Master of Science in Electrical Engineering in Power System
(M. Sc. EEPS)

Curriculum

Faculty of Science and Technology
Pokhara University

2019

Program Objectives

The Master of Science in Electrical Engineering in Power System (M.Sc. EEPS) program focuses in providing a domain capability to each student that allows them to have a meaningful career in power system analysis, design and development, making reliable and economic power system. The course offers several optional and self-contained modules in the field of Power System Engineering. Different areas, such as power system dynamics, power electronics in power system, operation and control of power system, power quality and many more are covered through different modules of this program. The specific objectives of the program are as follows:

- To provide depth knowledge and understanding of the power system dynamics, its detailed modeling and simulation.
- To develop self-motivation in solving problem and to act autonomously in planning and implementation tasks at a professional level in Power System Engineering with full knowledge of software used in Power System Engineering.
- To develop independent research in a topic relating to Power System.
- To create the competent & skilled human resources to ensure them the careers and employment and in this way fulfill the requirement of National and Multinational Power and other industries.
- Promotion of research activities at the Faculty of Science and Technology
- Promotion of faculty development activities by creating special opportunities for its existing junior faculties by allowing them to participate in the graduate programs.
- Sustainability of existing academic programs

Major Components of Curriculum

The curriculum is designed to equip students with the competencies, knowledge, skills, and attitudes needed for success in technical positions. The coursework gives students a broad and holistic view of the complexity of technologies concerning different power system analysis and design in today's world. The curriculum comprises the following distinct components

- Foundation & Analytical Courses:
  The foundation and analytical courses provide the necessary academic background and analytical tools for M. Sc. study and are pre-requisite to advanced core courses.

- Core and Functional Courses:
  The core and functional courses as mentioned in the curriculum structure of M. Sc. EEPS provide students with the concept of advanced power system analysis, prevailing concept in reliable and secure design, familiar with international code of practices and use of advance software.

- Electives:
  A student is required to take four courses of three credit hours as electives. The objective of elective courses is to provide flexibility to the students in selecting course in which they have special interest. She/he can choose any course from the areas offered as mentioned in the course structure of M. Sc. EEPS

- Thesis:
  Students are required to undertake novel and original graduate research in the field of Electrical Power system to analyze the problem and find the appropriate technical as well as feasible solution. Students are also required to prepare a research report on a prescribed format. This course covers 12 credit hours. 4 credits are also allocated for research and project works prior to thesis dissertation

to provide pre- requisite for the thesis. A six-moth dissertation provides students with an opportunity to gain basic preliminary practical as well as theoretical experience of the research.

Program Features

The features of the program are competitive learning environment, research-driven concentrations, and program certainty. The M. Sc. in Electrical Engineering in Power System is a two-year program spread over four semesters. A student needs to successfully complete 60 credit hours of course work. Students also undertake Research and project work and Dissertation during the third & fourth semesters.

The regular M.Sc. in Electrical Engineering in Power System program is to be completed within four semesters. The duration of each semester will be 12 weeks excluding examinations.

The M. Sc. in Electrical Engineering in Power System covers courses in Electric Power Engineering including systems and components where electricity is principally used to transfer energy. The programme is concerned with understanding, modelling and analysing a wide range of topics related to design, operation, and control of individual power system components as well as power system in its entirety. After successful completion of the programme, participants shall be able to pursue a professional career in industry as well as an academic research career. An important influence of this master programme is real life problem-based learning including case studies and problem solving with quantitative and qualitative models using commercially available modelling software.

The course structure is based on the Semester system. Each Year is divided in first and second Semester. In first year, first semester, four core courses and laboratory works are offered and in second semester, three core courses and two Elective together with laboratory works are offered. The second year, first semester consists of one core course two elective courses and a Research and project work. The second year second semester is entirely allocated for dissertation work. The dissertation shall be individual's work and be entirely research based. Students shall be encouraged to publish research papers in national and international journals as an outcome of their dissertation work.

Entry Requirements and Admission Procedures

Eligibility

Students with Bachelor degree in Electrical Engineering or Electrical and Electronics Engineering or its equivalent are eligible to join the program. Also, the applicant must have along with the above criteria a minimum of 16 years formal education (12 years of schooling plus four years of graduation). Furthermore, the applicant must have secured a minimum of second division or CGPA of 2.00 (out of 4.00) or equivalent at the Bachelor degree level. The final decision on admission is taken on the basis of merit scores on the admission entrance test, however the criteria for scholarship should fulfil all these requirements and the criteria for scholarship as mentioned by the act of Pokhara University.

Documents Required

The applicant is required to submit the following documents with the application form made available by the concerned college by paying a predetermined application fee:

- Completed and signed application form
- Official transcripts from all the academic institutions attended.
- Certificate of experience

Certificates of all degrees and experience should be photocopied and submitted with proper attestation. Enrolment is conditional upon completion of all admission formalities including payment of all fees as determined by the college. Incomplete applications shall not be processed.

Admission Procedures

A notice inviting applications for admission is publicly announced. Application forms and information brochures are provided, on request, after the payment of the prescribed fee. The concerned college scrutinizes the application. The eligible candidates are informed to take the entrance test. The date and time for the entrance test are informed to the applicants by the concerned colleges.

Final selection of students will be made on the basis of their aggregate scores in the entrance test. The subjects and weightage for each subject areas of the entrance test will be as mentioned below

Engineering Mathematics	20%
Electrical Engineering subjects	70%
Computer and programming Skill	10%

The college may also hold interviews for the candidates before their final selection for admission. Eligible foreign national students may be admitted against limited seats on the basis of an interview to be conducted by the college. The candidates, who are given provisional admission pending submission of the qualifying certificates, are required to submit all necessary documents within a week of the beginning of regular classes.

Academic Schedule and Course Registration

The academic session consists of four terms. However, admission to the program will only be given twice a year as per the schedule published by the college.

Students are required to register courses at the beginning of each semester. Since registration is a very important procedural part of the credit system, all students must present themselves at the college for registration. Registration in absence may be allowed only in rare cases. A student's nominee cannot register for courses but will only be allowed to complete other formalities.

Attendance Requirements

The students must attain every lecture, tutorial and practical class. However, to accommodate for late registration, sickness and other such contingencies, the attendance requirements will be a minimum of 80% of the classes actually held. Students will get NOT QUALIFIED (NQ) status if s/he fails to maintain 80% attendance in any course.

Normal and maximum duration of study

The normal duration and the maximum duration for the completion of the requirements for the various programs are as follows:

Normal duration: 24 months (4 semesters)
Maximum duration: 4+1 years from the date of registration.

(All the courses have to be completed within 4 years, and additional 1 year can be given to thesis work on special request upon the approval of concerned authority or on request of the principal supervisor)

Evaluation System

A student's academic performance in a course is evaluated in two phases as:

- Internally by the concerned faculty member and
- Externally by the Office of the Controller of Examinations through semester-end examinations.

A sixty percent weight is given to internal evaluation and forty percent weight is given to external evaluation. The pass mark for both the internal evaluation and external evaluation is sixty percent. A student must qualify in both evaluations separately to get a pass grade in a particular course. The final grade awarded to a student in a course is based on his/her consolidated performance in both internal and external evaluations.

The internal evaluation may consist of various components like project works, quizzes, presentations, written examinations, reflection notes preparation, and the like. A student will get NOT QUALIFIED (NQ) status in the internal evaluation if his/her performance falls below the minimum requirement. Such students will not be allowed to appear in the semester-end examination of that particular course. The evaluation of laboratory works depends on the laboratory head.

Grading System

Pokhara University follows a four-point letter grade system. The letter grades awarded to students will be as follows:

Letter Grade	Grade Point	Description
A	4.0	Excellent
A-	3.7	
B+	3.3	Good
B	3.0	Fair
B-	2.7	
C+	2.3	
C	2.0	Pass in Individual Course
F	0.0	Fail

If a student cannot finish all the assigned works for the course, he/she will be given an incomplete grade 'I'. If all the required assignments are not completed within the following semester, the grade of 'I' will automatically be converted into 'F'.

The performance of a student is evaluated in terms of two indices: (a) Semester Grade Point Average (SGPA) which is the grade point average of the particular semester, and (b) Cumulative Grade Point Average (CGPA) which is the grade point average of all the semesters.

CGPA = [Total honor points earned] / [Total number of credits completed]

where,

Honour Point = Grade point earned in a subject × Number of credits assigned to that subject

Degree Requirements

To graduate from the M.Sc. program, a student should have

- A 'C' or better grade in each of the courses as specified in the curricular structure section;
- completed all the courses, and research project work as specified in the curricular structure section within the maximum time period specified in the normal and maximum duration of the study section;
- A final CGPA of 3.0 or better on the University's 4.0 grade scale.

Distinction and Dean's List

A student who obtains a cumulative GPA of 3.75 or better will receive the M.Sc. degree with distinction. The Dean's list recognizes outstanding academic performance in the program. To qualify to this list, a student must have a CGPA of 3.80 or better.

Repeating a Course

A course may be taken only once for grade. Since passing of all courses individually is a degree requirement, students must retake the failing course when offered and must successfully complete the course. A student will be allowed to retake maximum of two courses to achieve a minimum CGPA of 3.0. The grade earned on the retake examination will substitute the earlier grade earned by the student in that course. A student can retake a course only when it is offered by the college/university.

Credit Transfer and Withdrawal

A maximum of 25% of the total credit hours of course work completed by a student in an equivalent program of a recognized university/institution may be transferred/ waived for credit by the Dean on the recommendation of the principal/head of the school/college. However, for such transfer of credit, a student must have received a grade of 'B' or better in the respective course. Courses taken more than two years earlier than the date of application will not be accepted for transfer of credit.

Credit transfers will also be allowed from different programs of Pokhara University. In such cases, all credits earned by students in compatible courses with a minimum grade of B may be transferred to the new program.

The student may apply for withdrawal from the entire semester only on medical grounds. However, partial withdrawal from courses registered in a semester will not be considered.

Unfair Means

Students are strictly forbidden from adopting unfair means in class assignments, tests, report-writing, final examination and thesis work. The following would be considered as adoption of unfair means during examination:

- Communicating with fellow students for obtaining help.
- Copying form another student's script/report/paper.
- Copying from disk, mobile, palm of hand or other incriminating documents and equipment.
- Possession of any incriminating documents, whether used or not.
- Any approach in direct or indirect form to influence teacher concerning grade.
- Unruly behavior which disrupts academic program.

If the instructor detects a student using unfair means, the student may be given an 'F' grade at the discretion of the Examination Board. Adoption of unfair means may result in the dismissal of the student from the program and expulsion of the student from the college and as such from Pokhara University.

Dismissal from the Program

A student is normally expected to obtain a GPA of 3.0 in the semester-end examinations of the M. Sc. program. If a student's performance falls short of maintaining this CGPA continuously over the semesters, he/she may be advised to leave the program or dismissed from the program.

Detailed Curricular Structure

The Academic year starts at the end of February /beginning of March and ends at the end of January / beginning of February. The year is divided into two semesters; each of the semesters has fifteen-week study periods.

The program consists of 60 credits, corresponding to two years of full-time studies. The program includes the following subject areas:

- Electric Power Systems focusing on power system dynamics, stability and control, as well as electricity markets
- Information and Control Systems focusing on automation, operation, and control of electric power systems
- Electrical Energy conversion focusing on electrical machines and power electronics and renewable energy

Curriculum Structure

Year 1, Semester -1					
S.N.	Course Code	Course	Credit Hours	Contact hours/week	Type
1	EPS 501	Computer Aided Power System Analysis	4	6	C
2	EPS 502	Distribution System Planning and Design	3	3	C
3	EPS 503	Advanced Power Electronics	3	5	C
4	EPS 504	Optimization Techniques	3	3	C
5	EPS 505	Power Market and Deregulation	3	3	C
		Total	16	20	

Year 1, Semester -2					
S.N.	Course Code	Course	Credit Hours	Contact hours/week	Type
1	EPS 551	Power System Dynamics and Stability	4	6	C
2	EPS 552	Advanced High Voltage Engineering	3	3	C
3	EPS 553	Power System Operation and Control	3	3	C
4	EPS 591	Seminar	2	2	C
5		Elective I	3	3	E
		Total	15	17	

Year 2, Semester -1					
S.N.	Course Code	Course	Credit Hours	Contact hours/week	Type
1	EPS 601	Power System Reliability	3	3	C
2	EPS 602	Engineering Project Planning and Management	3	3	C
3	EPS 603	Project	2	2	C
4		Elective II	3	3	E
5		Elective III	3	3	E
		Total	14	14	

Year 2, Semester -2					
S.N.	Course Code	Course	Credit Hours	Contact hours/week	Type
1	EPS 691	Dissertation	15	15	
		Total	15	15	
		Total Credits	60		

Elective Courses

Elective I

Course Code	Course
EPS 571	Advanced Electrical Drives
EPS 572	Dynamic Modeling of Electrical Machines
EPS 573	Flexible AC Transmission Systems
EPS 574	Micro Controller and DSP based System Design

Elective II

Course Code	Course
EPS 631	Advance Power System Protection
EPS 632	Distributed Generation and Micro Grid
EPS 633	Risk Assessments of Power System
EPS 634	Non-Linear Control System Design

Elective III

Course Code	Course
EPS 641	Power Quality and Harmonics
EPS 642	Artificial Intelligence Applications in Power System
EPS 643	Social and Environment Impact of Engineering System
EPS 644	Renewable Energy Sources and Grid Integration

EPS 501 Computer Aided Power System Analysis (4 credits)

Course Objectives

- To understand the fundamental static modeling of power system components.
- To impart in-depth knowledge on different methods of power flow solutions.
- To perform short circuit fault analysis and understand the consequence of different type of faults.
- To perform power system security analysis and optimal power flow solutions in detail.
- To perform the computer aided analysis of large-scale power system.

Course Contents

UNIT I: General Introduction **8 hours**

Review of basics of power transmission networks, Static modeling of power system and its component, modeling of lines, transformers, generators and loads, Introduction to Wide Area Measurement Systems (WAMS) and Phasor. Measurement Unit (PMUs) and State Estimation and its application in power system

UNIT II: Power Flow Analysis **15 hours**

Power flow equations, Formation of Y-bus matrix, Formulation of Z-bus matrix, Power flow solution algorithms ,Review of Gauss, Gauss-Seidel, Newton Raphson and Fast Decoupled power flow methods, Sensitivity factors for P-V bus adjustment , DC load flow method , Sparsity of network admittance matrices and triangular decomposition**.**

UNIT III: Short Circuit Analysis **12 hours**

Fault calculations using sequence networks for different types of faults, Bus impedance matrix (Z bus) construction algorithm for lines with mutual coupling, Computer method for fault analysis using Z bus and sequence components for different types of faults

UNIT IV: Power System Security **10 hours**

Review, Factors affecting power system security, Static Security Analysis at Control Centers and Contingency analysis of generator and line outages using linear sensitivity factors

UNIT V: Optimal Power Flow **15 hours**

Introduction to Optimal power flow , The Gradient method and Newton's method , Linear sensitivity analysis :Sensitivity coefficients of an AC Network Model , Linear programming methods: Linear programming method with only real power variables and with AC power variables and detailed cost functions and Security constrained optimal power flow

Laboratory Works

1. Power flow analysis by Newton-Raphson method and Fast decoupled method
2. Power system fault analysis
3. Contingency analysis: Generator shift factors and line outage distribution factors
4. Optimal Power Flow

Recommended Software for Laboratory Works

1. MATLAB 2013 Version
2. Power System Analysis Toolbox (PSAT)
3. Electrical Transient and Analysis Program (ETAP)
4. PSS/E
5. DigSilent

References

1. W. D. Stevenson Jr, “Elements of Power System Analysis”, McGraw Hill, 3rd Edition.
2. GW Stagg, A.H El. Abiad “Computer Methods in Power System Analysis”, McGraw Hill.
3. P. Kundur, “Power System Stability and Control”, McGraw Hill.
4. A. J. Wood and B.F. Wollenberg, “Power Generation Operation and Control”, John Wiley and Sons, New York.
5. I. J. Nagrath, D.P Kothari, “Power System Engineering”, McGraw Hill.
6. Hadi Saadat, “Power System Analysis”, Tata McGraw Hill.
7. K. Zollenkopf, “Bi-Factorization: Basic Computational Algorithm and Programming Techniques; pp.: 75-96; Book on “Large Sparse Set of Linear Systems” Editor: J. K. Rerd, Academic Press.
8. M. A. Pai, “Computer Techniques in Power System Analysis”, Tata McGraw-Hill Publishing Company Limited, New Delhi.
9. D. Thukara, H. M. Wijekoon Banda & Jovitha Jerome, 'A robust three phase power Flow algorithm for radial distribution systems', Electric Power Systems Research 50 (1999) 227–23
10. IEEE Transactions on Power System.

EPS 502 Distribution System Planning and Design (3 credits)

Course Objectives

- Design, analyze and evaluate distribution system and design based on forecasted data
- Identify and select appropriate sub–station location and components sizing
- Design and evaluate a distribution system for a given geographical service area from alternate design alternatives

Course Contents

UNIT I: System Planning **8 hours**

Introduction, Distribution system planning, short term planning, long term planning, dynamic planning, Factors affecting system planning, present planning techniques, planning models, Introduction to optimum line network. Future trends in planning, systems approach, distribution automation, Load Characteristic: Basic definitions, relation between load and loss factors, maximum diversified demand, Load forecasting, methods of forecast – regression analysis – correlation analysis and time series analysis, Load management, Modeling of components, Distribution system analysis, Power flow and fault studies and Distribution system expansion planning

UNIT II: System Design and Operation **8 hours**

Criteria, system developers, dispersed generation: Dispersed generation from renewable and non-renewable sources, Technical and economic impacts of DG technologies, isolated and grid connected DGs, distribution systems, economics and finance, mapping , Design of substation and feeder, bus schemes, description and comparison of switching schemes, types of feeders, Operation criteria, voltage measurements, harmonics, load variations, system losses and Introduction to energy management

UNIT III: Voltage Regulation and Automation **8 hours**

Quality of Service and Voltage Standards, Voltage Control, Line Drop Compensation, Distribution capacitor automation, Voltage fluctuations, Basic Architecture of distribution automation system, SCADA and Communication with Load Dispatch Centers and GIS and GPS based mapping of distribution system

UNIT IV: Distribution System Protection **6 hours**

Objective of distribution system protection**,** High impedance faults**,** Coordination of protective devices: fuse to fuse co-ordination, re-closer to re-closer coordination, re-closer to fuse coordination, re-closer to substation transformer high side fuse coordination, fuse to circuit breaker coordination, re-closer to circuit breaker coordination, lightning protection and Protection issues with DGs

UNIT V: Grounding **6 hours**

Grounding system – earth and safety – nature and sizes of earth electrodes – design – earthing schemes

UNIT VI: Case Studies **9 hours**

Complete Design of Distribution System / Distribution substation design

References

1. Gonen, Turan, 'Electric Power Distribution System Engineering', CRC PRESS, Third Indian Reprint, 2012.
2. A.S. Pabla, 'Electric Power Distribution', 6th Ed., TMH, 2011.
3. 'Electric Power Distribution Handbook' Thomas Allen Short.
4. IEEE Transactions on Power System.

EPS 503 Advanced Power Electronics (3 credits)

Course Objectives

- To impart the knowledge of power semiconductor devices and its switching characteristics for selecting device
- To impart the knowledge of converter and inverter design and its application in renewable energy, motor drives and industrial applications
- To impart knowledge of complex behavior of converters and load (grid)

Course Contents

UNIT I: Power Semiconductor Devices **8 hours**

Switching devices (Power Diode, SCR, MOSFET, GTO IGBT and other emerging devices) operations , Static and dynamic switching characteristics, protection circuits, Gate and Base drive circuits, Preliminary design considerations, Temperature control of power devices, Heat sink design, and Design of Magnetic components

UNIT II: AC to DC Converters **8 hours**

Single phase and three phase converters circuit operation for R and R-L load, evaluation of performance parameters**,** Continuous and discontinuous mode, effect of the source inductance and Improvement of power factor, Self and Line commutated current source converter

UNIT III: DC to DC Converters **6 hours**

Dc to DC converter types, Design of (Buck and Boost) converter, Analysis of Fly-back, forward converter, Push pull, half bridge and full bridge converter, Design considerations and comparison

UNIT IV: Inverters **8 hours**

Review of single-phase bridge inverters, 3-phase bridge inverters, Pulse width modulated inverters, Single pulse and multi pulse modulation, Sinusoidal PWM, Space Vector PWM, Reduction of harmonics and Selective Harmonic Elimination Technique

UNIT V: Multilevel Converters **7 hours**

Multi-level converter, applications, Operation Diode clamped, Flying capacitor, Cascade Bridge, ANPC, Hybrid topology, Comparison of MLIs Current source MLI and Parallel operation of inverter and PWM for MLIs

UNIT IV: Application **8 hours**

Solar Energy, Application converters in solar power, principle of MPPT, Wind Energy, operation of back to back connected converters for DFIG and HVDC and Static VAR Compensation

Simulation Exercises

- Three-phase converter for R (resistive) and R-L load
- Three phase sinusoidal pulse width modulated voltage source Inverter
- Closed Loop and Open loop dc to dc converter simulation
- Space vector modulation based three phase inverter simulation

- Simulation of Cascade H bridge Multilevel Inverter

References

1. Mohan, Undeland, Robbins: Power Electronics: Converters, Applications and Design. 3rd Edition. John Wiley og Sons, 2003.
2. Rashid, M. H., "Power Electronics Circuits, Devices, and Applications, Prentice-Hall of India Pvt. Ltd., New Delhi, 2nd edition, 1999.
3. Bin Wu, 'High-Power Converters and AC Drives', Wiley - IEEE Press, 2006,
4. José Rodríguez *et al.*: Multilevel Voltage source Converter for Industrial MV Drives IEEE Transactions on Industrial Electronics Vol.54 No.6 December 2007
5. Bimal K. Bose "Power Electronics and Motor Drives Advances and Trends" Academic Press is an imprint of Elsevier ISBN 13: 978-0-12-088405-6
6. IEEE Transactions on Power Electronics.

EPS 504 Optimization Techniques (3 credits)

Course Objectives

- To impart the knowledge of Linear Equations in Linear Algebra and approaches in solving linear equations
- To impart the knowledge of control and optimization of linear and non-linear system
- To impart the knowledge of developing robust controller for power system and power electronics devices

Course Contents

UNIT I: Review of Linear Algebra and its Application 5 hours

Linear Equations in Linear Algebra: Row Reduction and Echelon forms, Vector equations, matrix equations, solution sets of linear systems, application of linear systems , Matrix Algebra: Matrix operations, inverse of a matrix, matrix factorizations, Leontief input-output models, Dimensions and Rank, Determinants and its properties, Cramer's rule volume and linear transformations, Vector Spaces: vector spaces and subspaces, linearly independent sets, coordinate systems, dimension and rank of a vector space, Eigen values and Eigen vectors: the characteristic equations, diagonalization, Eigen Vectors and linear transformation, complex Eigen Values, Discrete dynamical, Systems, application to differential equations, Orthogonality and least Squares: inner products, length and orthogonality, orthogonal, sets, orthogonal projection, gram Schmidt process

UNIT II: State Space Analysis 10 hours

Analysis of system, advantages of state space techniques, state space representation for electrical networks, nth order differential equations and transfer function, Solution of time invariant state equation, transfer matrix, computation of state, transition matrix, block diagram of linear systems in state variable form, controllability and observability, Time varying systems, controllability and observability of time variant system, similarity transformation, state space representation in controllable canonical form, observable canonical form and diagonal canonical form, Decomposition of transfer function, direct decomposition, cascade decomposition, parallel decomposition, Effect of pole zero cancellation in transfer function, Basic state space method, for controller design: state feedback, pole placement via the, controllability form, Ackermann's formula, pole placement by direct matching of coefficients

UNIT III: Linear Systems 10 hours

Representation of Linear systems: impulse response and weighting functions, transfer functions matrices, transfer operator, input output equations**,** Properties of Linear systems: solving the system of equations, controllability and observability, poles and zeros, stability, frequency response and frequency functions, model reduction, discrete time systems**,** Selection of pole location, selection of static gains **,**Disturbance models: Disturbances, signal size and scaling, disturbances in time ,domain, observer and Kalman filters

UNIT IV: Linear Control Theory 10 hours

Closed loop system: transfer function and stability of the closed system, sensitivity and robustness, specification in time domain and frequency domain, Controller structures and control design: configuration of multivariable controllers, internal model control, feedback from reconstructed states, Minimization of quadratic criteria: criterion and main idea, optimal controller, robustness for linear quadratic regulators (LQR) , State dependent Riccati equation and design Loop shaping: direct method, formalization of the requirement, optimal H2 control, optimal Hα control, robust loop shaping

UNIT V: Nonlinear Control Theory **10 hours**

Describing nonlinear systems, Stability of Non-linear systems, stability and Lyapunov functions, and the circle criterion, Controller synthesis for nonlinear system: Linear design and non-linear verification, non-linear internal model control, parameter optimization, state feedback and Observer, Model predictive control: basic idea to predict the output, k step prediction for linear systems, the criterion and the controller, compensate exactly for non-linearity's

References

1. David C. Lay "Linear Algebra and its application" Addison-Wiley
2. Gene F. Franklin, J. David Powell, and Abbas Emami-Naeini, Feedback control of dynamic systems, 6th ed., Pearson Prentice Hall, Inc., Upper Saddle River, New Jersey, 2010
3. Torkel Glad and Lennart Ljung, Control theory Multivariable and nonlinear method,Taylor and Francis

EPS 505 Power Market and Deregulation (3 credits)

Course Objectives

- To provide in-depth understanding of operations of deregulated electricity market systems.
- To examine typical issues in electricity markets and how these are handled worldwide in various markets.
- To enable students to analyze various types of electricity market operational and control issues using new mathematical models.

Course Contents

UNIT I: Power Sector **6 hours**

Introduction to various institutions in Nepalese Power sector such as NEA, National Planning commissions, Ministry of Energy, Water Resources and Irrigation, utilities and their roles. Critical issues, challenges before the Nepalese power sector , Salient features of Hydropower Development Policy 2058, Electricity Act 2049, Electricity Regulation 2050, Electricity Regulatory Commission Act 2074 ,Water Energy Commission Secretariat (WECS) and Alternative Energy Promotion Center (AEPC), Role of Private Sector in the promotion of power sector, Introduction to Power Markets: Monopoly, Monopsony, Oligopoly, Competitive, Market Power; Power Sector Reform, Milestones of Power System Reform in the world , Need of regulation and deregulation of power sector. Conditions favoring deregulation in power sector

UNIT II: Power Sector Economics and Regulation **12 hours**

Typical cost components and cost structure of the power sector, Different methods of comparing investment options, Concept of life cycle cost, annual rate of return, methods of calculations of Internal Rate of Return (IRR) and Net Present Value (NPV) of project, Short term and long-run marginal costs, Different financing options for the power sector ,Different stakeholders in the power sector, Role of regulation and evolution of regulatory commission types and methods of economic regulation, regulatory process , Electricity Pricing: Different tariff principles (marginal cost, cost to serve, average cost), Consumer tariff structures and considerations, different consumer categories, interruptible tariff, different tariff-based penalties and incentives etc., Subsidy and cross subsidy, life line tariff, Comparison of different tariff structures for different load patterns , Effect of renewable energy and captive power generation on tariff, Determination of tariff for renewable energy, Non-price issues in electricity restructuring , Quality of supply and service, standards of performance by utility, environmental and social considerations; Global Power Market Evolution

UNIT III: Deregulation and Reconfiguring Power systems **12 hours**

Deregulation, Reconfiguring Power systems, unbundling of electric utilities, Background to deregulation and the current situation around the world, benefits from a competitive electricity market after effects of deregulation **,** Role of the independent system operator: ISO in Pool markets, ISO in Bilateral markets, Genco in Pool and Bilateral markets, market participation issues, competitive bidding, Power wheeling, Transmission open access, pricing of power transactions, Security management in deregulated environment, and congestion management in

Deregulation, General description of some ancillary services, ancillary services management in various countries, and reactive power management in some deregulated electricity markets

UNIT IV: Electricity Markets and Pricing **6 hours**

Electricity price basics, Market operation, Market efficiency, gate closure, settlement process, Market Clearing Price (MCP), Zonal and locational MCPs, Dynamic: spot pricing and real time pricing, Dispatch based pricing, Power flows and prices. Optimal power flow, Spot prices for real and reactive power, Unconstrainedreal spot prices, constraints and real spot prices , Global experience with electricity reforms in different countries , Financial Internal Rate of Return (FIRR), Modified Internal Rate of Return (MIRR) , Economic Internal Rate of Return (EIRR), Benefit by Cost(B/C) Ratio, Debt Service, Coverage Ratio (DSCR), Cash After Debt Amortization (CADA) of project, Feed in tariff, Step Tariff, Pre-Paid Tariff) Clean Development Mechanism (CDM), Carbon Trading

UNIT V: Transmission Planning and Pricing **9 hours**

Transmission planning, Different methods of transmission pricing, Different transmission services, Congestion issues and management, Transmission cost allocation methods, Locational marginal price, firm transmission rights , Transmission ownership and control, Transmission pricing model, Availability based tariff, role of load dispatch centers (LDCs), concept of arbitrage in Electricity markets, game theory methods in Power System, security constrained unit Commitment, Ancillary services for restructuring, forward ancillary service auction and Power Purchase agreements

References

1. K. Bhattacharya, MHT Bollen and J.C Doolder, “Operation of Restructured Power Systems”, Kluwer Academic Publishers, USA, 2001.
2. Lei Lee Lai, “Power System restructuring and deregulation”, John Wiley and Sons, UK. 2001.
3. Fred I Denny and David E. Dismukes, “Power System Operations and Electricity Markets”, CRC Press, LLC, 2002.
4. Fundamentals of Power System Economics by D.S. Kirschen and G. Strbac, John Wiley & sons.
5. Electricity Economics Regulation and Deregulation, by G. Rothwell and T Gómez, Wiley Inter Science.
6. Sally Hunt, “Making Competition Work in Electricity”, 2002, John Wiley Inc.
7. Electric Utility Planning and Regulation, Edward Kahn, American Council for Energy Efficient Economy
8. IEEE Transactions on Power System.
9. NEA Publications
10. EPPAN Publications

EPS 551 Power System Dynamics and Stability (4 Credits)

Course Objectives

- To provide knowledge on dynamic modeling of a synchronous machine.
- To provide and enhance small signal stability problem in power systems.
- To perform transient stability analysis using unified algorithms and familiarize the methods of transient stability enhancement.
- To analyze voltage stability problem in power system.

Course Content

Unit I: Dynamic Modeling of Power System Components 15 hours
Synchronous machine modeling: Three-phase synchronous machine- physical description, Mathematical model of electrical parts, balanced steady-state operation, simplified form of voltage equations for balanced operation; Three-phase synchronous machine parameters; Modeling of mechanical part of the synchronous machine; Synchronous Machine Model for stability analysis-Electrical part; Modeling of mechanical part for stability analysis; Modeling of excitation system (IEEE standard models), modeling of turbine and governing systems, loads and flexible AC transmission system controllers.

Unit II: Small-Signal Stability 15 hours
Fundamental concepts of stability of dynamic system: State-space representation, stability of dynamic system, linearization, eigen properties of the state matrix; Small-signal stability of s single-machine infinite bus system; Effect of excitation system and power system stabilizer; Small signal stability of multi-machine system; Enhancement of small signal stability.

Unit III: Transient Stability 15 hours
An elementary view of transient stability: Single machine-infinite bus system, multi-machine stability; Network reduction and numerical integration methods; Simulation of power system dynamic response; Case study of transient stability of large system; Enhancement of transient stability.

Unit IV: Voltage Stability 15 hours
Transmission system aspects: Single-load infinite bus system, maximum deliverable power, power voltage relationships, generator reactive power requirement, effect of compensation, V-Q curves; Generator aspects: a review of synchronous machine theory, frequency and voltage controllers, limiting devices affecting voltage stability, voltage-reactive characteristics of synchronous generators, capability curves, effect of machine limitation on deliverable power; Load aspects: Voltage dependence of loads, load restoration dynamics, induction motors, load tap changers, thermostatic load recovery, generic aggregate load models.

References

1. P. Kundur, "*Power System Stability and Control*", McGraw-Hill, 1993.
2. R. Ramnujam, "*Power System Dynamics Analysis and Simulation*", PHI Learning Private Limited, New Delhi, 2009.

3. T. V. Cutsem and C. Vournas, "Voltage *Stability of Electric Power Systems*", Kluwer publishers, 1998.
4. P.W. Sauer and M.A. Pai, "*Power System Dynamics and Stability*", Stipes Publishing Co, 2007.

EPS 552 Advanced High Voltage Engineering (3 Credits)

Course Objectives

- To provide in-depth knowledge of high voltage phenomena and high voltage systems.
- To enable students to analyze different high voltage systems using various models.

Course Contents

Unit I: High Voltage Systems **2 hours**

History of high voltage engineering, emerging trends in high voltage engineering, Power handling capacity and line loss of transmission lines, temperature rise of conductors and current carrying capacity.

Unit II: Line and Ground Parameters **6 hours**

Line Parameters evaluations techniques, Charge-potential relations for multi conductor lines; surface voltage gradient, distribution of voltage gradient on sub-conductors of bundle, voltage gradients in the presence of ground wires, Electrostatic and magnetic fields of EHV lines: Capacitance of long object, Electrostatic and magnetic fields of AC lines, Induced voltage in unenergized circuit of D/C line and ground wires, Effects of electrostatic and magnetic field on humans, animals and plants.

Unit III: High Voltage Testing **6 hours**

Generation and measurement of high AC, DC and Impulse voltages and currents, High voltage testing of electrical apparatus, non-destructive testing of materials and apparatus, High voltage testing procedures and statistical treatment of results: Laboratory test procedures, testing with power frequency voltage.

Unit IV: Electrical Discharge Mechanisms **8 hours**

Breakdown in gases: Ionization and decay processes, cathode processes – secondary effects, the Townsend Mechanism, Paschen's law¸ Partial discharge (PD) and corona, corona power loss, AN and RI, Breakdown in liquid dielectrics: Electronic breakdown, suspended solid particle mechanism and cavity breakdown, Electroconvection and electrohydrodynamic model of dielectric breakdown, breakdown in solid dielectrics: Intrinsic breakdown, streamer breakdown, electromechanical breakdown, thermal breakdown, treeing and tracking.

Unit V: Outdoor Insulators **9 hours**

Design of Insulators: ceramic and polymeric (composite), Operation in a contaminated environment, Flashover mechanism of polluted insulators, Mitigation of contamination flashover, Measurement and tests: Measurement of insulator dimensions, Measurement of pollution severity, Contamination testing – clean fog and salt fog testing, Ageing of polymer insulators: Tracking and erosion, Artificial ageing methods of polymer insulators, application of nano-filled polymeric insulator for preventing tracking and erosion.

Unit VI: Overvoltage and Insulation Coordination **8 hours**

Power frequency overvoltage, switching overvoltage, reduction of switching overvoltage, switching surge test voltage characteristics, Lightning overvoltage: The lightning mechanism, simulated lightning surges, Tower footing resistance, Operating characteristics of lightning arresters, Insulation coordination of HV systems: Insulation level, statistical approach to insulation coordination, correlation between insulation and protection levels.

Unit VII: EHV Cable Transmission **6 hours**

Electrical characteristics of EHV cables, properties of cable insulation materials, tests on cable characteristics, examples of cable designs, Gas insulated EHV lines.

References

1. Kuffel, Zaengl and Kuffel, "*High Voltage Engineering Fundamentals*", Newnes, 2000.
2. R. D. Begamudre, "*Extra High Voltage AC Transmission Engineering*", New Age International Publishers, 2011.
3. M. Khalifa, "*High Voltage Engineering: Theory and Practice*", Dekker, 1990.
4. Kuffel and Abdulla. M. "*High Voltage Engineering*", Pergamon press, 1998.
5. Wadhwa C L., "*High Voltage Engineering*", Wiley Eastern Limited, New Delhi, 1994.
6. IEEE, IEC and CIGRE Standards and Test Procedures.

EPS 553 Power System Operation and Control (3 Credits)

Course Objectives

- To provide the knowledge of power system operation and control.
- To impart knowledge of power system security and ELD applications.
- To understand economic operation of power system, control and planning.

Course Contents

Unit I: Introduction 5 hours
Economic Operation, Economic load dispatch, Hydro thermal scheduling, Independent system operation, State estimation, Unit commitment, Frequency control, Automatic generation control.

Unit II: Power system security and Reactive power generation control 8 hours
System security, Optimal power flow considering security constraints, Power quality constraints, Operational constraints, Reactive Power Generation Control: Control strategy of reactive power generation, Methods of supplying reactive power, Reactive power capability of alternator, Basic concept of reactive power dispatch.

Unit III: State Estimation and Economic Load Dispatch Problem with Application 16 hours
State estimation fundamental, DC state estimation, Least-squares estimation, AC state estimation, Advanced topics in state estimation, Application of power system state estimation, Economic load dispatch problems, Operating characteristics of thermal and hydro generators, Sparsity techniques, Security assessment, Optimal power flow problem, Application in ELD Problems.

Unit IV: Real Time Modeling, System Security Monitoring & Control 10 hours
Real time modeling subsystem, SCADA system, Power system communications, Security monitoring and controls, Simultaneous transfer capability analysis, Impact of deregulation, Modeling of governing system, Generator and load modeling, Static and dynamic response.

Unit V: Energy/Economy Functions, Control and Planning 6 hours
Energy/economy functions and control, Automatic generation control, Interchange control, Reactive power control, Operations planning and electrical load forecasting.

References

1. Meliopolous, “Power System Modeling, Analysis”, Control and operations.
2. Wood and Woolenberg, “Power system, generation, operation and control”, Willey and sons.
3. J. Wood and B. F. Wollenberg, “Power generation, operation and control”.
4. O. I. Elgerd, “Electric Energy System Theory”, Tata McGraw Hill, 2003.
5. Dhillon Kothari, “Power System Optimization”, Prentice--Hall of India Pvt. Ltd.
6. N. S. Rau, “Optimization principles: Practical Applications to the Operation and Markets of the Electric Power Industry”.

EPS 591 Seminar (2 Credits)

Course Description

In this course students shall review recent journal/conference papers of electrical power engineering Students should undergo literature survey and identify the topic of seminar and finalize in consultation with Guide/Supervisor.

Students should use multiple literatures and understand the topic and compile the report in standard format and present in front of Panel of Examiners.

Seminar assessment should be based on following points:

- Quality of Literature survey and Novelty in the topic.
- Relevance to the specialization
- Understanding of the topic
- Quality of Written and Oral Presentation

Important Notes

- Assessment of Seminar will be carried out by a pair of Internal and External examiner
- Literature survey in case of seminar is based on the broader area of interest in recent developments and for dissertation it should be focused mainly on identified problem.
- At least 4-5 hours of course on Research Methodology should be conducted which includes Literature Survey, Problems Identification, Analysis and Interpretation of Results and Technical Paper Writing in the beginning of second Semester.

EPS 601 Power System Reliability (3 Credits)

Course Objectives

- To impart the reliability concepts and method of estimating the system reliability of simple and complex systems.
- To use reliability theory as a tool for decision support for design, operation and planning of electric power system.

Course Contents

Unit I: Review of Probability and Probability Distribution **4 hours**

Probability: Standard definitions and concepts; Conditional Probability, Baye‘s theorem. Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance, Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness and Kurtosis.

Unit II: Concept of Reliability **6 hours**

Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve. Hazard rate, Failure density, Failure Rate, Mean Time to Failure (MTTF), MTBF, Schedule outage, Forced outage rate Reliability Functions. Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate.

Unit III: Reliability Evaluation of Simple and Complex System **9 hours**

Network modeling, Simple system: series and parallel system, Complex system: Conditional probability approach, Cut set method, Tie set method, Matrix method and Event tree method, Fault tree method.

Unit IV: Reliability Evaluation using Probability Distribution **6 hours**

Reliability Evaluation using Exponential, Normal and Poisson Distribution, Determination of MTTF and MTBF of time dependent system.

Unit V: Markov Model **10 hours**

Discrete Markov Chain, Continuous Markov Process, State Space Diagrams, Time Dependent State Probabilities, Limiting State Probabilities, State space modeling Frequency Balance Approach for State Probability.

Unit VI: Generation and Distribution Systems Reliability **10 hours**

Generation system model, Capacity outage probability table, Reliability indices using loss of load probability, Technique to evaluate LOLP, LOLE, LOEE and other reliability indices. Evaluation technique, Customer oriented indices, Load point and energy-oriented indices.

References

1. Roy Billinton and Ronald N. Allan, “Reliability Evaluation of Engineering Systems”, Second Edition, Plenum Press 1996.

2. R. Marvin and H. Arnljot “System Reliability Theory: Models, Statistical Methods, and Applications”, Second Edition.
3. E.E. Lewis “Introduction to Reliability Engineering” Second edition.
4. Department of Mechanical Engineering Northwestern University Evanston, Illinois 1994.
5. J. Endrenyi, “Reliability Modelling in Electric Power Systems”, John Wiley & Sons, NY. 1979.

EPS 602 Engineering Project Planning and Management (3 Credits)

Course Objectives

- To describe the process involved in each phase of the project management life cycle.
- To apply project management tools, procedures, techniques, and skills for successful completion of the project.
- To create a Work Breakdown Structure (WBS) and a Project Management Plan.
- To apply project monitoring and control tools for cost, time and quality control of project.
- To apply project appraisal and evaluation techniques to determine the viability of projects.

Course Contents

Unit I: Project Management Concepts, Body and Organization Structure 4 hours
Project Management Concepts and Definitions, Functions of Management, Project Life Cycle Phases, Project Objectives, Resource Requirements, Organizational Structure, Functional Organization, Matrix Organization, Organizational Structure Influences, Communication, Leadership, Project Management Office, Drivers of Project Success.

Unit II: Project Planning and Scheduling 4 hours
Deliverables Sequencing, Developing Schedules and Resource Requirements, WBS – Work Breakdown Structure, Gantt/Bar chart & its Limitations, Network Planning, Network analysis, Critical path and type of Floats, PERT Analysis.

Unit III: Budgeting and Cost Estimating 4 hours
Cost of project, Cost Estimating Tools, Types of Cost Estimates, Estimating Process and Accuracy, Cost Budgeting, Cost Aggregation, Deriving Budget from Cost Activity.

Unit IV: Project Appraisal and Investment Evaluation Criteria 11 hours
Types of Appraisals, Cost and Benefits of Projects, Economic and Financial Analysis, Elements of Cash Flow, Cost Benefit Analysis, Preparation of Incremental Cash Flow, Evaluation Techniques, Discounting Criteria such as NPV, modified NPV, IRR, Benefit- Cost ratio); Non-Discounting Criteria such as Urgency, Payback period, ARR), Assessment of various methods.

Unit IV: Financing of Infrastructure Projects 2 hours
Capital Structure, Menu of Financing, Financial Structure, Public and Private Project Financing.

Unit V: Project Risk and Uncertainty 2 hours
Project Risk and Origin, Risk Identification, Risk Management Plan, Qualitative and Quantitative Risk Analysis Process, Resolution of Risk, Risk Monitoring and Control Process.

Unit VI: Project Monitoring and Control 10 hours
Quality theories, Project Quality Requirements, Quality Management Plan, QAP, Quality Control Process, Testing of Electrical Equipment and Plants, Cost Control Process and Methods, Resource Smoothening and Levelling, Resource Optimization, Project Monitoring Methods and Charts, Earned Value Analysis, Project Management Software.

Unit VII: Project Evaluation and Termination ***2* hours**

Evaluation of Success against Objectives, Closure of Project Financial Accounts, Documentation of Project Summary, Lessons Learned.

Unit VIII: Case Studies **6 hours**

One case study each on Hydropower/generation projects, transmission line projects and rural electrification.

References

1. Project Management Institute Inc., A Guide to the Project Management Body of Knowledge (PMBOK Guide)".
2. Rory Burke, **"**Fundamentals of Project Management".
3. Prasanna Chandra, "Projects Planning, Analysis, Selection, Financing, Implementation and Review".

EPS 603 Project (2 Credits)

Course Description

The project work is introduced in 3rd semester in M.Sc. Program in electrical power system engineering and it is the integral part of M.Sc. dissertation. This will be the individual work of the students. In this component of the M.Sc. Dissertation students should do literature survey and identify the problem/research gap for Dissertation and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem. As a outcome of this course student shall defend their proposal for the dissertation

Key Notes

Project work should be assessed based on following points

- Quality of Literature survey and Novelty in the problem
- Clarity of Problem definition and Feasibility of problem solution
- Relevance to the specialization
- Clarity of objective and scope

Project works should be assessed through a presentation/ viva by a panel of Internal and external examiners by appointed by the Head of the Department/Institute of respective Program.

EPS 691 Dissertation (15 credits)

In Dissertation, the student shall implement the proposal defended in project works. Dissertation will consist of simulation, fabrication of set up required for the project, work station, experiments and results, analysis, validation of results, conclusions and dissertation writing. The students are allowed to take part in final defense only after completing core and elective courses.

Keynotes

Mid Term /Final Defense of the Dissertation should be assessed through a presentation jointly by Internal and External Examiners appointed by the Faculty of the science and technology. Midterm /Final Defense of the Dissertation should be assessed based on following criteria

- Quality of Literature survey and Novelty in the problem
- Clarity of Problem definition and Feasibility of problem solution
- Relevance to the specialization or current Research / Industrial trends
- Clarity of objective and scope
- Quality of work attempted
- Validation of results
- Quality of Written and Oral Presentation

Students should publish at least one paper based on the work in reputed International/ National Conference / Refereed Journal.