Pearson Education, 2000.
6. D. Hall, “Microprocessor and Interfacing”, Tata McGraw-Hill, 2012.

EC 307: Microprocessor and Interfacing Laboratory

L	T	P	Credit
0	0	2	1

Course Objectives

The course has been designed:

1. to introduce students to basic concepts of microprocessor
2. to give a knowledge on assembly level language.
3. to introduce interfacing of peripheral with microprocessor.

List of Practical:

1. Introduction to 8085 / 8086 Kit and Peripheral Boards.
2. Program set for Architecture Operations.
3. Program set for Logical and Decimal.
4. Program set for Subroutines and Delay.
5. Program set for Program Control.
6. Interfacing with 8255.
7. Interfacing with 8279.
8. Interfacing with 8253.
9. Interfacing with ADC/DAC

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: students will have the thorough understanding of the evolution of microprocessor

CO2: students will get to know the interfacing knowledge to get a kick start in embedded world

CO3: students will get the idea of doing lively embedded design projects

EE 307: Power Electronics

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is design to:

1. understand advanced topics of power electronics,
2. introduce improved power quality ac-dc converters,
3. acquire knowledge of power quality mitigation devices,

Course Content:

Power semiconductor devices:

Introduction: Concept of Power Electronics, scope and applications, desired Characteristics of controllable switches Power semiconductor switches and their characteristics: Power Diode, Power BJT, Power MOSFET, IGBT, SCR, TRIAC, GTO.

Thyristor: Rating and protection, Methods of SCR commutation, Gate Drive Circuit, Series and Parallel operation.

DC-DC Converters:

Introduction, Control Strategies, Buck converter, Boost Converter, Buck-Boost converter, Analysis of buck converter, Special Types of DC-DC converters-CUK and SEPIC converter, Switched Mode power Supply (SMPS).

Phase Controlled Converters:

Single phase half wave-controlled rectifier with various loads, Effect of freewheeling diode. Single phase fully controlled and half controlled bridge converters with various loads. Performance Parameters of single phase uncontrolled and controlled converters. Three phase half wave converters, three phases fully controlled and half controlled bridge converters, Effect of source impedance, Single phase and three phase dual converters.

AC Voltage Controllers:

Principle of On-Off and phase controls, Single phase ac voltage controller with resistive and inductive loads, sequence control, Introduction to Matrix converter.

Cyclo-Converters:

Basic principle of operation, single phase to single phase, three phases to single phase output voltage equation

Inverters:

Single phase and Three phase bridge inverters, VSI, CSI, Voltage control of single-phase inverters, Series and Parallel inverter-Analysis of basic series inverter, Modified series inverter, Half bridge series inverter, PWM Techniques, Introduction to Multi level inverter.

Applications:

Speed control of AC and DC motors. HVDC transmission. Static circuit breaker, UPS, static VAR controller.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: relate basic semiconductor physics to properties of power devices, and combine circuit mathematics and characteristics of linear and non-linear devices.

CO2: compare the performance of basic power semiconductor devices any analyze their circuit performance.

CO3: analyse and Identify power converters for particular system application.

CO4: recognize the role of power electronics in different renewable energy applications and their importance in different emerging research areas.

Text Books:

1. M.H. Rashid, “Power Electronics: Circuits, Devices and Applications”, Pearson India, 4th Edition,2018.
2. Ned Mohan, T. M. Undeland and W. P. Robbins, “Power Electronics: Converters, Applications and Design”, Wiley India Ltd,2008.

Reference Books:

1. P.S. Bhimbra, “Power Electronics”, Khanna Publishers.

2. P.C. Sen, “Power Electronics”, McGraw Hill Education (India) Pvt. Ltd.
3. V.R. Moorthy, “Power Electronics: Devices, Circuits and Industrial Applications”, Oxford University Press,2007.
4. M.S. Jamil Asghar, “Power Electronics”, Prentice Hall of India Ltd., 2004

EE 308: Power Electronics Laboratory

L	T	P	Credit
0	0	2	1

Course Objectives:

The course is design to:

1. understand advanced topics of power electronics,
2. introduce improved power quality ac-dc converters,
3. acquire knowledge of power quality mitigation devices,

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: identify different simulation and analytical soft-wares for power electronics application

CO2: analyze simulation results and do effective documentation.

CO3: develop skills for designing, simulating and developing hard-wares for power electronic circuits.

CO4: acquire expertise in usage of modern power electronic hardware and software tools.

List of Practical:

1. Study of IGBT, MOSFET, BJT switching characteristics.
2. Triggering circuits for SCR, MOSFET, IGBT, BJT & UJT.
3. Experimental Evaluation of Class-A, Class-B, Class-C, Class-D and Class-E commutation of thyristor.
4. Experimental Evaluation of Step-Up chopper circuit.
5. Experimental Evaluation of Step-Down Chopper circuit.
6. Experimental Evaluation of Voltage commutated chopper circuit.
7. Experimental Evaluation of Single-phase full phase-controlled rectifier with R Load, R-L Load and RLE load.
8. Experimental Evaluation of Single-phase full bridge Inverter.
9. Experimental Evaluation of Current source inverter circuit.
10. Experimental Evaluation of single phase AC voltage controller.
11. Experimental Evaluation of single phase PWM control.
12. Experimental Evaluation of single phase cyclo-converter.

EE 321: Switchgear and Protection

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is designed to:

1. introduce students to fundamentals of protection equipment used in power systems, concept of primary and backup relaying
2. analysis the power system under various faults. And to solve this power system constraint which are the tools to make use of. Solving faults problems has become a new challenged to power Engineers,
3. imparting theoretical and practical knowledge of modern switchgear and current trends in protective relaying,

Course Content:

Switchgear Protection: Importance of protective relaying power systems –fundamental requirements of a good protection scheme–Primary and Back-up Relaying. Distribution substation: Types of substations, Location of Substation, Substation — equipment and accessories, Earthing of Substation.

Classification of Relays: Constructional (Viz., elector mechanical and Static Relays) and Functional viz. Over current, Directional, Differential, Distance relays etc. their principles and applications. Current Trends in Protective Relaying: Microprocessor and PC based Relaying.

Switchgear: Classification of Switchgear, Fault Analysis, Symmetrical Faults on a synchronous machine, Fault clearing process, Arcing Phenomena and principles of arc interruption.

Circuit Breaker: AC and DC circuit breakers, Different types of circuit breakers and their constructional features, Testing and Selection of circuit breakers. Auto- reclosing feature – three pole and single pole auto reclosing, Problems of capacitive and low inductive current interruptions Distance relays their settings, errors and remedies to errors. Static and Digital Relaying: Generalized approach for two input and multi input comparators, Phase and amplitude comparison, inputs for different types of static distance protection, hardware for static relays, concept of digital relaying, main components of digital relays.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: understand various power system protection schemes.

CO2: select suitable circuit breaker for various protection systems.

CO3: analyze operation of protective relays under various faults.

CO4: develop suitable protection schemes for power system components.

Text Books:

1. P. Peter, “The Elementary Council, Power System Protection”, Vol.1-3, Wiley Publications.
2. A. R. Van, A.R., and C. Warrington, “Protective Relays: Their Theory and Practice”, Vol.1 and 2, Chapman and Hall.

Reference Books:

3. Y. G. Paithankar, “Transmission Network Protection: Theory and Practice”, Marcel Dekker Inc.
4. P.H.J. Crane, “Switchgear principles”, IEEE Press.
5. S. Rao, “Switchgear Protection and Power Systems”, Khanna Publishers, 14th Edition, 1977.

EE 322: Power System Operation and Control

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is designed to:

1. introduce overview of power system operation and control,
2. acquire knowledge of modelling power frequency dynamics to design power frequency controllers,
3. model reactive power-voltage interaction and the control actions to be implemented for maintaining voltage profile against varying system load.

Course Content:

Review of the structure of a Power System and its components. Analysis of Power Flows: Formation of Bus Admittance Matrix. Real and reactive power balance equations at a node.

Load and Generator Specifications. Application of numerical methods for solution of nonlinear algebraic equations – Gauss Seidel and Newton-Raphson methods for the solution of the power flow equations. Computational Issues in Large-scale Power Systems.Swing Equations of a synchronous machine connected to an infinite bus. Power angle curve.

Description of the phenomena of loss of synchronism in a single-machine infinite bus system following a disturbance like a three--phase fault. Analysis using numerical integration of swing equations (using methods like Forward Euler, Runge-Kutta 4thorder methods), as well as the Equal Area Criterion. Impact of stability constraints on Power System Operation.

Effect of generation rescheduling and series compensation of transmission lines on stability. Turbines and Speed-Governors, Frequency dependence of loads, Droop Control and Power Sharing. Automatic Generation Control. Generation and absorption of reactive power by various components of a Power System. Excitation System Control in synchronous generators, Automatic Voltage Regulators. Shunt Compensators, Static VAR compensators and STATCOMs. Tap Changing Transformers.

Power flow control using embedded dc links, phase shifters and Overview of Energy Control Centre Functions: SCADA systems. Phasor Measurement Units and Wide-Area Measurement Systems. State-estimation. System Security Assessment.

Normal, Alert, Emergency, Extremis states of a Power System. Contingency Analysis. Preventive Control and Emergency Control.Basic Pricing Principles: Generator Cost Curves, Utility Functions, Power Exchanges, Spot Pricing. Electricity Market Models (Vertically Integrated, Purchasing Agency, Whole-sale competition, Retail Competition), Demand Side-management, Transmission and Distributions charges, Ancillary Services. Regulatory framework.

Course Outcome:

At the end of this course, students will demonstrate the ability to

CO1: use numerical methods to analyse a power system in steady state.

CO2: understand stability constraints in a synchronous grid.

CO3: understand methods to control the voltage, frequency and power flow.

CO4: understand the monitoring and control of a power system.

CO5: understand the basics of power system economics.

Text Books:

1. J. Grainger and W. D. Stevenson, “Power System Analysis”, McGraw Hill Education, 1994.
2. O. I. Elgerd, “Electric Energy Systems Theory”, McGraw Hill Education, 1995.

Reference Books:

1. R. Bergen and V. Vittal, “Power System Analysis”, Pearson Education Inc., 1999.
2. D. P. Kothari and I. J. Nagrath, “Modern Power System Analysis”, McGraw Hill Education, 2003.
3. B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, “Electric Power Systems”, Wiley, 2012.

EE 323: Electrical Drives

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is design to:

1. to familiarize students with the concepts of electric drives, study DC Drives, study AC Drives.
2. provide in-depth knowledge of power converters fed AC and AC drives in open and closed loop,
3. control of different AC and DC Drives.

Course Content:

Electrical drive: Concept, classification, parts and advantages of electrical dives. Dynamics of Electrical Drives: Types of Loads, Components of load toques, Fundamental torque equations, Equivalent value of drive parameters for loads with rotational and translational motion. Steady state stability, Transient stability. Multiquadrant operation of drives. Load equalization, Motor power rating: Thermal model of motor for heating and cooling, classes of motor duty, determination of motor rating for continuous, short time and intermittent duty, equivalent current, torque and power methods for fluctuating and intermittent loads.

Starting of Electric Drives: Effect of starting on Power supply, motor and load, methods of starting of electric motors, Acceleration time Energy relation during starting, methods to reduce the Energy loss during starting.Braking of Electric Drives: Types of braking, braking of DC motor, Induction motor and Synchronous motor, Energy loss during braking.

DC motor drives: Single phase, three phases fully controlled and half controlled rectifier fed DC drives. Dual converter control of DC drives. Power factor, supply harmonics and ripple in motor current. Chopper control of DC drives. Induction motor drives: Stator voltage variation by three phase controllers, Speed control using chopper resistance in the rotor circuit, slip power recovery scheme. Introduction to Pulse width modulated inverter fed and current source inverter fed induction motor drive, Volts/Hertz Control and Vector or Field oriented control.

Synchronous motor drive: Variable frequency control, Self-Control, Voltage source inverter fed synchronous motor drive.

Introduction to Solar and Battery Powered Drive, Stepper motor, Switched Reluctance motor, Brushless DC motor drive.

Course Outcome:

At the end of this course, students will demonstrate the ability to

CO1: understand the steady state and transient characteristics of an electricdrive system.

CO2: select a suitable motor for a specific drive application.

CO3: identify suitable control techniques for DC and AC motor drives.

CO4: discuss the use of special machines like stepper and switched reluctance motors in Electric Drive application

Text Books:

1. S.K. Pillai, "A first course on Electrical Drives", New Age International Publication.
2. G.K. Dubey, "Fundamental of Electrical Drives", New Age International Publication.

Reference Books:

1. R. Krishnan, "Electric motor Drives", Pearson Education.
2. B. K. Bose, "Modern power Electronics and AC drives", Prentice Hall of India.
3. G. K. Dubey, "Power Semiconductor Controlled Drives", Prentice Hall of India
4. V. Subrahmanyam, "Electric Drives", Tata McGraw Hill.

EE 324: Electrical Drives Laboratory

L	T	P	Credit
0	0	2	1

Course Objectives:

The course is design to:

1. to familiarize students with the concepts of electric drives, study DC Drives, study AC Drives.
2. provide in-depth knowledge of power converters fed AC and AC drives in open and closed loop,
3. control of different AC and DC Drives.

List of Practical:

1. Thysistor controlled DC Drive.
2. Chopper fed DC Drive
3. SAC Single phase motor-speed control using TRIAC.
4. PWM Inverter fed 3 phase Induction Motor control using PSPICE /MATLAB / PSIM Software.
5. VSI / CSI fed Induction Motor Drive analysis using MATLAB/PSPICE/PSIM Software.
6. V/f control operation of 3phase induction motor drive.
7. Permanent magnet synchronous motor drive fed by PWM Inverter using Software.
8. Regenerative / Dynamic braking operation for DC Motor - Study using software.
9. Regenerative / Dynamic braking operation of AC motor - study using software. PC/PLC based AC/DC motor control operation.

Course Outcome:

At the end of this course, students will demonstrate the ability to

CO1: understand the steady state and transient characteristics of an electric drive system.

CO2: select a suitable motor for a specific drive application.

CO3: design suitable control technique for an electric drive.

CO4: analyse the performance of an electric motor in an application.

EE 325: Electrical Machine Design

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is design to:

1. teach the basics of electrical machine design.
2. familiarize students with design of cooling methods of electrical machineries.
3. impart knowledge of analytical calculations of electrical machine parameters.

Course Content:

Major considerations in Electrical Machine Design - Electrical Engineering Materials – Space factor – Choice of Specific Electrical and Magnetic loadings - Thermal considerations - Heat flow – Temperature rise - Rating of machines – Standard specifications.

DC MACHINES

Output Equations – Main Dimensions - Magnetic circuit calculations – Carter's Coefficient – Net length of Iron –Real and Apparent flux densities – Selection of number of poles – Design of Armature – Design of commutator and brushes – performance prediction using design values.

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.

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 and 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

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.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: study mmf calculation and thermal rating of various types of electrical machines.
CO2: design armature and field systems for D.C. machines.
CO3: design core, yoke, windings and cooling systems of transformers.
CO4: design stator and rotor of induction machines.
CO5: design stator and rotor of synchronous machines and study their thermal behaviour.

Text Books:

1. A. K. Sawhney, "A Course in Electrical Machine Design", Dhanpat Rai and Sons, New Delhi, 1984.
2. S. K. Sen, "Principles of Electrical Machine Designs with Computer Programmes", Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 1987.

Reference Books:

1. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
2. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.
3. A. S. Langsdorf, "Alternating current machines", McGraw Hill Education, 1984.
4. P. C. Sen, "Principles of Electric Machines and Power Electronics", John Wiley and Sons, 2007.

EE 326: Electrical Machine Design Laboratory

L	T	P	Credit
0	0	2	1

Course Objectives:

The course is design to:

1. teach the basics of electrical machine design.
2. familiarize students with design of cooling methods of electrical machineries.
3. impart knowledge of analytical calculations of electrical machine parameters.

List of Practical:

1. Design of lap and wave winding.
2. Design of armature slots of rotating machines.
3. Calculation of design parameters of a DC motor.
4. Calculation of design parameters of a single-phase induction motor.
5. Calculation of design parameters of a synchronous machine.
6. Design of cooling tubes for a distribution transformer.
7. Design of windings of a distribution transformer.
8. Design and estimation of air gap of a synchronous machine.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: understand the basic structure of electrical machines.

CO2: select suitable electrical and magnetic loading for electrical machines.

CO3: design rotating electrical machines and power transformers for a particular application/duty cycle

CO4: devise proper cooling method for electric machines based on application/duty cycle

EE 327: Utilization of Electrical Power

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is design to:

1. introduce application fields of electrical power.
2. teach various industrial electrical systems.
3. impart the knowledge of illumination engineering and energy efficacies.

Course Content:

Traction: System of Traction Electrification, Train movement and energy consumption (Speed-time curves, Crest speed, Average speed and Schedule speed), Tractive effort, Factors affecting energy consumption (Dead weight, Acceleration weight and Adhesion weight), Protective devices.

Electric Traction motor and their control: Starting, breaking with special emphasis on power electronic controllers, Current collector, Interference with telecommunication circuit. A brief outline of linear Induction motor principle in Traction.

Illumination: Laws of illumination, Polar cuvees, Photometry, Integrating sphere, Types of Lamps: Conventional and Energy Efficient, Basic principle of Light control, Different lighting scheme and their design methods, Flood and Street lighting.

Heating: Types of heating, Resistance heating, Induction heating, Arc furnace, Dielectric heating, Microwave heating.

Welding: Resistance welding, Arc welding, Ultrasonic welding, Electron bean welding, Laser beam welding, Requirement for good welding, Power supplies for different welding schemes.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: understand different utilities of electric energy.

CO2: analyze an industrial process like electrochemical, welding, heating etc.

CO3: design suitable lighting scheme for a particular application.

CO4: select a suitable motor for electric traction and hybrid vehicles.

Text Books:

1. C. L. Wadha, Generation, "Distribution and Utilization of electrical energy", New Age International Ltd.
2. H. Partab, "Art and Science of Utilization of Electrical Energy", Dhanpat Rai and Sons.

Reference Books:

1. E. Openshaw and Taylor, "Utilization of Electric Energy", Orient Longman.
2. S.K. Sahdev, "Utilization of electrical energy and traction", New Age International.
3. K. Sivanagaraju, "Electric Energy: Generation, Utilization and Conservation", Pearson Publications.

MH 306: Professional Communication

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is designed to make students:

1. become aware of the numerous career opportunities within the field of communication.
2. enrol in the TOFEL and IELTS examinations.
3. show an understanding of opportunities in the field of communication.
4. apply effective communication skills in variety of public and interpersonal settings
5. discover the impact of changing communication methods on society

Course Content:

Introduction to English for national and international examinations and placements. International English Language Testing System (IELTS)- Test for English as a Foreign Language (TOFEL)- Civil Service (Language related verbal ability)- Cambridge Proficiency in English (CPE). Activity: Online mock drills and practices.

Interview Skills. Different types of interview formats-answering questions: one to one and one to panel-offering information-body language-dress code- articulation of sounds-intonation, pitch- Interview and professional etiquettes- FAQs related to job interviews. Activity: mock interviews by experts.

Interview Preparation: Writing- writing job application-résumé, bio-data, CV, letters, email, reports (via email and hard copy), online blog. Group Discussion: Introduction to GD, understanding dynamics of GD, brainstorm the topics, questioning and clarifying-GD strategies-activities to improve GD skills-negotiation skills. Activity: Role plays and GDs.

Interview Preparation: Speaking- self-introduction-organizing materials for speaking-discourse markers-presenting visuals/maps/numerals/charts effectively- PPT presentation-dos and don’ts-time management in speaking and answering questions. Activity: Story completion, Group role plays, mock stage talks.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: become aware of the numerous career opportunities within the field of communication.
CO2: enrol in the TOFEL and IELTS examinations.
CO3: show an understanding of opportunities in the field of communication.
CO4: apply effective communication skills in variety of public and interpersonal settings
CO5: discover the impact of changing communication methods on society

Text Books:

1. R. Meenakshi and S. Sharma, “Professional Communication”, Oxford University Press-2014
2. B. K. Mitra, “Personality Development and Soft Skills”, Oxford University Press-2016.

Reference Books:

1. P. Patnaik, “Group Discussion and Interview Skills”, 1st Edition, Cambridge-2011.

EE 401: Renewable Energy Sources (Open Elective)

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is design to:

1. teach various renewable energy resources available in the country, their potential, exploitation/achievements etc.,
2. introduce solar energy radiation on the earth surface and outside earth atmosphere, solar radiation measurement and estimation etc.,
3. familiarize students with wind resource assessment, site selection for wind turbines, wind systems, physics of wind and wind measurements and instruments,
4. inculcate knowledge of small hydro resource assessment, hydrographs, estimates for flow, head, and power site selection,
5. impart working principles of geothermal, wave, tidal and OTEC resources assessment, estimation of power potential, site selection,
6. introduce bio-energy resource assessment, physical and chemical properties, composition.

Course Content:

Introduction: Renewable Energy Sources: Solar, biomass, wind, tidal, geothermal, micro hydel, etc. their availability and potential.

Solar Energy Resources: Solar radiation: Spectrum of EM radiation, sun structure and characteristics, extra-terrestrial radiation, solar constant, air mass, beam, diffused and total solar radiation, spectral distribution Sun-earth movement in different seasons, solar geometry, solar radiation on tilted surface, local apparent time, irradiance, insolation attenuation of solar radiation by the atmosphere, albedo, beam and diffuse components of hourly and daily radiation, clearness index, Radiation augmentation Different climatic zones and their impact on site selection.

Solar Photovoltaic:

Solar photovoltaic conversion: Solar cell fundamentals: Semiconductors, p-n Junction Generation of Electron-Hole pair by photon absorption, photoconduction, Solar cell characteristics: I-V Characteristics, Effect of Variation of Insolation and Temperature, Energy Losses and Efficiency, Maximizing the Performances, Cell size, Energy Payback Period (EPP), Solar Cell Basic principle of SPV conversion, types of solar Cells, fabrication of SPV cells, modules.

Wind power plants: Introduction: - Modern wind turbines, wind resources, wind vs. traditional electricity generation, technology advancements, material Usage. Applications: grid connected power, industrial applications, stand-alone system, water pumping, offshore prospects. Wind Resource Assessment: Introduction, spatial variation, time variations, seasonal and monthly variability, diurnal variations. Characteristics of steady wind: turbulence, types of turbulence models, turbulence intensity, wind power density. Weibull wind speed distribution function: Estimating Weibull distribution factor. Wind Measurement: Vertical profiles of the steady wind. Wind speed measurement parameters, Monitoring station instrumentation, cup anemometer, propeller anemometer, Ultrasound anemometer, wind vane, data loggers, remote wind speed sensing techniques- Sodar, Lidar, SAR, LWS, Satellite remote sensing. Aerodynamics: Aero foil, two-dimensional airfoil theory, relative wind velocity. Wind flow models, wind flow pattern. Axial momentum theory, Momentum theory, blade element theory. Wind machine characteristics. Wind Turbines: Historical development, Classification of wind turbines. Turbine components. Wind turbine design: Introduction, rotor torque and power, Power control, braking systems. Turbine blade design. Blade material, SERI blade sections, Transmission and generation efficiency, Energy production and capacity factor, Torque at constant speeds, Drive train oscillations.

Hydropower generation: Introduction, Large, Mini and micro hydropower plants, its advantages; disadvantages, daily load curve, Selection of site for hydroelectric plant, Pump Storage Hydropower plants,

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: understand the need and impact of renewable energy and energy conservation.

CO2: illustrate different methods to extract energy from available alternative energy sources.

CO3: estimate energy potential and saving.

CO4: analyse the characteristics and control of various energy conversion and utilisation systems

CO5: design of systems for energy extraction from various renewable sources.

Text Books:

1. G. L. Johnson, "Wind Energy Systems", Prentice Hall India, 2006
2. S. Mathew, "Wind Energy: Fundamentals, Resource Analysis and Economics", Springer, 2006.

Reference Books:

1. T. Burton and D. Sharpe, "Wind Energy Handbook", John Wiley, 2001
2. A. R. Jha, "Wind Turbine Technology", CRC Press, Taylor and Francis, 2011
3. G. N. Tiwari and M. K. Ghosal, "Fundamentals of Renewable Energy Sources", Narosa Publications.
4. Godfrey Boyle, "Renewable Energy", Wiley Publications.

EE 401: Renewable Energy Sources Laboratory

L	T	P	Credit
0	0	2	1

Course Objectives:

The course is design to:

1. teach various renewable energy resources available in the country, their potential, exploitation/achievements etc.,
2. introduce solar energy radiation on the earth surface and outside earth atmosphere, solar radiation measurement and estimation etc.,
3. familiarize students with wind resource assessment, site selection for wind turbines, wind systems, physics of wind and wind measurements and instruments,
4. inculcate knowledge of small hydro resource assessment, hydrographs, estimates for flow, head, and power site selection,
5. impart working principles of geothermal, wave, tidal and OTEC resources assessment, estimation of power potential, site selection,
6. introduce bio-energy resource assessment, physical and chemical properties, composition.

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: understand the need and impact of renewable energy and energy conservation.
CO2: illustrate different methods to extract energy from available alternative energy sources.
CO3: estimate energy potential and saving.
CO4: analyse the characteristics and control of various energy conversion and utilisation systems
CO5: design of systems for energy extraction from various renewable sources.

List of Practical:

1. Determining the intensity of solar radiation.
2. Arrangement of Photovoltaic cells.
3. Setting up of the Photovoltaic panel with the help of the given settings to get the maximum exposure of the sunlight.
4. Aero generator operation as per the variation of wind speed.
5. Generator angle of incidence variation.
6. Operation differences using the three available blades configurations (aero generator with 6, 3 or 2 blades).
7. Operation differences depending on the angle of the blades.
8. Load variation influence on the aero generator.
9. Detailed study on the pumped storage hydro power plant,
10. Operation of hydropower plant and to find out the terminal voltage and frequency,
11. Synchronization of power plant with grid system.

EE 403A: High Voltage Engineering

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is design to:

1. design a simple protection system for a section of a power system, such as a feeder, a transformer or a motor.
2. select appropriate hardware for certain applications in power system protection and high voltage engineering,
3. describe the principles of the generation and measurement of high voltage AC, DC and impulse voltages,
4. describe the fundamentals of breakdown and partial discharge in insulating solid and gas at high voltages,
5. appreciate the advantages of new technological solutions in new and existing power system installations.

Course Content:

Breakdown Phenomena: Breakdown of Gases: Charge multiplication, Secondary emission, Townsend Theory, Streamer Theory, Paschen's Law, Determination of Minimum breakdown voltage, Breakdown in non-uniform field, Effect of polarity on corona inception and break down voltage. Partial Discharge: definition and development in solid dielectric. Break Down of Solids: Intrinsic breakdown, Electromechanical breakdown, Thermal breakdown, Streamer Breakdown. Breakdown of Liquid: Intrinsic Break down, Cavitation Theory, Suspended particle Theory.

Lightning Phenomena: Electrification of cloud, Development of Lightning Stroke, lightning induced over voltage, direct stroke, indirect stroke. Protection of Electrical Apparatus against over voltage: Lightning Arrestors, Valve Type, Metal Oxide arresters, Expulsion type. Effect of location of lightning arresters on protection of transformer. Protection of substation, Earth wire. Insulation Coordination: Basic Insulation level. Basic Impulse level, Switching Impulse level. Volt time characteristics of protective devices, Determination of Basic Impulse level of substation equipment.

Generation of High Voltage: Generation of high AC voltage by testing transformer, cascaded transformer, series resonant circuit, single stage and multi stage. Advantages of Series Resonant Circuit in testing of cables. Generation of DC high voltage: Cockcroft Walton doubler and multistage circuit. Definition of Impulse Voltage as per Indian Standard Specification, Wave front and wave tail time, Generation of Impulse Voltage, Multistage impulse generator, triggering of Impulse Generator.

Measurement of High Voltage: Sphere gap voltmeter: AC, DC and impulse, high voltage measurement as per Indian Standard Specifications. Resistance and Capacitance Potential dividers, Peak voltmeters for measurement of high AC voltage in conjunction with capacitance dividers. Capacitance Voltage Transformer, Rotating Voltmeter for the measurement of DC high voltage, Electrostatic VoltmeterHigh Voltage testing: Testing as per Indian Standard Specifications: Power frequency withstand, induced over voltage and impulse test on transformers, Power frequency wet withstand test and impulse test on insulators.

Course Outcome:

At end of this course, students will demonstrate the ability to:

CO1: understand and formulate equations for uniform and non-uniform electric field and electric field in different geometric boundaries.

CO2: analyze the breakdown behaviour of gas, liquid and solid dielectric materials.

CO3: illustrate the circuits for generation and measurement of high voltage ac, dc and impulse

CO4: discuss the non-destructive test techniques for measuring dielectric properties
CO5: investigate measures for testing of power apparatus used in high voltage applications.
CO6: assess the standard specifications for high voltage testing procedures.

Text Books:

1. E. Kuffel, W.S. Zaengl, “High Voltage Engineering Fundamentals”, Pergamon press, Oxford.
2. M. S. Naidu and V. Kamraju, “High Voltage Engineering”, Tata McGraw Hill.

Reference Books:

1. C. L.Wadhwa, “High Voltage Engineering”, New Age International.
2. S. Roy, “An introduction to High Voltage Engineering”, Prentice Hall of India.
3. S. Hadad and K. Warene, “Advances in High Voltage Engineering”, IET.

Syllabus for B. Tech in Electrical Engineering, NIT Arunachal Pradesh

EE 403B: Advanced Control System

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is design to:

1. make students understand the concept of nonlinear control, Internal Model Control and Optimal Control.
2. study the stability of Non Linear and Linear systems.

Course Content:

State variable model of continuous dynamic systems: Converting higher order linear differential equations into state variable form. Obtaining SV model from transfer functions. Obtaining characteristic equation and transfer functions from SV model. Obtaining SV equations directly for R-L-C and spring-mass-dashpot systems. Concept and properties associated with state equations. Linear Transformations on state variables. Canonical forms of SV equations. Companion forms. Solutions of state equations, state transition matrix, properties of state transition matrix. Derivation of transfer function from state model, diagonalization, Eigen values, Eigen vectors, generalized Eigen vectors.

Controllability and observability, Linear State variable feedback controller, the pole placement techniques, stability improvement by state feedback, necessary and sufficient conditions for arbitrary pole placement, state regulator design, and design of state observer, Controllers- P, PI, PID.

Introduction to non-linear systems: Block diagram and state variable representations. Behaviour of non-linear systems, common physical non linearity-saturation, friction, backlash, dead zone, relay, multi variable non-linearity. Phase plane analysis of linear and non-linear second order systems. Methods of obtaining phase plane trajectories by graphical method – isoclines method. Qualitative analysis of simple control systems by phase plane methods. Describing Function method. Limit cycles in non-linear systems. Prediction of limit cycles using describing function.

Stability concepts for nonlinear systems. BIBO vs. State stability. Lyapunov's definition. Asymptotic stability, Global asymptotic stability. The first and second methods of Lyapunov methods to analyse non-linear systems.

Course Outcome:

At end of this course, students will demonstrate the ability to:

CO1: review of linear system in state space approach.

CO2: design state feedback controller for linear dynamic systems.

CO3: analyze non-linear systems in state space frame work.

CO4: investigate non-linear system stability.

CO5: outline of advanced control concepts.

Text Books:

1. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall, 2010
2. Richard C. Dorf, Robert H. Bishop, "Modern control systems", Prentice Hall.

Reference Books:

1. D. Roy Choudhuri, "Control System Engineering", Prentice Hall of India.
2. Franklin, Powell, Workman, Addison Wesley, "Digital Control of Dynamic Systems", Wiley.
3. D. K. Anand, R. B. Zmood, "Introduction to Control Systems", Asian Books.
4. H. Goodwin, "Control System Design", Pearson Education.

EE 403C: Special Electrical Machines

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is design to:

1. to familiarize students with the concepts of electric drives, study DC Drives, study AC Drives.
2. provide in-depth knowledge of power converters fed AC and AC drives in open and closed loop,
3. control of different AC and DC Drives.

Course Content:

Synchronous Reluctance Motors: Constructional features –Types–Axial and radial air gap motors–Operating principle–Reluctance–phasor diagram- Characteristics–Vernier motor.

Stepping Motors: Constructional features–Principle of operation –Variable reluctance motor–Hybridmotor–Single and multi-stack configurations –Theory of torque predictions – Linear and non-linear analysis–Characteristics–Drive circuits.

Switched Reluctance Motors: Constructional features–Principle of operation–Torque prediction–Power controllers–Non-linear analysis–Microprocessor based control- Characteristics–Computer control.

Permanent Magnet Brushless D.C. Motors: Principle of operation–Types–Magnetic circuit analysis– EMF and torqueequations–Power controllers–Motor characteristics and control. Permanent Magnet Synchronous Motors: Principle of operation–EMF and torque equations–Reactance–Phasor diagram–Power Controllers-Converter-Volt-ampere requirements–Torque speed characteristics- Microprocessor based control.

Course Outcome:

At end of this course, students will demonstrate the ability to:

CO1: identify the application of Special electric machines.

CO2: understand the operating principle of various Special electric machines.

CO3: analyze the properties of different magnetic materials for permanent magnet machines.

CO4: choose a suitable permanent magnet material for special purpose machine.

CO5: develop a control circuit for SRM/BLDC motors.

Text Books:

1. S.K. Pillai, “A first course on Electrical Drives”, New Age International Publication.
2. G.K. Dubey, “Fundamental of Electrical Drives”, New Age International Publication.

Reference Books:

1. R. Krishnan and B. K. Bose, “Electric motor Drives, Pearson Education. Modern power Electronics and AC drives”, Prentice Hall of India.
2. G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall of India.
3. V. Subrahmanyam, “Electric Drives”, Tata McGraw Hill.

EE 404A: Flexible AC Transmission Systems (FACTs)

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is designed to:

1. introduce concept of FACTS and the types of devices used with an emphasis on working principle.
2. teach operation of TCSC in various modes and its applications.
3. familiarize students with emerging facts controllers and their coordination with existing system.

Course Content:

FACTS Concepts: Transmission line inter connections, Power flow in an AC system, loading capability limits, Dynamic stability considerations, importance of controllable parameters, basictypes of FACTS controllers, benefits from FACTS controllers.

Voltage Source Converters: Single phase three phase full wave bridge converters, transformer connections for 12, 24 and 48 pulse operation. Three level voltage source converters, pulse width modulation converter, basic concept of current source Converters, comparison of current sourceconverters with voltage Source converters.

Static Shunt Compensation: Objectives of shunt compensation, midpoint voltage regulation, voltage instability prevention, improvement of transient stability, Power oscillation damping, Methods of controllable var generation, variable impedance type static var generators, switching converter type var generators, hybrid var generators.

SVC and STATCOM: The regulation and slope transfer function and dynamic performance, transient Stability enhancement and power oscillation damping, operating point control and summary of compensator control.

Static Series Compensation: Concept of series capacitive Compensation, improvement of transient stability, power oscillation damping, Functional requirements, GTO Thyristor controlled series capacitor (GSC), Thyristor switched series capacitor (TSSC) and Thyristor controlled series capacitor (TCSC), control schemes for GSC, TSSC and TCSC.

Course Outcome:

At end of this course, students will demonstrate the ability to:

CO1: understand load ability of the transmission line.

CO2: emphasize the importance of the voltage and reactive power control in electrical systems

CO3: state different compensation techniques through facts devices

CO4: analyse the real and reactive power flow and control in transmission lines

Text Books:

1. M. Mathur, R. Rajiv, K.Varma, "Thyristor–Based Facts Controllers for Electrical Transmission Systems", Wiley Publishers.
2. A.T. John, "Flexible AC Transmission System", IEEE Press.

Reference Books:

1. N. G. Hingorani, L. Gyugyl, "Understanding FACTS Concepts and Technology of Flexible AC Transmission System", Wiley Publishers.
2. A. R. Bergen, "Power Systems Analysis", Pearson Publications.
3. K. R. Padiyar, "FACTs Controller in Power Transmission and Distribution", New Age International.

EE 404B: Advanced Power Electronics

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is design to:

1. study power quality mitigation devices,
2. study different facts devices,
3. study different types of HVDC transmission.

Course Content:

Introduction; Linear power supply (voltage regulators); Switching voltage regulators; Review of basic dc-dc voltage regulator configurations -Buck, Boost, Buck-Boost converters and their analysis for continuous and discontinuous mode; Other converter configurations like Flyback converter, Forward converter, half bridge, Full bridge configurations, Push-pull converter, Cuk converter, Sepic Converter; Design criteria for SMPS; Multi-output switch mode regulator.

Introduction, need of resonant converters, Classification of resonant converters, load resonant converters, Resonant switch converters, zero-voltage switching dc-dc converters, zero current switching dc-dc converters, clamped voltage topologies.

Need for multi-level inverters, Concept of multi-level, Topologies for multi-level: Diode Clamped, flying capacitor and Cascaded H-bridge multilevel Converters configurations; Features and relative comparison of these configurations applications, Introduction to carrier based PWM technique for multi-level converters.

Concept of multi-pulse, Configurations for m-pulse (m=12, 18, 24 ….) converters, Different phase shifting transformer (Y-Δ1, Y-Δ2, Y-Z1 and Y-Z2) configurations for multi-pulse converters, Applications.

Course Outcome:

At end of this course, students will demonstrate the ability to:

CO1: understand various converter topologies used for switched mode power supplies

CO2: analyse different modes of power converter operations.

CO3: design closed loop control system for switched mode power supplies

CO4: devise adequate protection system for power converters.

CO4: validation of converter design using simulation tools and experiments.

Text Books:

1. P. C. Sen, “Power Electronics”, Tata McGraw Hill.
2. G. K. Dubey, “Power Electronics”, Tata McGraw Hill.

Reference Books:

1. G. K. Dubey, “Thyristorised power controllers”, Tata McGraw Hill.
2. M. Rashid, “Power Electronics”, Pearson Publications.
3. V. Subramanyam, “Power Electronics and Drives”, New Age International.

EE 404C: Electrical Estimating and Costing

L	T	P	Credit
3	0	0	3

Course Objectives:

The course is designed to:

1. introduce the concept of electrical estimating and costing works.
2. design calculations of electrical wiring.
3. make familiar students with estimation draft preparation of various electrical works.

Course Content:

Tools: Introduction, Screw drivers, Pliers, Hammers, Saws, Drill, Hacksaw, Files, Wrenches, Precautions in handling the tools.

Wires splicing and terminations: Size of wires, Wire gauge, Types of wires, Western union spice or twist splice, married joint, T-Joint, Tap-joint, insulation tape and its uses.

Installation of wiring system: Introduction, cleat wiring, PVC casing capping, surface and concealed wiring, PVC conduit installation,

Lighting accessories: introduction, switches, MCB, main switches, cut-outs, bas-bars, holders, ceiling rose, plugs and sockets, Law of illumination, Lamberts's Cosine Law, types of electric lamps.

Internal wiring and lamp circuits: Introduction, service connections, wiring system, wiring of a building, position of electrical fittings,

Electrical earthing and shock: Introduction, neutral wire, grounding wire, Methods of earthing, Electric shock, Artificial Respiration.

Estimation for internal wiring: Estimating, schedule of rates, procedures for estimation, length of casing capping, length of negative wire, length of positive wire, Power wiring installations, total internal wiring estimation.

Installation and estimation of service connection: Overhead and underground estimation.

Course Outcome:

At end of this course, students will demonstrate the ability to:

CO1: know the functions of the various tools used for installation for internal wiring.

CO2: understand the various methods for internal wirings.

CO3: analyze the various requirements good lightings, electrical shocks, and earthing.

CO4: create an estimation of building internal wiring and service connections.

Text Books:

1. J. B. Gupta, "A course in electrical installation estimating and Costing", Katson, 2013.
2. K.B. Raina, "Electrical Design estimating and costing", New Age, 2015.

Reference Books:

1. Surjit Singh, "Electrical Estimating and Costing", Dhanpat Rai and Co, 2016.
2. S.L. Uppal and G. C. Garg, "Electrical wiring, Estimating and Costing", Khanna Publishers.,2013.