Africa Centre of Excellence for Sustainable Power and Energy Development (ACE-SPED)

University of Nigeria, Nsukka

Curriculum for Masters of Engineering (M.Eng)/Masters of Science (M.Sc) Programme in

Power Systems and High Voltage Engineering

Hosted in Collaboration with the Department of Electrical Engineering

April 2020

1. COURSE CODES, TITLES AND CREDIT HOURS

First Semester

Course No		Title	Credit Hours
EEE	601	Advanced Methods of Analysis in Electrical Engineering	3
PGC	601	Research Methodology and ICT in Engineering	3
EEE	612	Advanced Semiconductor Power Circuits	3
EEE	611	Theory and Modeling of Electrical Machines	3
EEE	621	Power System Analysis	3
EEE	631	Advanced Theory of Control Systems	3

Second Semester

EEE	628	High Voltage Engineering	3
EEE	625	Economic Operation of Power System	3
EEE	623	Power System Planning and Optimization	3
EEE	622	Power System Control and Protection I	3
EEE	602	Masters Seminar	3
EEE	651	M. Eng. Project Report	6

ELECTIVE COURSES (ADDITIONAL COURSES MAY BE RECOMMENDED FROM HERE BASED ON THE DISCRETION OF SUPERVISORS)

First Semester

Course No		Title	Credit Hours
EEE	624	Power System Distribution I	3
EEE	635	Non-Linear and Time Varying Control Systems	3
EEE	626	Power System Dynamics I	3
EEE	627	DC Transmission	3

Second Semester

EEE	619	Special Applications of Electromagnetic Fields	3
EEE	634	Discrete Time Control Systems	3
EEE	633	Introduction to Stochastic Control	3
EEE	637	Special Topics in Control System Design	3

2. COURSE DESCRIPTIONS

EEE 601: Advanced Methods of Analysis in Electrical Engineering (3 Credit Hours)
Review of Matrices. Time domain and transfer techniques for linear continuous and discrete time systems. State variable methods. State transition matrix for time-invariant and time varying continuous and discrete systems. Adjoint Systems. Singularity functions and superposition integrals for linear systems. Fourier, Laplace, Z-transform and generalized transform techniques. Introduction to controllability,

observability, and stability. Distributed parameter system analysis. Transfer function, integral equation representation, and state model for selected control systems. Selected numerical analysis methods and applications

PGC 601: Research Methodology and ICT in Engineering (3 Credit Hours)
Use of advanced analytical tools like MATLAB/SIMULINK, SCILAB/XCOS, etc. for solution of engineering problems and their applications (Application of these soft wares depends on the various problems formulated in different departments). Information literacy, information sources (media, publishers, aggregators); validity of information, plagiarism and legal aspects. Information search – search engines, journal repositories, academic (social) networks, search strategies, personal contacts, tools for managing references. Integrating information literacy in research, cloud computing, audiovisual tools, e.g PowerPoint presentations. Literature review: Reading and summarizing relevant articles, critical analysis and evaluation of research, identification of themes and comparators, writing review documents and identification of research (or knowledge) gaps. Scientific method and nature of evidence: Experimental methods and design methods (as may be applicable to individual departments and research areas), data collection and management of quantitative data. Human participants – expert reviews, focus groups, questionnaires and interviews. Project management and report writing: project planning, report structure and style, general report writing techniques.

EEE 611: Theory & Modeling of Electrical Machines (3 Credit Hours)
Equivalent circuits of complex magnetic systems, transformer frequency-dependent equivalent circuits, inrush currents, DQ representation of AC. Machines (induction machines, synchronous machines, reluctance machines etc.) AC machine dynamics using dq models. Special characteristic features of dc and ac machines.

EEE 612: Advanced Semiconductor Power Circuits (3 Credit Hours)
Two pulse, six pulse, twelve pulse and twenty-four pulse rectifier circuits. Fixed and variable frequency AC controllers. DC to DC step-up or step-down converters. Adjustable voltage adjustable frequency inverters. Pulse-width modulated inverters. Current-fed inverters. Elimination of undesired harmonics in power converters

EEE 613: Electro-Heating Processes (3 Credit Hours)
Resistance heating. Three-phase and two-phase electrode arc furnaces. Types of induction heating furnaces. Frequency selection in induction heating power supplies: mains frequency, mains frequency triplers, motor generator sets and variable frequency inverters and cyclo-inverters.

EEE 614: Electric Drives (3 Credit Hours)
Rectifier-fed DC motors. Chopper-fed DC motors. Design and applications of DC drives. Classification, analysis and control of AC drives. Design and applications of AC drives. Microprocessors in industrial drives.

EEE 615: Special Topics in Electrical Machines (3 Credit Hours)
Some special transformation devices such as instrument transformers, direct current transducers and saturable reactors. Permanent magnet dc motors. Synchros. Linear induction motors. Iron-cored and air-cored linear synchronous motors. Variable reluctance and permanent magnet stepping motors. Field pattern plotting methods in electrical machines.

EEE 616: Logic Control Circuits in Power Engineering (3 Credit Hours)
Digital logic families, linear integrated circuit components, small signal discrete components and their main specifications. Common transducers, Microprocessor programmed logic. Design of firing/gating logic circuits for controlled rectifiers, inverters, choppers and cycloconverters. Design of voltage, current, power and frequency regulation circuits for motor drives and power supplies. Microprocessor-based logic control methods.

EEE 617: Electromagnetic Field Analysis (3 Credit Hours)
Review of Vector arithmetic, vector algebra and vector calculus. Electric field calculations. Energy and potential due to distributed and line charges. Conductor and dielectric properties and boundary conditions. Experimental field mapping methods. Poisons and Laplace equations. The steady magnetic field, magnetic forces materials and inductance. Time varying fields and Maxwell's equations. The Poynting vector and power considerations. Field propagation in good conductors and skin effect. Use of field equations in determining transmission line parameters.

EEE 618: Advanced Electric Machine Design (3 Credit Hours)
Magnetic Core Material types, characteristics and applications; M insulation types and applications; Electric machine cooling methods. Elements of inductor design and construction; Transformer design and construction. DC and AC machine design techniques.

EEE 619: Special Applications of Electromagnetic Fields (3 Credit Hours)
Computer aided steady state and transient solutions of selected field problems in induction devices. Electric induction pumps. Methods of Electromagnetic stirring. transportation and pouring of molten metals for continuous casting. Levitation principles. Eddy current distribution in and power transferred to a work piece in contactless heating. Metal circulation and induced currents in electrode arc furnaces. Current, force and/or velocity distributions in channel and coreless furnaces.

EEE 621: Power System Analysis (3 Credit Hours)
The Power Flow Problem:- numerical methods for solution of AC and DC models of the power system. Analysis of faulted power systems: balanced and unbalanced faults, Symmetrical Components, Sequence impedances of power system components - transmission lines, synchronous, machines, and transformers; series and shunt faults,

simultaneous faults. Power System Stability:- Analysis of steady-state stability of simple and complex power systems.

EEE 622: Power System Control and Protection (3 Credit Hours)

Relay principles and types, instrumentation for system parameters, relay characteristics, and responses, system component, protection, solid-state relaying, under frequency relays, load shedding, elements of high-power circuit interruption, circuit breakers, types and problems. Power system control principles and communications.

EEE 623: Power System Planning and Optimization (3 Credit Hours)

Power system components functions, application and performance. Relative cost and scaling parameters, over-all planning problem considering present worth and cost-benefit principles, system reliability, load forecasting. Non-linear programming-unconstrained and constrained minimization methods. Lagrange multi-pliers, Kuhn-Tucker conditions, Linear, quadratic and integer programming. Applications of optimization techniques to power systems - e.g. economic dispatch, optimal load shedding, transmission planning etc.

EEE 624: Power System Distribution (3 Credit Hours)

Objectives and basic definitions. Standard specifications of cables, transformers and distribution voltages. Code applications with regards to conductors, protection and equipment. Utility system distribution. Consumer premises distribution. Engineering problems and environmental considerations. Power measurements and billings. Trends for the future.

EEE 625: Economic Operation of Power Systems (3 Credit Hours)

Concepts of economic operation — Unit characteristics and economical operation, transmission loss coefficients, general loss formula, generator scheduling - automatic economic load dispatch, Models for inter-change and for multi-area dispatch, operating security, Resource modeling and hydro-thermal coordination.

EEE 626: Power System Dynamics (3 Credit Hours)

The dynamic characteristics and control requirements of power systems are introduced. Consideration is given to the detailed modeling of synchronous machines and its controls such as excitation systems and turbine-governor; power system loads; load-frequency control; power exchange between networks etc. Time scales and reduced order models; non-linear and linear multi-machine models etc. The modeling and control requirements will be discussed for small and large disturbances as well as voltage stability studies. Methodologies, tools and techniques for performing these studies will be introduced.

EEE 627: DC Transmission (3 Credit Hours)

Advantages of dc systems; converter bridge circuits and system parameters; compounding and regulation; fault consideration and system protection; application of dc transmission as aneconomic system component, and method of improving a.c. system dynamics.

EEE 628: High Voltage Engineering (3 Credit Hours)

High Voltage generation and measurements: testing transformer set, d.c. multiplier circuits. Impulse generation analysis and testing, safety practices. Dielectric phenomena dielectric loss evaluation, discharge detection and measurement. Elements of high power circuit interruption, circuit and physical phenomena, circuit breakers, types and problems.

EEE 633: Introduction to Stochastic Control (3 Credit Hours)
Stochastic processes – probability theory and random processes. Introduction to the design problem for systems perturbed by random inputs. Minimization of the mean square error, Estimation of system parameters in the presence of noise. Stochastic differential equations, Gaussian, Markov, and Veiner-Levy processed. The matched filter. Introduction to adaptive control.

EEE 634: Discrete Time Control Systems (3 Credit Hours)
Classical analysis and design of sampled data control system; Z-transform, sampling of continuous time functions, data system. State variable formulation of linear and nonlinear discrete time systems. Stability of discrete time systems, Application of Lyapunov's second method. Optimal control of discrete systems, Discrete time maximum principle; sensitivity. Computer solutions.

EEE 635: Theory of Non-Linear and Time Varying Systems (3 Credit Hours)
Analysis of periodic linear time-varying systems - Floquet Theory. Analysis of nonlinear conservative systems. Lyapunov stability theorems. The Aizerman problem. Frequency domain stability criteria. Popov's criteria, sustained oscillation; graphical methods by Lienard and Vander-Pol; limit cycles. Optimization of non-linear systems. Controllability and observability. Synthesis of sub-optimal controllers by means of Lyapunov's functions.

EEE 637: Special Topics in Control System Design (3 Credit Hours)
Transducer Types, characteristics and applications, position, speed; flow rate pressure, and temperature control methods and applications. Computer aided optimization techniques for the transient response of classical and modem feedback control techniques.