DEPARTMENT OF APPLIED PHYSICS
UNIVERSITY COLLEGE OF TECHNOLOGY
UNIVERSITY OF CALCUTTA

Regulation for 3-year 6-semester Part Time M. Tech. course in Electrical Engineering with specialization in Power Systems w. e. f. the academic year 2021 - 2022

1. Department of Applied Physics, University College of Technology, University of Calcutta shall provide instructions leading towards the 3-year, 6-semester Part Time M. Tech. degree in **Electrical Engineering with specialization in Power Systems**. The course is of three (3) years duration comprised of six (6) Semesters, each Semester being of six (6) months' duration.

2. A candidate, who has passed the 3-year B. Tech. degree in Electrical Engineering from University of Calcutta or its equivalent degree from any other university or institute approved by All India Council for Technical Education (AICTE), will be eligible to apply for admission to the 3-year, 6-semester Part Time **Master of Technology (M. Tech.)** course in **Electrical Engineering with specialization in Power Systems** of the University of Calcutta.

3. The award of the said **M. Tech. Degree** in **Electrical Engineering with specialization in Power Systems** will be conferred to students who are successful in all of the six (6) Semester examinations. End-Semester Examination (ESE) and at least one class test will be held for each theoretical paper in each Semester. End-semester examination will be held for each practical paper in each Semester. The schedule of both theoretical and practical papers and distribution of marks and credit for the said six (6) Semesters are given in course structure.

4. Four (4) lecture hours per week shall be allotted to each theoretical paper of 100 marks and seven (7) practical hours and one (1) tutorial hour per week shall be allotted to each practical paper of 100 marks in a laboratory. For seminar papers of 100 marks six (6) practical hours and two (2) tutorial hours per week shall be allotted. For Thesis phase –I paper of 100 marks twelve (12) practical hours and four (4) tutorial hours per week shall be allotted. For Thesis phase –II paper of 100 marks twenty four (24) practical hours and eight (8) tutorial hours per week shall be allotted. However, for general viva-voce paper no contact hour will be provided.

5. A candidate shall be eligible for appearing at any of the Semester examinations provided he/she prosecutes a regular course of studies in the Department of Applied Physics maintaining the minimum percentage of attendance as specified by the University.

6. (a) Each theoretical paper of 100 marks shall be comprised of 20 marks for Teacher Assessment (TA), 10 marks for Class Test (CT), and 70 marks in End Semester Examination (ESE). TA and CT put together will form the sessional component of the total marks in any theoretical paper.
(b) Teacher Assessment (TA) will be divided ordinarily into three components – attendance, group discussion and performance. Marks for each class test will be awarded by conducting at least one test.

(c) Duration of End Semester Examination for each theoretical paper shall be of three (3) hours. For each theoretical paper there shall ordinarily be two (2) internal paper setters. Each theoretical paper shall be examined by the internal examiners.

(d) Each practical paper shall be of 100 marks, out of which 50 marks is assigned for Teacher Assessment (TA) to be assessed by the internal examiner(s) on the basis of performance in the laboratory and records of experiments and 50 marks for ESE. For 50 marks of ESE for each practical paper, an assessment will be made through a representative practical test and viva-voce, which shall ordinarily be made by a board of examiners consisting of at least two (2) members.

7. (a) On the basis of total marks (TA+CT+ESE) secured in each paper, **Grade (G)** and **Grade Point (GP)** shall be awarded to a student.
The equivalence between grades, grade points and the percentage marks is given by:

Percentage (%) of marks	Grade (G)	Grade Point (GP)
≥ 90	E	10
89 – 80	A	9
79 - 70	B	8
69 - 60	C	7

59 - 50	D	6
< 50	F	0

(b) Each paper shall carry **Credit (C)** according to the number of hours allotted per week and as indicated in the following table:

Paper/subject	No. of hours/week	Credit (C) assigned
Theoretical	1	1
Tutorial	1	0.5*
Practical	1	0.5*

*: For fractional credit, calculation is to be made by rounding off.

(c) In the course structure, the credit assigned to each semester is as follows:

Semester	Credit
1	10
2	10
3	10
4	10
5	10
6	16
TOTAL	66

(d) In any paper, a candidate securing a grade higher than `F`, that is, Grade Point greater than zero, will be eligible to earn `credit` assigned to that paper. In other words , if a student is unable to secure a grade higher than 'F', that is, grade point greater than zero, he/she fails to earn any 'credit' assigned to that paper/subject.

(e) The performance of a candidate in n^{th} (n = 1,2,3,4,5,6) Semester examination, who earns all the credits of that semester, will be assessed by the '**Semester Grade Point Average' (SGPA), 'S_n'** to be computed as:

$$SGPA\,[S_n\,] = \frac{\sum_k [C_k\; GP_k]}{\sum_k C_k}$$

where 'k' denotes the number of papers in a particular semester

and $\sum_k C_k$ denotes the total credits of a particular semester and GP_k is the grade point of k^{th} paper.

(f) On completion of the M.Tech. course, the overall performance of a candidate will be assessed by the '**Cumulative Grade Point Average' (CGPA)** to be computed as:

$$CGPA = \frac{\sum_{n=1}^{6} [C_n\, S_n]}{\sum_{n=1}^{6} C_n}$$

where, $C_n = \sum_k C_k$ and $\sum_{n=1}^{6} C_n$ denotes total credits of all the semesters i.e. 80 credits.

8(a) Each candidate shall opt two (2) elective papers of 100 marks each, one in 2^{nd} and another in 4^{th} semester, from the list of elective papers to be notified in respective semesters. Such topics of elective papers may be revised from time to time as per recommendation of the Board of PG studies in Applied Physics.

(b) Each candidate shall have to submit a report on a Mini Project with seminar work of 100 marks assigned to him/her under the guidance of a faculty member(s) of the Department during 5^{th} semester examination. He / she has to defend his/her seminar report in an open session. The assessment of this report shall be made by a board of examiners consisting of at least three (3) members.

(c) (i) Each candidate shall execute a Thesis work assigned to him/her during the 5th and 6th Semester courses under faculty member(s) of the Department and he/she has to submit a report on the same at least

5 (five) days before the date of examination. The Thesis is divided into two phases. Thesis Phase-I of 100 marks with 8 credits is assigned during 5th semester while Thesis Phase-II of 100 marks with 16 credits is assigned during 6th semester. The candidate has to present and defend his/her Thesis work in an open session, which shall include internal and external examiners.
Out of the 100 marks assigned to Thesis Phase-I and Thesis Phase-II, 40 marks is earmarked for Sessional work to be assessed by the internal supervisor(s), 60 marks for the presentation of the Thesis and viva voce on the Thesis work. The assessment of the presentation of the Thesis and Thesis viva voce shall be done by a board consisting of at least five (5) examiners of whom ordinarily two (2) shall be external examiners.

(ii) A candidate may also carry out his/her Thesis work during 5th and 6th Semester under joint guidance of a faculty member(s) of the Department and a competent person from any industry/academic institution subject to the approval of Departmental Committee. He/she may carry out his/her Thesis work either in the Department or in the concerned industry/academic institute.

9. Candidates appearing in a semester examination shall join classes in the next semester immediately, wherever applicable, after completion of the examination.

10. Candidates of 1st to 5th Semester examinations will be allowed to continue in the next semester classes provided he/she secures at least the following credit respectively and for the 6th semester, he / she has to secure the following credit:

Semester	Minimum Credit to be obtained
1	06
2	06
3	06
4	06
5	06
6	16

11. A candidate earning credit less than that mentioned in **clause number 10** in any semester will be declared as **'unsuccessful'** candidate in that semester examination. He/she will have to take readmission in the corresponding semester in the next academic session as per CU rules and he/she will be allowed two (2) such chances to earn the **minimum credit**.

12. The shortfall in credits, being termed as **'due credit'** (the candidate being unsuccessful in one or more papers) of a semester will have to be earned by the candidate by appearing in the said paper(s) at the examination of the corresponding semester in the next academic session and he/she will have two (2) more such chances to earn his/her **due credit** within the maximum allowable duration of 5 years to complete the course**.**

13. (a) For a candidate who fails to earn all the '**credit**' of a semester but continues to the next semester by virtue of earning minimum credits **(clause number 10),** it is necessary that, total accumulation of shortfall in credit carried by the candidate does not exceed 16 (sixteen) at any stage. In such a case **he/she shall not be allowed to continue the course any further.**

(b) In order to complete the M. Tech. course, a candidate will have to utilize all the allowed chances within five (5) years from the date of first admission. A candidate who fails to earn all the credits of the M. Tech. course within the permissible chances **will not be allowed to continue the course any further**.

(c) If a candidate is unable to appear at any of the theory or practical examination(s), he/she will earn zero (0) credit in that paper(s).

14. The CU syndicate shall publish a list of successful candidates of the M. Tech. examination for each of the Semester examinations.

15. At the end of each Semester examination, a Grade-Sheet showing the Semester performance (Semester Grade Sheet) indicated by **SGPA** will be issued to the students. However, SGPA will not be calculated for those candidates who fail to earn all the credits in that Semester.
The Semester Grade Sheet should have the following basic information:

Paper	Details of courses	Full Marks	Marks obtained	Credit	Grade	Grade Point	SGPA	Remarks

16. (a) A consolidated Grade-Sheet, showing the overall performance in the M. Tech course indicated by **CGPA**, will be issued only to those successful students who have earned 80 (eighty) credit in the M. Tech. course.

The consolidated grade sheet shall consist of two components. The first component will have the information of the 6th Semester itself as follows:

Paper	Details of courses	Full Marks	Marks obtained	Credit	Grade	Grade Point	SGPA	Remarks

And the second component will have a **summary** of all the semesters having the following basic information:

Semester	Total credit	Credit obtained	Back credit	SGPA	Full marks	Marks obtained	Cumulative statement	
6	16				100		Total credit	66
5	10				200		CGPA	
4	10				300		Total Full marks	1500
3	10				300			
2	10				300		Marks obtained	
1	10				300		Result	*

The asterisk (*) in the last row of last column will contain the information regarding the final achievement of the candidate in all the examinations. This box will contain only one (1) of the following three (3) information: '1st Class' / '2nd Class' / 'Failed'.

(b) Candidates securing at least 66 (sixty six) percent of the total marks in M. Tech. Examination (total of Semester-1 to Semester-6 examinations) shall be placed in the First Class and those securing 50 (fifty) percent marks or more but less than 66 (sixty six) percent marks shall be placed in the 'Second Class'. Candidates securing less than 50 (fifty) percent shall be declared 'Failed'.

17. All exclusions of this regulation, if any, the decision will be taken in the Departmental Committee meeting in consultation with the Controller of Examination, University of Calcutta. The decision taken in the DC meeting will only be applicable subject to the approval of Hon'ble Vice-Chancellor.

18. The Degree of **"3 Year Master of Technology in Electrical Engineering with specialization in Power Systems"** from the Department of Applied Physics under the seal of the University shall be awarded to a successful candidate mentioning the grade and class he/she has obtained.

Course structure for 3-Year 6-Semester
Part Time M.Tech. Degree in Electrical Engineering with specialization in Power Systems
(w. e. f. the academic year 2021 - 2022)

Semester I Examination

Theoretical

PAPER NO.	SUBJECT	PERIODS per week			EVALUATION SCHEME				CREDITS
		L	T	P	TA	CT	ESE	TOTAL	
MET11	Fuzzy Logic & ANN	4	-	-	10	20	70	100	4
MET12	Advanced Electrical Machines	4	-	--	10	20	70	100	4
Practical									
MEP11	Advanced Electrical Machines Lab	-	1	7	50		50	100	2
Total								**300**	**10**

Semester II Examination

Theoretical

PAPER NO.	SUBJECT	PERIODS per week			EVALUATION SCHEME				CREDITS
		L	T	P	TA	CT	ESE	TOTAL	
MET21	Embedded Systems and Applications	4	-	-	10	20	70	100	4
MET22	Elective Paper I	4	-	-	10	20	70	100	4
Practical									
MEP21	Embedded Systems Lab	-	1	7	50		50	100	2
Total								**300**	**10**

Semester III Examination

Theoretical

PAPER NO.	SUBJECT	PERIODS per week			EVALUATION SCHEME				CREDITS
		L	T	P	TA	CT	ESE	TOTAL	
MET31	Dynamics of Linear Systems	4	-	-	10	20	70	100	4
MET32	Smart Grid Architecture	4	-	--	10	20	70	100	4
Practical									
MEP31	Advanced Power Systems Lab	-	1	7	50		50	100	2
Total								**300**	**10**

Semester IV Examination

Theoretical

PAPER NO.	SUBJECT	PERIODS per week			EVALUATION SCHEME				CREDITS
		L	T	P	TA	CT	ESE	TOTAL	
MET41	Electric Vehicles	4	-	-	10	20	70	100	4
MET42	Elective Paper II	4	-	-	10	20	70	100	4
Practical									
MEP41	Research Methodology and Term Paper leading towards Thesis	-	1	7	50		50	100	2
Total								**300**	**10**

Semester V Examination

PAPER NO.	SUBJECT	PERIODS per week			EVALUATION SCHEME				CREDITS
		L	T	P	TA	CT	ESE	TOTAL	
MEP51	Mini Project with Seminar	-	2	6	50	-	50	100	2
MEP52	Thesis Phase I	-	2	12	50	-	50	100	8
Total								**200**	**10**

Semester VI Examination

PAPER NO.	SUBJECT	PERIODS per week			EVALUATION SCHEME				CREDITS
		L	T	P	TA	CT	ESE	TOTAL	
MEP61	Thesis Phase II	-	8	24	50	-	50	100	16
Grant Total								**1500**	**66**

Elective Papers:

Elective - I: MET22:
EL11 : EHVAC, HVDC Transmission
EL12 : Advanced Electric Drives
EL13 : Sustainable Power Generation and Supply
EL14 : Power System Harmonics, Quality and Reliability
EL15: Condition Monitoring and Predictive maintenance

Elective - II: MET42:
EL21 : Power Electronics in Grid Integration
EL22 : Converters, Storage and FACTs
EL23 : High Voltage Engineering
EL24 : Power System Analysis
EL25 : Advanced Control Techniques

Detailed syllabus for Semester system for
3-year 6-semester Part Time M. Tech. course in Electrical Engineering with specialization in Power Systems w. e. f. the academic year 2021 - 2022

Semester I

Theoretical Papers:

MET11: Fuzzy Logic & ANN

Module1: Fuzzy Sets: Classical sets and fuzzy sets, fuzzy sets and probability, fuzzy numbers, operations and properties, membership functions and its types.
Module2: Fuzzy inference mechanism, fuzzy rule base and reasoning – linguistic variables, concept of approximate reasoning. Engineering examples.
Module3: Artificial Neural Network (ANN): Neuron model – Biological neuron, artificial neuron, activation function, mathematical model.
Module4: ANN architecture – feed-forward network, single layer and multi layer, Learning mechanism in ANN.

References:
1. J M Zurada , "An Introduction to ANN", Jaico Publishing House.
2. Simon Haykins, "Neural Networks", Prentice Hall.
3. Timothy Ross, "Fuzzy Logic with Engg.Applications", McGraw. Hill.
4. Bart Kosko, "Fuzzy Thinking", Flamingo Books.
5. George J. Klir and Bo Yuan, "Fuzzy Sets and Fuzzy Logic: Theory and Applications", Pearson, 1995.
6. Jyh-Shing Roger Jang, Chuen-Tsai. Sun, Eiji Mizutani, "Neuro Fuzzy and Soft Computing", Pearson Education India; 1st edition, 2015.

MET12: Advanced Electrical Machines

Module 1: Review of conventional electrical machines: Transformer, DC machine, Polyphase induction machine and Synchronous machines.
Module 2: Generalized theory of electrical machines: Rotational frame; Holonomic and non holonomic reference frame, quasi holonomic reference frame. Impedance matrix, torque matrix, rotational matrix, flux and current density matrices. Modeling and analysis of different electrical machines. Analysis of machines in Clarke, Park and dqo planes.
Module 3: Dynamics of electrical machines: Need for study of machine dynamics. Dynamics of DC machine – open loop and closed loop model and its responses, speed control of separately exited DC motor.
Module 4: **Dynamics of synchronous machines** – Parallel operation of alternators, swing equation of single machine connected to infinite bus and its stability considerations in light of Lyapunov stability theory.

References:
1. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education.
2. M. G. Say, "Performance and design of AC machines", CBS Publishers.
3. C.I. Hubert, "Electric Machines: Theory, Operating Applications and Control", Pearson
4. F. Puchstein and T.C. Lloyd, "Alternating Current Machines", John Wiley & Sons, Inc.
5. V. Richardson, "Rotating electric machinery and transformer technology", Prentice-Hall Inc.
6. L. Kosow, "Electric Machinery & Transformers", PHI
7. A.S. Langsdorf, "Alternating current machines", McGraw Hill Education, 1984.
8. G. S. Brosan and J. T. Hayden "Advanced Electrical Power and Machines"

Practical Papers:

MEP11 Advanced Electrical Machines Lab.
1. Equivalent parameter evaluation tests of induction motor
2. To study the working of Induction motor as frequency changer
3. To study the working of induction motor as induction generator
4. Short heat run test and dielectric measurement test of single phase transformer
5. Paralleling of alternator with the existing 3 phase buses.
6. Parallel operation of an alternator to study V curves of synchronous generator

7. Parallel operation of an alternator to study V curves of synchronous Motor

Semester II

Theoretical Papers:

MET21 : Embedded Systems and Applications

Module 1: General Concepts:
Embedded systems defined; Princeton and Harvard architecture; Peripheral interfaces; Timer and serial communication architecture; synchronous and asynchronous bus protocols; handling of interrupts.
Module 2: 8051 Microcontroller architecture:
8051 functional block diagram, memory map; pin functions; timer and UART operations; interrupts of 8051; introduction to assembly level programming.
Moule 3: PIC microcontrollers:
Pic-16 series microcontrollers: Block diagram, pin functions, memory map; power down modes; Use of digital IO, Timers, interrupt handling, serial interface, ADCs, SPI and I2C bus handling; Introduction to embedded C- programming.

Module 4: Applications of embedded systems:
Interfacing of ADCs, DACs, LEDS, Relays using 8051 and PIC series microcontrollers; microcontroller based DAQ system development; Use of PWM generation for power control, interfacing to wireless transceivers.

Reference Books:

1. Microcontrollers in Practice: M. Mitescu and I. Susnea (Springer)
2. Analog Interfacing to Embedded Microprocessor Systems: Stuart R. Ball
3. The 8051 Microcontroller: 3rd Ed: K. Ayala (Thomson Delmer learning)
4. The 8051 Microcontroller and Embedded Systems Using Assembly and C language: Mazidi, Mazidi & Mckinlay
5. Designing Embedded Systems with PIC Microcontrollers: Principles and applications: Tim Wilmshurst (Newnes)
6. Programming 8-bit PIC Microcontrollers in C: With Interactive Hardware Simulation: Martin P. Bates (Newnes)

MET22 Elective Paper I

Practical Papers:

MEP21 Embedded Systems Lab
1. Develop the program for LED On/Off at a variable frequency with AT89C51 and/ PIC 16F877A
2. Develop the program for 16x2 LCD display
3. Develop the program for 4x4 keyboard interface and to display the key scan code in LCD
4. Develop the program for half and full duplex serial communication using RS232 protocol
5. Develop the program for PWM signal generation to control the triac based light intensity
6. Develop the program for Stepper motor speed control with half, full and microstep operation
7. Design and develop a LDR based light intensity controller using a microcontroller

Semester III

Theoretical Papers:

MET31: Dynamics of Linear Systems

Module1: State space analysis: Concept of state space and state models, state transition matrix for time varying system, similarity transformation, special cases of determining the state transition matrix.
Module2: State-space representation of discrete-time systems, solving the discrete-time state equation.

Module3: Controllability and observability concepts and criterion. Pole placement method, concept of full-order and reduced order state observer, conditions for state observation.
Module4: Linear-quadratic regulator (LQR), linear-quadratic Gaussian (LQG), Kalman filter and its variants.

References:

1. K. Ogata, "Modern Control Engineering" Fifth Edition,. Prentice Hall Inc.
2. Benjamin C. Kuo "Automatic Control Systems" Seventh Edition, PHI
3. K. Ogata, "System-Dynamics" Fourth Edition, Pearson Education, Inc.
4. Norman S. Nise "Control System Engineering" Sixth Edition, John Wiley & Sons, Inc
5. Ogata K., "Discrete-Time Control Systems", Prentice Hall, Englewood Cliffs, N.J.
6. Dorf R C & Bishop R.H.: Modern Control System ; Addison – Wisley
7. Nagrath I. J. and Gopal M., "Control Systems Engineering", Third Edition, New Age Int. Ltd.
8. Madan Gopal, Control Systems , Principles & Application , 2/e ,TMH

MET32: Smart Grid Architecture

Module1: Introduction – Comparison of Power grid with Smart grid, General View of the Smart Grid Market Drivers, Stakeholders. Functions of Smart Grid Components.
Module2: Smart Grid Communications Protocols: Communication Protocols – RS 232, RS 485, SCADA, ZigBee/PLC, CRC., HAN, NAN, WAN, Smart Meter: need, construction and operation. Advanced metering infrastructure.
Module3: Introduction of renewable energy integration, Demand Side Integration: Need for DSI, Demand Response, Demand side management, Components of DSI, Concept of energy efficient load, consumers participation in DSI.
Module 4: Phasor Measurement Unit (PMU), Smart Meters, Wide area monitoring systems (WAMS).

References:

1. J. Ekanayake, K. Liyanage, J. Wu, A. Yokoyama, N. Jenkins - "Smart Grid Technology and Applications" Wiley publication, 2012
2. James Momoh, "Smart Grid Fundamentals of Design and Analysis" IEEE press, Wiley publication, 2012
3. D.P. Bernardon, V.J.Garcia, Smart Operation for Power Distribution Systems concepts and Applications" Springer Publication
4. Momoh, James A. Smart grid: fundamentals of design and analysis. Vol. 63. John Wiley & Sons, 2012.
5. Gottschalk, Marion, Mathias Uslar, and Christina Delfs. The Use Case and Smart Grid Architecture Model Approach: The IEC 62559-2 Use Case Template and the SGAM Applied in Various Domains. Springer, 2017

Practical Papers:

MEP31 Advanced Power Systems Lab.

List of Experiment
1. Design and simulation of power system faults using RTDS, ETAP/Digsilent/ Matlab
2. Design and simulation of different length of transmission line parameters RTDS, ETAP/ Digsilent/ Matlab
3. Design and simulation of distance protection system using RTDS, ETAP/ Digsilent/ Matlab
4. Design and simulation of FACTs system with RTDS, ETAP/ Digsilent/ Matlab
5. Design and simulation of SPV system interface with power grid RTDS, ETAP/ Digsilent/ Matlab
6. Design and simulation of Hardware-in-loop testing of inverters with the grid RTDS
7. Hardware simulation of 400 kV ac transmission system.
8. 400 kV HVDC transmission system.
9. Test bed operation of microgrid, load flow control of DFIG and PV inverters.

References: Reference manuals for (PSCAD, RSCAD, ETAP, Digsilent, Matlab), SG Test Bed

Semester IV

Theoretical Papers:

MET41: Electric Vehicles

Module 1: Introduction to Electric Vehicle, Evolution in Electric vehicles, EV architecture, Environmental issues.

Module 2: Electric drives - Electrical machines used in EVs, Power electronics converters and controllers for various motor drives, Drive Controller design.

Module 3: Energy Source and power system - Various types of energy sources for different types of EVs, Battery modelling, Charging and discharging of EVs, impact on power system due to charging and discharging, Energy Management System.

Module 4: EV Modelling- Introduction, Tractive effort, vehicle acceleration modelling, Aerodynamics and energy considerations

References:

1. Larminie, James, and John Lowry, "Electric Vehicle Technology Explained" John Wiley and Sons, 2012
2. Emadi, A. (Ed.), Miller, J., Ehsani, M., "Vehicular Electric Power Systems" Boca Raton, CRC Press, 2003
3. Sheldon S. Williamson, "Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles", Springer, 2013
4. Chris Mi, Abul Masrur& David Wenzhong Gao, "Hybrid electric Vehicle- Principles & Applications with Practical Properties", Wiley, 2011.
5. Iqbal Husain, " Electric and Hybrid Vehicle Design Fundamentals" Boca Raton, CRC Press, 2003

MET42 Elective Paper II

Practical Papers:

MEP41: Research Methodology and Term Paper leading towards Thesis

Semester V

MEP51: Mini Project with Seminar

MEP52: Thesis Phase I

Semester VI

MEP61: Thesis Phase II

ELECTIVE PAPER I: MET22

EL11: EHVAC, HVDC Transmission

Module1: EHVAC Transmission; Choice of working voltage and line length, common operating problems of uncompensated EHVAC transmission lines, Need for compensation.

Module2: Voltage Stability in Power Transmission: Controls and Improvements. Technical problems in EHVAC system,

Module3: HVDC Transmission: Advantages, principles, terminal equipment, necessity of control of a DC link, power reversal of DC link.

Module4: CSC and VSC Transmission. Harmonics and filters, Fault and protection schemes in HVDC systems.

References:

1. Begamudre, Rakosh Das. Extra high voltage AC transmission engineering. New Age International, 2006.
2. Naidu, Motukuru S., and M. KAMARAJU NAIDU. High voltage engineering. Tata McGraw-Hill Education, 2013.
3. Padiyar, K. R. HVDC power transmission systems: technology and system interactions. New Age International, 1990.
4. Eremia, Mircea, Chen-Ching Liu, and Abdel-Aty Edris, eds. Advanced solutions in power systems: HVDC, FACTS, and Artificial Intelligence. John Wiley & Sons, 2016.

EL12: Advanced Electric Drives

Module 1: Drive Concept: Different machine and load characteristics, four quadrant operation, DC machine speed control: State feedback control and sliding mode control of separately excited dc machine, modeling and control of separately excited dc machine in field weakening region and discontinuous converter conduction mode, control of dc series motor.

Module 2: Induction machine drive: Review of variable frequency operation of three phase symmetrical induction machine, 12 pulse / 18 pulse inverter, scalar control methods (constant volts/Hz and air gap flux control), vector control of induction machine, methods of flux sensing/estimation, PWM control.

Module 3: Traction drives: important features of traction drive, conventional ac and dc drives, diesel electric traction, ac traction, dc traction.

Module 4: Special machines drive: Speed control of BLDC machine, SRM, PMSM, linear induction motor.

References:

1. N. Mohan, "Power Electronics – converters, Application and Design".
2. M. Rashid, "Power Electronics - Circuits, Devices and Applications"
3. G. K. Dube, "Fundamental of Electrical Drive"
4. W. Leonhard, "Control of Electric Drives", Springer Science & Business Media, 2001.
5. P.C. Sen, "Thyristor Dc Drives", John Wiley, NY.
6. B.K. Bose, "Modern Power Electronics and AC Drives", PHI.

EL13: Sustainable Power Generation and Supply

Module 1: Different forms of sustainable power sources**:** Solar, biogas, wind, tidal, geothermal, Basic bio-conversion, Fuel cells, mechanism, mechanism of generation of electricity and their supply to the grid.

Module 2: Wind and tidal energy generation**;** turbine parameters and optimum operation, Ocean thermal energy conversion, Geothermal energy- hot springs and steam injection, power plant based on Wind, Tidal, OTEC and geothermal springs.

Module 3: Energy from the sun: Fundamentals of the technology, increase of efficiency, study of nano-structures, limitation of photo voltaics efficiency.

Module 4: Different Direct energy conversion methods: Fusion energy, Controlled fusion of hydrogen, helium etc. Energy release rates, present status and problems, future possibilities. Intergration aspects of these energies into the grid.

References:

1. Randolph, John, and Gilbert M. Masters. Energy for sustainability: Technology, planning, policy. Island Press, 2008.
2. Khan, B. H. Non-conventional energy resources. Tata McGraw-Hill Education, 2006.
3. Chauhan, D. S. Non-Conventional Energy Resources. New Age International, 2006.
4. Fahrenbruch, Alan, and Richard Bube. Fundamentals of solar cells: photovoltaic solar energy conversion. Elsevier, 2012.

EL14: Power System Harmonics, Quality and Reliability

Module 1: Power system disturbances: types, definitions, Harmonics: sources, analysis, effects, computation of harmonic flows, reduction of harmonics, passive and active filters, their controls and uses.

Module 2: Power system Quality: Different factors, definitions, measurements techniques, effects on power system operation and control.

Module 3: Power system Restructuring: Need of restructuring, basis of restructuring, Distributed Generation, Co-generation, importance of power quality in restructured environment.

Module 4: Power system reliability: Its necessity, basic principles, different techniques to improve reliability.

References:

1. Arrillaga, Jos, and Neville R. Watson. Power system harmonics. John Wiley & Sons, 2004.
2. Zobaa, Ahmed F., Shady Aleem, and Murat Erhan Balci, eds. Power system harmonics: analysis, effects and mitigation solutions for power quality improvement. BoD–Books on Demand, 2018.
3. Elmakias, David, ed. New computational methods in power system reliability. Vol. 111. Springer Science & Business Media, 2008.
4. Chowdhury, Ali, and Don Koval. Power distribution system reliability: practical methods and applications. Vol. 48. John Wiley & Sons, 2011.

EL15: Condition Monitoring and Predictive maintenance

Module 1: Condition monitoring and diagnostic engineering: objective, instrumentation and data acquisition systems for vibration, current, voltage, lubrication, temperature of electrical equipment, advanced non-destructive measurements using ultrasonic and eddy current techniques.
Module 2: Condition monitoring of rotating electrical machines: stator, rotor and winding faults, insulation ageing, mechanical faults, bearing faults, shaft alignment faults, crawling in induction motor;
Module 3: Condition monitoring of transformers and high voltage equipment: winding frequency analysis and dissolved gas analysis; discharge monitoring, electrical capacitance tomography, condition-based maintenance (CBM), Predictive and preventive maintenance.
Module 3: Signal processing tools and AI techniques methods condition monitoring: FFT, DWT, HT, current signature analysis for induction machine fault detection; Feature extraction and minimization techniques, pattern classifier applications: Fuzzy logic and Neural network, remaining useful life prediction.

References:
1. Condition Monitoring of Rotating Electrical Machines: P. Tavner (IEE Press)
2. An Introduction to Predictive Maintenance: K. Keith Mobley (Butterworth Heinimann)
3. Induction Motor Fault Diagnosis Approach through Current Signature Analysis: S. Karmakar *et. al.* (Springer)
4. Condition Monitoring and Assessment of Power Transformers Using Computational Intelligence- W. H. Tang Q. H. Wu (Springer-Verlag London)
5. Non destructive testing: B.Hull and V. John (Macmillan Education)

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EL21: Power Electronics in Grid Integration

Module1: Inverters and converter: Stand alone mode, Parallel mode of operations, Grid interface mode of operation.
Module2: Renewable Energy and Storage, Renewable Energy Resources, Storage Technologies, Grid integration issues of renewable energy sources, Induction Generators /other special machines.
Module3: Stability Analysis Tools for Smart Grid: Voltage Stability Assessment Techniques, angle stability assessment in smart grid, approach of smart grid to State Estimation, Energy management in smart grid.
Module 4: Different Load flow techniques for smart grid design, contingencies studies for smart grid.

References:
1. Yazdani, Amirnaser, and Reza Iravani. Voltage-sourced converters in power systems. Vol. 39. Hoboken, NJ, USA: John Wiley & Sons, 2010.
2. Bose, Bimal K. "Power electronics and AC drives." Englewood Cliffs (1986).
3. Luo, Fang Lin, and Ye Hong. Renewable energy systems: advanced conversion technologies and applications. Crc Press, 2017.
4. Zhong, Qing-Chang, and Tomas Hornik. Control of power inverters in renewable energy and smart grid integration. Vol. 97. John Wiley & Sons, 2012.

EL22: Converters, Storage and FACTs

Module1: Converters: Introduction to voltage source inverters, analysis of 1-phase, square - wave voltage Source inverter, 3-phase voltage source inverter with square wave output, 3-phase pulse width modulated (PWM) inverter. Sine PWM and its realization, other popular PWM techniques. Current source inverter Load-commutated current source inverter.
Module2: Synchronization with grid: Grid-Imposed Frequency VSC System; Structure of Grid-Imposed Frequency VSC System, control in α - β- frame; control in d - q- frame; Phase-Locked Loop (PLL); real and reactive power control. Controlled-Frequency VSC System, voltage control, autonomous operation.
Module3: Storage: Introduction to energy storage for power systems: Role of energy storage systems, applications. Overview of energy storage technologies: Thermal, Mechanical, Chemical, Electrochemical, Electrical. Efficiency of energy storage systems. Electrical energy storage: Batteries, Super capacitors, Superconducting Magnetic Energy Storage (SMES), charging methodologies, SoC, SoH estimation techniques.
Module4: FACTS: Definition, concepts, classification, Types of Compensation. Static Shunt Compensators, Static Series Compensators, Static Voltage and Phase angle Regulator, UPFC, IPFC.
References:
1. Yazdani, Amirnaser, and Reza Iravani. Voltage-sourced converters in power systems. Vol. 39. Hoboken, NJ, USA: John Wiley & Sons, 2010.

2. Bose, Bimal K. "Power electronics and AC drives." Englewood Cliffs (1986).
3. A.G.Ter-Gazarian, “Energy Storage for Power Systems”, Second Edition, The Institution of Engineering and Technology (IET) Publication, UK, (ISBN - 978-1-84919-219-4), 2011.
4. Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt,” Energy Storage in Power Systems” Wiley Publication, ISBN: 978-1-118-97130-7, Mar 2016.
5. A. R. Pendse, “Energy Storage Science and Technology”, SBS Publishers & Distributors Pvt. Ltd., New Delhi, (ISBN - 13:9789380090122), 2011.
6. Hingorani, Narain G., and Laszlo Gyugyi. Understanding FACTS: concepts and technology of flexible AC transmission systems. IEEE press, 2000.

EL23: High Voltage Engineering

Module 1: Different types of breakdown in solid and liquids, Partial discharge and its measurement techniques. Basic Equations of Electric field analysis.
Module 2: Electric Field Analysis by Finite Difference Method – in 2D and Axi-Symmetric Systems with equal and unequal nodal distances,
Module 3: Measurement of High Voltages, Electrostatic Voltmeters, Compensated ac and impulse peak voltmeters, Different types of voltage dividers and their characteristics.
Module 4: Surge current and voltage recorders, Surge crest ammeter and Klydanograph. High Voltage Schering Bridge. Microprocessor based measurement techniques.

References:
1. K.R.Padiyar, “HVDC Power Transmission Systems”, New Age International Publishers, 2011.
2. J.Arrillaga, “High Voltage Direct Current Transmission”, Peter Peregrinus Ltd., 1983.
3. M.S.Naidu and V. Kamaraju, “High Voltage Engineering”, McGraw Hill Education, 2013.
4. C.L.Wadhwa, “High Voltage Engineering”, New Age International Publishers, 2007.
5. Kuffel, John, and Peter Kuffel. High voltage engineering fundamentals. Elsevier, 2000.
6. Ryan, Hugh McLaren, ed. High voltage engineering and testing. No. 32. Iet, 2001.

EL24: Power System Analysis
Module 1: Symmetrical fault: fault current calculations using computer in n-bus system, Asymmetrical fault: introduction to symmetrical components, sequence networks for generators, transformer and transmission line, Computer aided calculations; Application of fault analysis in power system co-ordination.
Module 2: Reflection in transmission line: reflection co-efficient, standing wave and traveling wave, standing wave ratio Smith transmission line chart: its origin and applications.
Module 3: Power system Tariff: its need and structure, Availability Based Tariff (ABT), its background, need, basic principle, areas of use and achievements in restructured power system.
Module 4: Power system measurement: energy: active, reactive and apparent, Demand and maximum demand, trivector meter, digital metering, SMART Metering.

References:
1. Saadat, Hadi. Power system analysis. Vol. 2. McGraw-hill, 1999.
2. Grainger, John J. Power system analysis. McGraw-Hill, 1999.
3. Glover, J. Duncan, Mulukutla S. Sarma, and Thomas Overbye. Power system analysis & design, SI version. Cengage Learning, 2012.
4. Anderson, Paul M., and Aziz A. Fouad. Power system control and stability. John Wiley & Sons, 2008.
5. J. Arrillaga, and C. P. Arnold. Computer Analysis of Power Systems. John Wiley & Sons, 1990.
6. Watson, Neville, Jos Arrillaga, and J. Arrillaga. Power systems electromagnetic transients simulation. Vol. 39. Iet, 2003.
7. Stevenson Jr, William, and John Grainger. Power system analysis. McGraw-Hill Education, 1994.

EL25: Advanced Control Techniques

Module1: Idea of ‘good control’, Controller performance index, Different tuning methods and their comparative study, Advanced tuning techniques.
Module2: Idea of MIMO systems, Tuning of MIMO systems, Relative gain array, Optimizing control. Special control techniques- Selective control, Override control, Limit control, Idea of Statistical process control. Self-tuning control- Deterministic self-tuning regulators, Stochastic and predictive self-tuning regulators.
Module3: Adaptive control- what is adaptive control, properties of adaptive systems, stochastic adaptive control, auto-tuning, gain scheduling.

Module4: Kalman Filter, Square root Kalman filter. Non-linear system optimization, Gradient optimization techniques, steepest ascent and decent in parameter plane.

References:

1. H. K. Khalil, “Nonlinear Systems”, 3rd edition, Prentice Hall, 2002.
2. S. Sastry and M. Bodson, “Adaptive Control”, Prentice-Hall, 1989.
3. K. S. Narendra and A. M. Annaswamy, “Stable Adaptive Systems”, Prentice-Hall, 1989.
4. J.J.E. Slotine, and W. Li, “Applied Nonlinear Control”, Prentice-Hall, 1991.
5. P. Ioannou& B. Fidan, “Adaptive Control Tutorial”, SIAM, Philadelpia, PA, 2006.
6. Karl Johan Astrom & Bjorn Wittenmark, “Adaptive Control”, Pearson, 1994.