Scheme & Syllabus for B.Tech. in Electrical Engineering according to Choice Based Credit System (CBCS)

(Semester-VII to Semester-VIII)

Department of Electrical Engineering
For Session 2021-22 onwards
(Batch 2018-19 onwards)

School of Engineering & Technology

CENTRAL UNIVERSITY OF HARYANA
MAHENDERGARH-123031
HARYANA

Central University of Haryana, Mahendergarh
B.Tech. 4th YEAR (SEMESTER – VII)
Choice Based Credit System Scheme of Studies& Examinations w.e.f. 2021-22
(Batch 2018-19 onwards)

S. No.	Course Code	Course Title	Teaching Schedule			Credits
			L	T	P	
1	BT EE701A	Electric Drives	3	0	0	3
2	BT EE702A	Project Stage –I	0	0	6	3
3	BT EE703A	Summer Internship Presentation	0	3	0	3
4		**Program Elective – 6**	3	0	0	3
5		**Program Elective – 7**	3	0	0	3
6		**General Elective or Open Elective-4**	3	1	0	4
Total			**12**	**04**	**06**	**19**

L = Lecture, T = Tutorial, P = Practical, & C = Credits

NOTE: **-** Examinees will be allowed to use only non-programmable scientific calculators in the examination. Other electronic gadgets and sharing of materials will not be permitted during the examinations.

PROGRAM ELECTIVE-6 (PE6)

EE704A	Digital Control Systems
EE705A	Control System Design
EE706A	Non-linear and optimal control theory

PROGRAM ELECTIVE-7 (PE7)

EE707A	Smart Grid
EE708A	Electrical and Hybrid Vehicles
EE709A	Power Quality and FACTs

Central University of Haryana, Mahendergarh
B.Tech. 4th YEAR (SEMESTER – VIII)
Choice Based Credit System Scheme of Studies & Examinations w.e.f. 2021-22
(Batch 2018-19 onwards)

Group A

S. No.	Course Code	Course Title	Teaching Schedule			Credits
			L	T	P	
1	BT EE801A	Project Stage II	0	0	20	10
2	BT EE802A	General Proficiency and Ethics	2	0	0	2
3		**Program Elective – 8**	3	0	0	3
4		**General Elective or Open Elective-3**	3	1	0	4
Total			**9**	**02**	**16**	**19**

L = Lecture, T = Tutorial, P = Practical, & C = Credits

Group B

S. No.	Course Code	Course Title	Teaching Schedule			Credits
			L	T	P	
1	BT EE801A	Industry Internship	0	0	24	14
2	BT EE802A	General Proficiency and Ethics (online)	2	0	0	2
3		**Program Elective – 8 (online)**	3	0	0	3
Total			**9**	**02**	**16**	**19**

L = Lecture, T = Tutorial, P = Practical, & C = Credits

NOTE: - Examinees will be allowed to use only non-programmable scientific calculators in the examination. Other electronic gadgets and sharing of materials will not be permitted during the examinations.

PROGRAM ELECTIVE-8 (PE8)

EE803A	Special Electrical Machines
EE804A	Power Electronics and Control for Renewable Energy Systems
EE805A	Robust Control

Program Name: B. Tech.-Electrical Engineering

<table>
<tr><td rowspan="2">Course Code: BT EE701 A</td><td colspan="2" rowspan="2">Course Name: ELECTRIC DRIVES</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>-</td><td>-</td><td>3</td></tr>
<tr><td>Year and Semester</td><td>4th year
7th Semester</td><td colspan="5">Contact hours per week: (3 Hrs) Exam: (3hrs.)</td></tr>
<tr><td rowspan="2">Pre-requisite of course</td><td rowspan="2">Electrical Machine, Power Electronics</td><td colspan="5">Evaluation</td></tr>
<tr><td>CIE: 30</td><td colspan="4">TEE: 70</td></tr>
<tr><td colspan="7">Course Outcomes: On completion of the course, student would be able to:</td></tr>
<tr><td>CO701.1</td><td colspan="6">Understand the principle of electrical drives & be able to understand the dynamics of electrical drive systems.</td></tr>
<tr><td>CO701.2</td><td colspan="6">Select a drive for a particular application based on power rating & to select a drive based on mechanical characteristics for a particular drive application</td></tr>
<tr><td>CO701.3</td><td colspan="6">Operate state space model of DC motor and apply different power electronics converters for control of DC drives.</td></tr>
<tr><td>CO701.4</td><td colspan="6">Learn speed control of induction motor drives in an energy efficient manner using power electronics</td></tr>
<tr><td>CO701.5</td><td colspan="6">Familiarize with efficient use of electric drive.</td></tr>
<tr><td>CO701.6</td><td colspan="6">Identify suitable form of electrical drives system</td></tr>
</table>

Module No	COURSE SYLLABUS CONTENTS OF MODULE	Hrs	Cos
1	**Electrical Drives:** Introduction, advantages, choice of electrical drives, status of ac and dc drives. **Dynamics of Electrical Drives:** Fundamental torque equations, multi-quadrant operation, equivalent values of drive parameters, load torque components, types of loads, steady state stability, load equalization. **Control of Electrical Drives:** Modes of operation, closed loop control of drives, sensing of current and speed**.**	**12**	**CO701.1,**
2	**Selection of Motor & its power rating:** Types of motors & their enclosures, thermal model of motor for heating & cooling, classes of motor duty, rate of motor**.** **Energy Conversion in Electric Drive**: losses in electrical drive system, energy conversion, use of efficient semiconductor converters, energy efficient operation of drives.	**10**	**CO701.2 CO701.5**
3	**DC Motor Drives:** Speed-torque characteristics of different types of dc motors, starting, types of braking, transient analysis, speed control methods, static control of dc motors. Converter fed dc drive & chopper fed dc drive.	**10**	**CO701.3**
4	**Induction Motor Drives:** Characteristics, analysis and performance, starting methods, braking methods, transient analysis, methods of speed control, vector control. Static control techniques- stator frequency control, stator voltage control, rotor resistance control. Static Scherbius system & static Kramer system.	**13**	**CO701.4 CO701.6**

	Special Drives: Switched Reluctance motor, Brushless dc motor. Selection of motor for particular applications.		

Text Books:

1. G.K. Dubey, “Fundamentals of Electric Drives”, Narosa publishing House.
2. S.K. Pillai, “A First Course on Electric Drives”, New Age International.
3. V. Subrahmanyam, “Electric Drives”, McGraw Hill Education

Reference Books:

1. M. Chilkin, “Electric Drives”, Mir Publishers, Moscow.
2. A. Mohammed El-Sharkawi, “Fundamentals of Electric Drives”, Thomson Asia, Pvt. Ltd. Singapore.
3. N.K. De and K.Sen Prashant, “Electric Drives”, Prentice Hall of India Ltd.
4. V. Subrahmanyam, “Electric Drives: Concepts and Applications”, Tata McGraw Hill.

Program Name: B. Tech.-Electrical Engineering

<table>
<tr><td rowspan="2">Course Code:
BT EE704 A</td><td colspan="2" rowspan="2">Course Name: DIGITAL CONTROL SYSTEMS</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>-</td><td>-</td><td>3</td></tr>
<tr><td>Year and Semester</td><td>4th year
7th Semester</td><td colspan="5">Contact hours per week: (3 Hrs) Exam: (3hrs.)</td></tr>
<tr><td rowspan="2">Pre-requisite of course</td><td rowspan="2">Control System, Signals and Systems</td><td colspan="5">Evaluation</td></tr>
<tr><td>CIE: 30</td><td colspan="4">TEE: 70</td></tr>
<tr><td colspan="7">Course Outcomes: On completion of the course, student would be able to:</td></tr>
<tr><td>CO704.1</td><td colspan="6">Obtain discrete representation of LTI systems.</td></tr>
<tr><td>CO704.2</td><td colspan="6">Analyse stability of open loop and closed loop discrete-time systems.</td></tr>
<tr><td>CO704.3</td><td colspan="6">Design and analyse digital controllers.</td></tr>
<tr><td>CO704.4</td><td colspan="6">Design digital compensator and discrete observer for LTI systems.</td></tr>
</table>

Module No	**COURSE SYLLABUS** **CONTENTS OF MODULE**	**Hrs**	**Cos**
1	**Introduction:** Terminology: continuous time, discrete-time & digital signals; Basic structure of digital control scheme and brief description of its blocks. Advantages & problems of digital control, General principles of signal conversion: operation by A/ D & D/A converters, A/D and D/A converter circuits; Sample and hold circuit: Mathematical analysis of sampling process, Ideal sampler, Choice of sampling frequency, Aliasing; Sampling theorem, The Hold operation, ZOH. Unit sample sequence, Unit step sequence & Unit sinusoidal sequence. Difference Equation models & Impulse response models for discrete time systems. State space models of discrete systems, state space analysis, Controllability, reachability, reconstructibility and observability analysis.	**10**	**CO704.1, CO704.2**
2	**Transform Domain Processing:** Definition of Z-transform; The Z-transforms of typical functions such as Unit sample sequence, Unit step sequence, sampled ramp function, sampled exponential function, sampled sinusoids; Operations with Z transform such as shifting (forward & backward); Z transform Inversion; Final value & Initial value theorems; Transfer function models; Unit delayer Transfer function; Dynamic response; Stability in z-plane; Jury Stability test; Z-plane poles v/ s stability (& the nature of response functions); Mapping s-plane to z-plane, Bilinear transformation.	**10**	**CO704.2**
3	**Models Of Digital Control Devices & Systems:** z-domain description of sampled continuous-time plants, model of ADC & DAC, Interconnection of discrete-time & continuous time systems & their equivalent transfer functions; Implementation of digital controllers, Recursive realizations: direct, cascade & parallel realizations, non-recursive realization; Digital PID controller: Positional & velocity forms; Tuning rules for digital PID. Design of digital control system with dead beat response. Practical issues with dead beat response design.	**10**	**CO704.3**

4	**Design of Digital Control Algorithms:** Basic structure of digital control system; Routes to the design of digital Controller, z-plane specifications of control system design: steady state accuracy, Steady state errors & error constants for type-0,-1,-2 systems, Transient accuracy, dominant poles, Effect of extra zero & pole on discrete time 2nd order system; Digital compensator design using frequency response plot; Digital compensator design using root locus plot. Design of discrete observer for LTI System. Design of set point tracker.	**10**	**CO704.4**

Text Books:

1. M. Gopal, “Digital Control Engg.”, New Age International Publishers, New Delhi.
2. M. Gopal, “Digital Control & State Variable Methods (Conventional and Intelligent Control System)”, Tata McGraw Hill Education Pvt. Ltd., New Delhi.
3. G.F. Franklin, J.D. Powell and M. L. Workman, “Digital Control of Dynamic Systems”, Addison-Wesley, 1998.

Reference Books:

1. B.C. Kuo, “Digital Control Systems”, Oxford University Press.
2. K. Ogata, “Discrete-time Control Systems”, Pearson Education, New Jersey.
3. C.L. Phillips, & Jr. H.T. Nagle, “Digital Control System Analysis”, Pearson Education, New Jersey.
4. C.H. Hopis and G.B. Lemont, “Digital Control System: Theory, Hardware & Software”, McGraw-Hill Publications, New York.

Program Name: B. Tech-Electrical Engineering

Course Code: BTEE705A	Course Name: CONTROL SYSTEM DESIGN	L	T	P	C
		3	0	-	3
Year and Semester	4th Year 7th Sem	Contact hours per week: (3 Hrs.) Exam: (3hrs.)			
Pre-requisite of course	Control System	Evaluation			
		CIE: 30	TEE: 70		

Course Outcomes: On completion of the course, student would be able to:	
CO705.1	Understand the different design specifications of Control System.
CO705.2	Design of Control System in time and frequency domain.
CO705.3	Design of PID controllers in time and frequency domain.
CO705.4	Understand the state space representation of Control system.
CO705.5	Understand the concept of controllability & observability.
CO705.6	Design of Control system in state space representation.

Module No	COURSE SYLLABUS CONTENTS OF MODULE	Hrs.	Cos
1	**Design Specifications:** Introduction to time-domain and frequency-domain design specification and its physical relevance. Effect of gain on transient and steady state response. Effect of addition of pole on system performance. Effect of addition of zero on system response	**10**	**CO705.1,**
2	**Design of Control System in Time-Domain:** Introduction to compensator design in time-domain. Design of Lag, lead and lag-lead compensator in time-domain. Feedback and Feed forward compensator design. Feedback compensation. Realization of compensators. **Design of Control System in Frequency-Domain:** Compensator design in frequency domain to improve steady state and transient response. Feedback and Feed forward compensator design using bode-plot.	**15**	**CO705.2**
3	**Design of PID Controllers:** Design of P, PI, PD and PID controllers in time-domain and frequency-domain for first, second and third order systems. Control loop with auxiliary feedback and Feed forward control.	**9**	**CO705.3**
4	**Control System Design in State Space:** Review of state space representation. Concept of controllability & observability, effect of pole-zero cancellation on the controllability & observability of the system, pole placement design through state feedback. Ackerman's Formula for feedback gain design. Design of Observer. Reduced order observer. Separation Principle.	**11**	**CO705.4, CO705.5 CO705.6**

Text Books:

1. N. Nise, "Control System Engineering", John Wiley, 2000.
2. I.J. Nagrath and M. Gopal, "Control System Engineering", New Age International, 2018.
3. B.C. Kuo, "Automatic Control system", Prentice Hall, 1995.

Reference Books:

1. J.J. D'Azzo and C. H. Houpis, "Linear control system analysis and design (conventional and modern)", McGraw Hill, 1995.
2. K. Ogata, "Modern Control Engineering", Prentice Hall, 2010.
3. R.T. Stefani and G. H. Hostetter, "Design of feedback Control Systems", Saunders College Pub, 1994.

Program Name: B. Tech-Electrical Engineering

Course Code: BTEE706A	**Course Name: A NON-LINEAR AND OPTIMAL CONTROL SYSTEM**		**L**	**T**	**P**	**C**
			3	**0**	**-**	**3**
Year and Semester	**4th Year 7th Sem**	**Contact hours per week:** (3 Hrs.) **Exam:** (3hrs.)				
Pre-requisite of course	Control System	**Evaluation**				
		CIE: 30	**TEE: 70**			

Course Outcomes: On completion of the course, student would be able to:

CO706.1	Demonstrate non-linear system behaviour by phase plane and describing function methods.
CO706.2	Perform the stability analysis nonlinear systems by Lyapunov method develop design skills in optimal control problems
CO706.3	Design and apply state-of-the-art classical and modern computational methods to define and solve optimisation problems.
CO706.4	Understanding of feedback optimal control system

Module No	**COURSE SYLLABUS CONTENTS OF MODULE**	**Hrs.**	**Cos**
1	Linear versus nonlinear systems- Describing function analysis: Fundamentals, common nonlinearities (saturation, dead - zone, on - off non - linearity, backlash, hysteresis) and their describing functions. Describing function analysis of nonlinear systems. Reliability of describing method analysis. Compensation and design of nonlinear system using describing function method. Phase plane analysis: Phase portraits, Singular points characterization. Analysis of non - linear systems using phase plane technique. Existence of limit cycles. Linearization: Exact linearization, input - state linearization, input - output linearization.	**10**	**CO706.1,**
2	Concept of stability, Zero - input and BIBO stability, stability in the sense of Lyapunov and absolute stability, Stability in the small and stability in the large, Lyapunov stability definitions, first method of Lyapunov, second (or direct) method of Lyapunov stability theory for continuous and discrete time systems, Aids to generate Lyapunov function – Krasovskii's theorem, Variable gradient method.	**15**	**CO706.2**
3	Aizerman's and Kalman's conjecture. Construction of Lyapunov function - Methods of Aizerman, Zubov, Variable gradient method. Lure problem. Popov's stability criterion, Formulation of the optimal control Problem, Calculus of variations, Minimum principle, Dynamic Programming, Numerical Solution of Two-point Boundary value problem.	**9**	**CO706.3**
4	**Optimal Feedback Control:** Discrete-Time linear State regulator, Continuous-Time Linear state Regulator results of solve other linear problems, Suboptimal Linear regulators, Minimum-time Control of Linear Time-Invariant System. Stochastic Optimal Linear Estimation and Control Stochastic	**11**	**CO706.4,**

	processes and linear systems, Optimal Estimation for Linear Discrete time Systems Stochastic Optimal Linear Regulator.		

Text Books:

1. M. Gopal, “Modern Control System Theory”, New Age International, 2005.
2. K. Ogatta, “Modern Control Engineering”, PHI, 2002.
3. B.C. Kuo, “Digital Control Systems”, Oxford University Press, 1980.

References Books:

1. Anderson, D.O. Brian and John B. Moore, “Optimal Control: Linear Quadratic Methods”, Courier Corporation, 2007.
2. J. Speyer and D. Jacobson, “Primer on Optimal Control Theory”, SIAM, 2010
3. R. Stengel, “Optimal Control and Estimation, Dover”, 1994
4. K. Astrom, “Introduction to Stochastic Control Theory”, Dover, 2006
5. B. Anderson and J. Moore, “Optimal Control”, Dover, 2007
6. A. Bryson and Y. Ho, “Applied Optimal Control”, Taylor & Francis, 1975
7. A. Bryson, “Applied Linear Optimal Control”, Cambridge University Press, 2002
8. M. Athans and P. Falb, “Optimal Control”, Dover, 2006
9. D. Naidu, “Optimal Control Systems”, CRC Press, 2002
10. F. Lewis and V. Syrmos, “Optimal Control”, Wiley-Interscience, 1995
11. P. Dorato, C. Abdallah, and V. Cerone, “Linear Quadratic Control”, Krieger Publishing, 2000

Program Name: B. Tech.-Electrical Engineering

Course Code: BT EE707A	Course Name: SMART GRID		L	T	P	C
			3	0	-	3
Year and Semester	**4th year 7th Semester**	**Contact hours per week:** (4 Hrs) Exam**:** (3hrs.)				
Pre-requisite of course	Power System Analysis	**Evaluation**				
		CIE: 30	**TEE: 70**			

Course Outcomes: On completion of the course, student would be able to:	
CO707.1	To Understand basic concept of smart grid and its need, opportunities and barrier and communication in smart grid.
CO707.2	Explain the advanced metering infrastructure, communication infrastructure and protocol and demand side integration for smart metering.
CO707.3	Understand the concept of micro grid its need, operation, application, protection and control, islanding mode and small scale different type of distributed energy resources.
CO707.4	Analyze power quality issues and control operation of micro grid and ICT for smart grid

Module No	COURSE SYLLABUS CONTENTS OF MODULE	Hrs	Cos
1	**Introduction to Smart Grid:** Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid ,CDM opportunities in Smart Grid, What is a Smart Grid?, The Smart Grid Enables the Electri Net SM, Local Energy Networks, Electric Transportation, Low-Carbon Central Generation, What Should Be the Attributes of the Smart Grid?, Why Do We Need a Smart Grid?, Is the Smart Grid a “Green Grid”?,	**10**	**CO707.1,**
2	**Sensing, Measurement, Control and Automation Technologies:** Smart metering and demand-side integration, Introduction, Smart metering, Evolution of electricity metering, Key components of smart metering, Smart meters: An overview of the hardware used Signal acquisition, Signal conditioning, Analogue to digital conversion, Computation, Input/output, Communication, Communications infrastructure and protocols for smart metering, Home-area network, Neighbourhood area network, Data concentrator, Meter data management system, Protocols for communications, Demand-side integration, Services provided by DSI, Implementations of DSI, Hardware support to DSI implementations, Flexibility delivered by prosumers from the demand side, System support from DSI.	**10**	**CO707.2,**
3	**Micro Grids and Distributed Energy Resources:** Concept of micro grid, need & applications of micro grid, formation of micro grid, issues of interconnection, protection & control of	**10**	**CO707.3,**

	micro grid. Islanding, need and benefits, different methods of islanding detection. Distributed Energy Resources: Small scale distributed generation, Distributed Generation Technology, Internal Combustion Engines, Gas Turbines, Combined Cycle Gas Turbines, Micro turbines, Fuel Cells, Solar Photovoltaic, Solar thermal, Wind power, Geothermal, - all sources as a DG. Advantages and disadvantages of DG.		
4	**Power Quality Management in Smart Grid:** Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit. Information and Communication Technology for Smart Grid: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighbourhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, Zig-Bee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Broadband over Power line (BPL)	**10**	**CO707.4,**

Text Books:

1. A. Keyhani, “Design of Smart power grid renewable energy systems”, Wiley IEEE, 2011.
1. W.G. Clark, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press, 2009.
2. S. Borlase, “Smart Grid: Infrastructure, Technology and solutions “CRC Press.
3. J. Ekanayake, N. Jenkins, K. Liyanage, J. Wu, A. Yokoyama, “Smart Grid: Technology and Applications”, Wiley.
4. A. Carvallo, J. Cooper, “The Advanced Smart Grid: Edge Power Driving Sustainability: 1”, Artech House Publishers July 2011
5. M. Kezunovic, G. A. Mark, P. A. Alexander, J. G. Gilbert, “Substation Automation (Power Electronics and Power Systems)”, Springer

Reference Books:

1. J.N. Green, R.G. Wilson “Control and Automation of Electric Power Distribution Systems (Power Engineering)”, CRC Press.
2. R.C. Dugan, M.F. McGranghan, S. Santoso, H.W. Beaty, “Electrical Power System Quality”, 2nd Edition, McGraw Hill Publication.
3. A.G. Phadke, J.S. Thorp, “Synchronized Phasor Measurements and Their Applications”, Springer.
4. J. Momoh, “Smart Grid: Fundamentals of Design and Analysis”, Wiley.

Program Name: B.Tech.-Electrical Engineering

<table>
<tr><td rowspan="2">Course Code: BT EE708A</td><td rowspan="2" colspan="2">Course Name: ELECTRICAL AND HYBRID VEHICLES</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>-</td><td>-</td><td>3</td></tr>
<tr><td>Year and Semester</td><td>4st year
7th Semester</td><td colspan="5">Contact hours per week: (4 Hrs) Exam: (3hrs.)</td></tr>
<tr><td rowspan="2">Pre-requisite of course</td><td rowspan="2">Electrical Vehicles</td><td colspan="5">Evaluation</td></tr>
<tr><td>CIE: 30</td><td colspan="4">TEE: 70</td></tr>
<tr><td colspan="7">Course Outcomes: On completion of the course, student would be able to:</td></tr>
<tr><td>CO708.1</td><td colspan="6">Understand objective and scope of Electric vehicle and its recent trends</td></tr>
<tr><td>CO708.2</td><td colspan="6">Explain the basics of conventional vehicle, their scope, performance, characteristic and its mathematical model.</td></tr>
<tr><td>CO708.3</td><td colspan="6">Analyse social and environment impact of EHV and various topologies of electric drives suitable for hybrid electric vehicles.</td></tr>
<tr><td>CO708.4</td><td colspan="6">Explain the basics and different topologies of Electric drive train and its configuration and analyse and control of advanced propulsion technique in EHV.</td></tr>
<tr><td>CO708.5</td><td colspan="6">Understand the use of different energy storage technologies used for hybrid electric vehicles and their sizing and control.</td></tr>
<tr><td>CO708.6</td><td colspan="6">Interpret working of different classification of energy management system used in Electric hybrid vehicle and its implementation and case study.</td></tr>
</table>

Module No	COURSE SYLLABUS CONTENTS OF MODULE	Hrs	COs
1	**Introduction:** Objective, scope and outcome of the course.	**1**	**CO708.1**
2	**Conventional Vehicles:** Basics of vehicle performance, vehicle power source characterization, Transmission characteristics, and mathematical model to describe vehicle performance.	**5**	**CO708.2**
3	**Hybrid Electric Vehicles:** History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive- trains on energy supplies. **Hybrid Electric Drive-trains:** Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.	**7**	**CO708.3**
4	**Electric Trains:** Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.	**10**	**CO708.4**
5	**Energy Storage:** Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery	**10**	**CO708.5**

	based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems.		
6	**Energy Management Strategies:** Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. **Case Studies:** Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).	**8**	**CO708.6**

Text Books:

1. I. Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003
2. M. Ehsani, Y. Gao, S. E. Gay, A. Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2004
3. S. Dhameja, "Electric Vehicle Battery Systems", Newnes, 2000

Reference Books:

1. J. Larminie, J. Lowry, "Electric Vehicle Technology Explained", Wiley, 2003
2. C. Mi, M.A. Masrur, D.W. Gao, "Hybrid Electric Vehicles: Principle and Applications with Practical Perspectives", John Wiley & Sons Ltd., 2011.

Program Name: B.Tech.-Electrical Engineering

<table>
<tr><td rowspan="2">Course Code: BT EE709A</td><td colspan="2" rowspan="2">Course Name: POWER QUALITY AND FACTS</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>-</td><td>-</td><td>3</td></tr>
<tr><td>Year and Semester</td><td>4th year
7th Semester</td><td colspan="5">Contact hours per week: (4 Hrs)
Exam: (3hrs.)</td></tr>
<tr><td rowspan="2">Pre-requisite of course</td><td rowspan="2">Power Quality and FACTS</td><td colspan="5">Evaluation</td></tr>
<tr><td>CIE: 30</td><td colspan="4">TEE: 70</td></tr>
</table>

Course Outcomes: On completion of the course, student would be able to:	
CO709.1	Understand objective and scope of power quality and Facts.
CO709.2	Explain the basics of reactive and active power in transmission.
CO709.3	Explain the basics and different topologies of SVC, TCSC.
CO709.4	Understand the use of different voltage source converter based (FACTS) controllers
CO709.5	Understand the use of different application of FACTS devices.
CO709.6	Explain the power quality problems in distribution systems

Module No	COURSE SYLLABUS CONTENTS OF MODULE	Hrs	Cos
1	**Introduction:** Objective, scope and outcome of the course.	**1**	**CO709.1**
2	**Transmission Lines and Series/Shunt Reactive Power Compensation:** Basics of AC Transmission. Analysis of uncompensated AC transmission lines. Passive Reactive Power Compensation. Shunt and series compensation at the mid-point of an AC line. Comparison of Series and Shunt Compensation	**5**	**CO709.2**
3	**Thyristor-based Flexible AC Transmission Controllers (FACTS):** Description and Characteristics of Thyristor-based FACTS devices: Static VAR Compensator (SVC), Thyristor Controlled Series Capacitor (TCSC), Thyristor Controlled Braking Resistor and Single Pole Single Throw (SPST) Switch. Configurations/Modes of Operation, Harmonics and control of SVC and TCSC. Fault Current Limiter.	**7**	**CO709.3**
4	**Voltage Source Converter based (FACTS) Controllers:** Voltage Source Converters (VSC): Six Pulse VSC, Multi-pulse and Multi-level Converters, Pulse-Width Modulation for VSCs. Selective Har- monic Elimination, Sinusoidal PWM and Space Vector Modulation. STATCOM: Principle of Operation, Reactive Power Control: Type I and Type II controllers, Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC): Principle of Operation and Control. Working principle of Inter phase Power Flow Controller. Other Devices: GTO Controlled Series Compensator. Fault Current Limiter.	**10**	**CO709.4**
5	**Application of FACTS:** Application of FACTS devices for power-flow control and stability improvement. Simulation example of power swing damping in a single- machine infinite bus system using a TCSC. Simulation example of voltage regulation of transmission mid-point voltage using a STATCOM.	**10**	**CO709.5**

6	**Power Quality Problems in Distribution Systems:** Power quality problems in distribution systems: transient and steady state variations in voltage and frequency. unbalance, sags, swells, interruptions, waveform distortions: harmonics, noise, notching, dc-offsets, fluctuations. flicker and its measurement. tolerance of equipment: cbema curve.	**8**	**CO709.6**

1. **Text books:**
2. N. G. Hingorani and L. Gyugyi, "Understanding FACTS: Concepts and Technol- ogy of FACTS Systems", Wiley-IEEE Press, 1999.
3. K. R. Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International (P) Ltd. 2007.
4. T. J. E. Miller, "Reactive Power Control in Electric Systems", John Wiley and Sons, New York, 1983.
5. R. C. Dugan, "Electrical Power Systems Quality", McGraw Hill Education, 2012.

Program Name: B.Tech.-Electrical Engineering

<table>
<tr><td rowspan="2">Course Code:
BT EE803A</td><td rowspan="2" colspan="2">Course Name: SPECIAL ELECTRICAL MACHINES</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>-</td><td>-</td><td>3</td></tr>
<tr><td>Year and Semester</td><td>4th year
8th Semester</td><td colspan="5">Contact hours per week: (4 Hrs) Exam: (3hrs.)</td></tr>
<tr><td rowspan="2">Pre-requisite of course</td><td rowspan="2">Power Quality and FACTS</td><td colspan="5">Evaluation</td></tr>
<tr><td>CIE: 30</td><td colspan="4">TEE: 70</td></tr>
<tr><td colspan="7">Course Outcomes: On completion of the course, student would be able to:</td></tr>
<tr><td>CO803.1</td><td colspan="6">Use different types of motor efficiently for various applications</td></tr>
<tr><td>CO803.2</td><td colspan="6">Maintain different types induction machines for different applications</td></tr>
<tr><td>CO803.3</td><td colspan="6">Maintain different types synchronous machines for different applications</td></tr>
<tr><td>CO803.4</td><td colspan="6">Maintain different types of Permanent magnet motors</td></tr>
<tr><td>CO803.5</td><td colspan="6">Maintain various types of Small specialised electric machines</td></tr>
</table>

Module No	**COURSE SYLLABUS CONTENTS OF MODULE**	**Hrs**	**COs**
1	**Stepping Motors:** Constructional features, principle of operation, types, modes of excitation, torque production in Variable Reluctance (VR) stepping motor, static and dynamic characteristics, introduction to drive circuits for stepper motor, suppressor circuits, closed loop control of stepper motor- applications	**1**	**CO803.1 CO803.2**
2	**Switched Reluctance Motors:** Principle of operation, constructional features, torque equation, power semiconductor switching circuits, frequency of variation of inductance of each phase winding - control circuits of srm- torque - speed characteristics, microprocessor based control of srm drive, applications.	**5**	**CO803.1 CO803.2**
3	**Synchronous Reluctance Motors Constructional Features:** Axial and radial air gap motors. operating principle, reluctance torque - phasor diagram, speed torque characteristics, applications.	**7**	**CO803.2 CO803.3**
4	**Permanent Magnet Brushless Dc Motors**: commutation in dc motors, electronic commutation - difference between mechanical and electronic commutators- hall sensors, optical sensors, construction and principle of pmbl dc motor, torque and e.m.f equation, torque-speed characteristics, power controllers-drive circuits, applications	**10**	**CO803.1 CO803.4**
5	**Permanent Magnet Synchronous Motors:** Construction and types, principle of operation, emf and torque equation, phasor diagram, torque speed characteristics, power controllers- self-control, vector control, microprocessor based control, applications	**10**	**CO803.4 CO803.5**

Text Books:

1. T. J. E. Miller, "Brushless Permanent Magnet and Reluctance Motor Drives", Oxford Science Publications, 1989.
2. T. Kenjo and A. Sugawara, "Stepping Motors and their Microprocessor Controls", Oxford Science Publications, 1984.

3. K. Venkataratnam, “Special Electrical Machines”, CRC Press, 2009.

Reference Books:

1. R. Krishnan, “Permanent Magnet and BLDC Motor Drives”, CRC Press, 2009.
2. X. Chang-liang, “Permanent Magnet Brushless DC Motor Drives and Controls”, June 2012

Program Name: B.Tech.-Electrical Engineering

<table>
<tr><td rowspan="2">Course Code:
BT EE804 A</td><td rowspan="2" colspan="2">Course Name: POWER ELECTRONICS AND CONTROL FOR RENEWABLE ENERGY SYSTEMS</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>-</td><td>-</td><td>3</td></tr>
<tr><td>Year and Semester</td><td>4th year
8th Semester</td><td colspan="5">Contact hours per week: (3 Hrs)
Exam: (3hrs.)</td></tr>
<tr><td rowspan="2">Pre-requisite of course</td><td rowspan="2">Power Electronics, Control Systems</td><td colspan="5">Evaluation</td></tr>
<tr><td colspan="2">CIE: 30</td><td colspan="3">TEE: 70</td></tr>
<tr><td colspan="7">Course Outcomes: On completion of the course, student would be able to:</td></tr>
<tr><td>CO804.1</td><td colspan="6">Analyze power electronics converters controls</td></tr>
<tr><td>CO804.2</td><td colspan="6">Apply power electronics converters in renewable energy systems</td></tr>
<tr><td>CO804.3</td><td colspan="6">Design advance power electronics converters control schemes</td></tr>
</table>

Module No	COURSE SYLLABUS CONTENTS OF MODULE	Hrs	COs
1	**Fundamentals of Power Converters:** DC/DC converters, AC/DC converters, DC/AC converters, Classical Multilevel Inverters, SPWM, SVPWM.	**10**	**CO804.1, CO804.2**
2	**Modelling of Power Converters:** Introduction to Power Electronic Converters Modelling, Switched Model, Classical Averaged Model, Generalized Averaged Model, Small Signal Analysis	**10**	**CO804.2**
3	**Control of Power Converters**: General Control Principles of Power Electronic Converters, Linear Control Approaches for DC-DC Power Converters, Linear Control Approaches for DC-AC and AC-DC Power Converters, Energy-Based Control of Power Electronic Converters, Variable-Structure Control of Power Electronic Converters.	**10**	**CO804.2, CO804.3**
4	**Control of Renewable Energy Systems**: Control of voltage source converters with LCL filters, Control of three-phase converters including Phase Locked Loop, Control of PV systems, Control of Wind Energy Systems.	**10**	**CO804.3**

Text Books:

1. A. I. Bratcu, I. Munteanu, and S. Bacha, “Power Electronic Converters Modelling and Control”, Springer Press, 2013.
2. F. Blaabjerg, “Control of Power Electronic Converters and Systems”, Academic Press, 2018.

Reference Books:

1. F.A. Farret, M.G. Simões, “Modelling Power Electronics and Interfacing Energy Conversion Systems”, John Wiley & Sons, 2017.

Program Name: B. Tech.-Electrical Engineering

Course Code: BT EE805A	Course Name: ROBUST CONTROL		L	T	P	C
			3	-	-	3
Year and Semester	4th year 8th Semester	Contact hours per week: (3 Hrs) Exam: (3hrs.)				
Pre-requisite of course	Control System	Evaluation				
		CIE: 30	TEE: 70			

Course Outcomes: On completion of the course, student would be able to:	
CO805.1	Understand LTI systems and its applications
CO805.2	Apply Lyapunov theorem for any stability problem
CO805.3	Design passive systems in frequency and time domain

Module No	COURSE SYLLABUS CONTENTS OF MODULE	Hrs	COs
1	Modelling of Uncertain Systems, Signals and Norms, Lyapunov theory for LTI systems.	10	CO805.1, CO805.2
2	Passive Systems – Frequency Domain Passive Systems – Time Domain	7	CO805.2
3	Robust Stability and Performance, Stabilizing Controllers – Coprime Factorization	8	CO805.2, CO805.3
4	LQR, LQG problems, Ricatti equations and solutions, Ricatti equation solution through LMI, H-infinity control and mu-synthesis, Linear matrix inequalities for robust control	10	CO805.3

Text Books:

1. L. Fortuna, M. Frasca (Eds.), "Optimal and Robust Control", CRC Press, 2012
2. K. Zhou, J.C. Doyle and K. Glover, "Robust and Optimal Control", Prentice Hall, 1996

Reference Books:

1. J.C. Doyle, B.A. Francis and A.R. Tannenbaum, "Feedback Control Theory", Macmillan, 1992