



DOCTOR OF PHILOSOPHY PROGRAM IN ELECTRICAL ENGINEERING

■ FACULTY OF ENGINEERING

DOCTOR OF PHILOSOPHY PROGRAM IN ELECTRICAL ENGINEERING

The Electrical Engineering Doctoral program offers a unique opportunity for the training of graduate students toward the completion of the Ph.D. in Electrical Engineering.

Our focal point covers the areas of power electronics engineering, electronics and embedded systems, control system and signal processing, communications electrical engineering, and rehabilitation engineering.

Graduate students are welcomed to have hands-on experiences in our thriving research centers, namely, Analysis and Development of Electric Drives System, Advanced Systems and Software Engineering Research Team: ASSERT, Embedded System and Smart Device Research Unit: ESSDRU, Device Lab and Computer Vision and Human Interaction Technologies Laboratories: Vision Lab.



Objectives

Upon graduation, candidates are to demonstrate the following qualifications.

- Outstanding in academic abilities, especially in implementation of research findings within the field of Electrical Engineering.
- Possessing an active inquiry mind to conduct advanced research in Electrical Engineering.
- Dynamic self-development to keep up to date with the rapid advancement of innovations in the field.

Admission

In accordance with the Graduate School Rules and Regulations. The program committee reserves the rights to require more qualifications as deemed appropriate.

Medium of Instruction

Thai and English

Research Focus

Power Electrical Engineering

- Distribution generation
- Energy conservation
- Energy-economy-environmental modeling
- Energy and environmental economics
- Energy efficiency and policy
- Efficient energy conversion
- Electrical machines analysis

- Energy planning and policy
- Finite element analysis
- Integrated climate-land-energy-water (CLEW) modeling
- Machine design
- Power electronics
- Power quality in distribution network
- Photovoltaic systems
- Power system modeling and analysis
- Renewable energy
- Rural electrification
- Storage batteries
- Smart Grid

Electronics and Embedded Systems

- Electronic circuits and systems
- Electrical and optical properties of semiconductor nanostructures
- Theoretical and numerical study on properties of various optical resonators, e.g. ring resonator, photonic crystals using finite-difference time-domain (FDTD) method

Control System and Signal Processing

- Artificial intelligent control
- Adaptive signal processing
- Automatic visual inspection technology
- Biomedical image processing
- Complex analysis
- Computational intelligence
- Control theory
- Data compression

- Digital image processing
- Laser electro photography
- Iterative learning control
- Intelligent systems
- Math finance for real analysis and stochastic processes with assets in the market
- Medical image processing
- Machine learning
- Multidimensional linear systems
- Mobile media recognition and retrieval
- Mobile robot navigation techniques
- Multimedia signal processing
- Neural networks
- Optimization and approximation
- Operator theory
- Robotics
- Robust and adaptive control
- Repetitive control
- Rehabilitation engineering
- Robotics and mechatronics
- Signal analysis

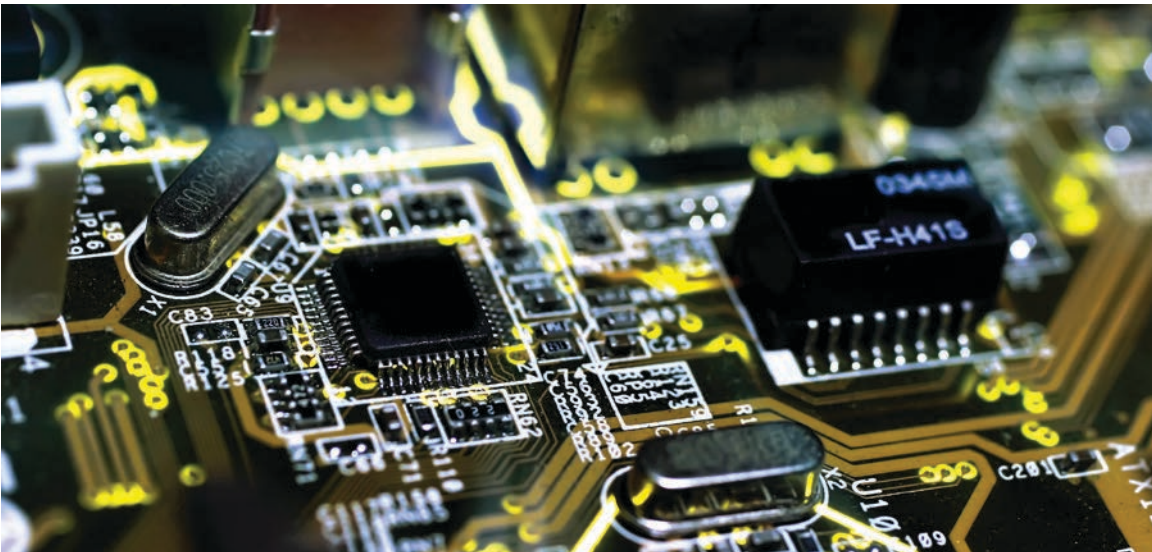
Communications Electrical Engineering

- Cellular and wireless communications
- Coding theory
- Computational electromagnetic
- Coding theory
- Computational electromagnetic
- Detection theory
- Dielectric antennas

- Finite element analysis
- Networking
- Optical communications
- Satellite communications
- Stochastic signals and systems

Requirement for Graduation

In accordance with the Graduate School Rules and Regulations.



Requirements	Option 2.1		Option 2.2	
	Course No.	Credits	Course No.	Credits
Optimization Theory and Its Applications	-	-	303552	3
Signal Processing	-	-	303561	3
Stochastic Signals and Systems 1	-	-	303571	3
Information Theory	-	-	303580	3
Electromagnetic Theory	-	-	303581	3
Total	1	3	13	≥12

3. Electives

Requirements	Option 2.1		Option 2.2	
	Course No.	Credits	Course No.	Credits
Organization and Finance of a Power Utility	-	-	303514	3
Optimization and Its Applications in Power Systems	-	-	303515	3
Advanced High Voltage Technology	-	-	303516	3
Electricity Economics and Planning	-	-	303517	3
Power System Dynamics and Stability	-	-	303518	3
Power Quality	-	-	303519	3
Advanced Energy Technology	-	-	303521	3
Electrical Machine Design	-	-	303522	3
Photovoltaic Systems Engineering	-	-	303523	3
Analysis of DC Power Converter Characteristics	-	-	303524	3
Electrical machine dynamics	303611	3	303611	3
Analysis and Model Synthesis for Photovoltaic Systems	303612	3	303612	3
Energy Policy and Planning Project	303621	3	303621	3
Methods for Energy Analysis	303622	3	303622	3
Energy Price Theory and Applications	303623	3	303623	3

Requirements	Option 2.1		Option 2.2	
	Course No.	Credits	Course No.	Credits
Advanced Network Synthesis and Design	-	-	303541	3
Real-Time System Programming	-	-	303542	3
Opto-Electronics	-	-	303543	3
Biomedical Electronics	-	-	303544	3
Mixed Signal System Design and Implementation	303631	3	303631	3
Advanced Biomedical Electronics	303632	3	303632	3
Radio-Frequency Circuit Design and CAD	303641	3	303641	3
Serial Communication Architectures of Electronic Circuits	303642	3	303642	3
Neural Network and Fuzzy Logic Control	-	-	303553	3
Optimal Control Systems	-	-	303554	3
Robust Control	-	-	303555	3
Image Processing	-	-	303562	3
Computer Vision	-	-	303563	3
Filter Design	-	-	303564	3
Mechatronics and Robotics Systems	-	-	303565	3
Wavelets	-	-	303566	3
Machine Learning Theory	-	-	303567	3
System Identification and Learning Theory	303651	3	303651	3
Iterative Learning Control	303652	3	303652	3
Nonlinear systems and adaptive control	303653	3	303653	3
Random Processes	303661	3	303661	3
Detection and Estimation Theory	303662	3	303662	3
Stochastic Signals and Systems 1	-	-	303571	3
Stochastic Signals and Systems 2	-	-	303572	3
Theory of Optical Fibers and Optical Communications	-	-	303573	3

Requirements	Option 2.1		Option 2.2	
	Course No.	Credits	Course No.	Credits
Communication System Design	-	-	303574	3
Microwave Circuits: Theory and Techniques	-	-	303575	3
Radio Wave Propagation	-	-	303576	3
Cellular Radio and Wireless Communications	-	-	303577	3
Advanced Digital System Communications	-	-	303578	3
Finite Element Method for Electrical Engineering	-	-	303582	3
Numerical Methods in Electromagnetics	-	-	303583	3
Queueing Theory and Applications	-	-	303584	3
Coding Theory	-	-	303585	3
Antenna Theory	-	-	303586	3
Spectral Estimation and Modeling	303671	3	303671	3
Radar System Analysis and Design	303672	3	303672	3
Spread Spectrum Communications	303673	3	303673	3
Optical Networks	303681	3	303681	3
Finite Element Method for Electromagnetics	303682	3	303682	3
Antenna Analysis and Design	303683	3	303683	3
Total	20	≥9	56	≥12

4. Required Non-credit Courses.

Requirements	Option 2.1		Option 2.2	
	Course No.	Credits	Course No.	Credits
Research Methodology in Science and Technology	-	-	303592	3
Seminar 1	-	-	303691	1
Seminar 2	303692	1	303692	1
Seminar 3	303693	1	303693	1

Requirements	Option 2.1		Option 2.2	
	Course No.	Credits	Course No.	Credits
Seminar 4	303694	1	303694	1
Total	3	3	5	7

5. Dissertation Credit Requirements.

Requirements	Option 2.1		Option 2.2	
	Course No.	Credits	Course No.	Credits
Dissertation 1	303695	6	303791	6
Dissertation 2	303696	6	303792	6
Dissertation 3	303697	6	303793	9
Dissertation 4	303698	9	303794	9
Dissertation 5	303699	9	303795	9
Dissertation 6	-	-	303796	9
Total	5	36	6	48

Course Descriptions

303511 Power System Operation and Control

3(2-2-5)

Modeling of power system components and load flow analysis of AC/DC systems; development of methods to analyse and design systems for steady state, transient, and dynamic conditions; state estimation; contingency analysis; load frequency control and automatic generation control; load flow analysis; computer-aided systems monitoring and communication; and computer laboratory session on the use of application software and sample study.

303512 Theory of Electrical Machines

3(3-0-6)

Complexor, phasor' flux linkage units; electromagnetic circuits and transformers; energy conversion; single excite and double excite; fundamentals of electric machinery; analysis and design; mathematical models of DC machines and fault detection; 3 phase transformers; 3 phase synchronous machines; 3 phase induction machines; 1 phase motors; transients on transmission lines, transformers, and machines; arcing and re-striking phenomena; and lightning arresters and insulation coordination.

303513 Energy Conversion Systems

3(3-0-6)

Characteristics and application of power switches,; various DC-DC, AC-DC, DC-AC, and AC-AC converter circuit topologies and their control techniques; total harmonic distortion and power electronic system protection; and application to uninterruptable power supplies, automobiles, computer systems, telecommunications, and industrial processes.

303514 Organisation and Finance of a Power Utility 3(3-0-6)

Policy and objectives of a power utility, electricity sector restructuring rationale models and frameworks, electricity sector privatization, electricity sector productivity, electricity market, management and account information, investment and finance, customer classification, electricity tariffs, and environmental constraints.

303515 Optimisation and its Applications in Power Systems 3(2-2-5)

A study of the following topics: the realm and concepts of optimization techniques for power systems, real time control of power systems, optimal power dispatch, unit commitment, AI applications, and computer laboratory session on the use of application software and sample study.

303516 Advanced High Voltage Technology 3(3-0-6)

The properties of dielectric materials and the basic concepts of atomic collision theory, ionization and uniform field breakdown in gases, single collisions or beam experiments, time lags of breakdown, calibration of apparatus, insulations and their applications, construction and performance of high voltage equipment, capacitance and dielectric losses measurement, and design and layout of high voltage power systems.

303517 Electricity Economics and Planning 3(3-0-6)

The nature of electricity planning, economic and technological dimensions of power systems, power supply requirements, electricity demand forecasting, generation planning and production costing, investment planning, electricity pricing, demand-side management and environmental management policies and their implications.

303518 Power System Dynamics and Stability 3(3-0-6)

Definitions and classifications, dynamic modeling of various power system components, transient stability analysis, small signal stability analysis, methods of improvement; power system stabilizers, sub-synchronous resonance, and voltage stability static and dynamic analysis.

303519 Power Quality**3(3-0-6)**

Power supply requirements; load growth and load shed; protection devices and their coordination; power quality requirements and their control; system reliability and security concepts; planning system security and reliability for normal, abnormal, and emergency conditions; strategies to improve reliability and security; and dispersed generations (DG)-installing and interfacing to the distribution grid.

303521 Advanced Energy Technology**3(3-0-6)**

Electrical power supply technology capabilities energy resources fossil and renewable energy energy consumption; environmental impacts, energy conversion–physical fundamentals, processes, and efficiencies; 3 phase AC drive technology; 3 phase machines; operating performance of synchronous generators; storage devices used in alternate energy systems; and electrical grid connection and controls between power plants and power.

303522 Electrical Machine Design**3(2-2-5)**

A study of the following topics: the design of electromagnetic rotating machines, the relationships between dimensions and rating of machines, an introduction to the optimal principles and techniques of winding design, developing techniques for the design of permanent magnet machines, and calculating representative winding reactance.

303523 Photovoltaic Systems Engineering**3(3-0-6)**

Operating principles of solar cells, characteristics curves of solar cells, mathematical models of solar cells, the effects of irradiance and temperature on solar cells, maximum power point tracking approaches, configurations of photovoltaic systems, and applications of power electronics in photovoltaic systems.

303524 Analysis of DC Power Converter Characteristics**3(3-0-6)**

DC power converter topologies, state-space models, state-space averaging technique, small signal analysis of DC power converters, transfer functions of DC power converters, and transient and steady-state responses of DC power converters.

303531 Microprocessor Based System Design**3(2-2-5)**

Microprocessor simulation of digital logic and real-time devices, design concepts, device hardware and software configurations, transducers and interfaces, efficient programming, high level language for control, design aids, and multiprocessing systems.

303532 Advanced Electronic Circuit Design**3(2-2-5)**

Analysis and design of analogue integrated circuits; constant current circuits; differential amplifiers; the effects of non-ideal characteristics of an operational amplifier, linear, and nonlinear applications of operational amplifiers, such as active filters, comparators, and multipliers; the design of various amplifiers; power supplies and regulators; phase-locked loop; waveform generators; computer aided analysis and design in electronic circuits; and the role of computers in the design process-tools and techniques.

303533 Noise Reduction Techniques**3(2-2-5)**

The theory and practice of E.M. noise coupling; techniques for noise reduction– shielding, grounding, and filtering; the measurement of EMI to comply with government regulations; EMI problems and solutions in switching power supply applications; and the design of EMI filter.

303541 Advanced Network Synthesis and Design**3(2-2-5)**

A study of the following topics: positive real and bounded real concepts, synthesis of two-element kind lumped networks, scattering description, synthesis of RLC impedances, approximation method for lumped filters, synthesis of microwave filters, synthesis of switched-capacitor networks, and design techniques for active RC filters modeled on classical structures.

303542 Real-Time Programming**3(2-2-5)**

An introduction to real-time systems, real-time system engineering, reliability, concurrency and concurrent programming, real-time scheduling, examples in real-time operating systems, interfacing with real-time hardware, and case studies.

303543 Opto-Electrics**3(3-0-6)**

Units and definitions used in light measurement, wave guide theories, wave propagation in a wave guide, light sources, semi-conductor sensors for light detection, noises in optoelectronic devices, light applications and electronic circuits, e.g., communication systems via light waves.

303544 Biomedical Electronics**3(2-2-5)**

Specifications of biomedical sensors and instrumentation, sensor/transducer characteristics and mathematical models, the effect of conditioning circuits on biomedical measurement, noise and errors, theory of positive and negative feedback around amplifier and frequency limits, signal preconditioning, instrumentation amplifier, A/D conversion, use of microcontrollers in bioengineering, instrumentation for the analysis of human blood, cardiology and instrumentation, ultrasonic diagnosis, ultrasound and blood flow measurement, and electrode and biosensors/chemosensors.

303551 Fundamentals of Control Theory**3(3-0-6)**

Space-state control with basic properties, state feedback, state observer design, output feedback, linear quadratic regulator (LQR) control, Kalman filter, linear quadratic Gaussian (LQG) control, tracking problems and disturbance rejection problems, and integral control design.

303552 Optimisation Theory and its Applications**3(3-0-6)**

Fundamentals of optimization theory, multi variable optimization with/without constraints, optimization with special techniques, and applications in signal processing and control systems.

303553 Neural Network and Fuzzy Logic Control**3(2-2-5)**

A study of the following: various structures of artificial neural networks and fuzzy logic systems as well as special learning mechanisms; fuzzy controller design; applications to classification problems, binary associative memories, self-organising maps, and non-linear modeling and control; and stability adaptive neuro-fuzzy control systems, parameters, and structure learning in neuro-fuzzy systems.

303554 Optimal Control Systems**3(2-2-5)**

Applications of dynamic programming and the calculus of variations to optimal control problems, the Pontryagin maximum principle, Hamilton-Jacobi theory and its applications, time-optimal control system design, fuel-optimal control system design, linear system design using quadratic criteria, and computational methods in optimal control systems.

303555 Robust Control**3(2-2-5)**

Linear systems theory, internal stability, modeling of uncertain systems, structured and unstructured uncertainties, linear fractional transformation (LFT), small gain theory, bounded real lemma, robust stability and robust performance, μ analysis and synthesis, Riccati equations, and LQR control: H_2 and H_∞ controller design: H_∞ loop-shaping design.

303561 Signal Processing

3(2-2-5)

The characterisation and classification of signals and systems, signal and system analysis in time-domains and frequency-domains, and continuous-time signal processing by discrete-time systems.

303562 Image Processing

3(2-2-5)

The theory of image and two-dimensional linear systems in time-domains and frequency-domains, edge detection, image enhancement, image restoration and estimation, image reconstruction, and image compression.

303563 Computer Vision

3(2-2-5)

The fundamentals of computer vision, techniques for image understanding and high-level image processing, image segmentation, geometric structures, relational structures, motion, matching, inference, vision systems, and object recognition.

303564 Filter Design

3(3-0-6)

Digital filter structures, techniques of digital filter design, approximation theory, design of linear and non-linear discrete-time systems, and applications in signal processing and control systems.

303565 Mechatronics and Robotics Systems

3(2-2-5)

Kinematic analysis and coordinate transformation, forces, movements and Euler's laws, sensors and actuators, electronic devices and measurements, some fundamentals in image processing, trajectory interpolation and control, rigid motion and homogenous transformations, forward and reverse kinematics, velocity kinematics, dynamics and control, non-linear trajectory control, feedback control, joint controllers, and motion planning.

303566 Wavelets**3(3-0-6)**

The fundamentals of wavelets, wavelet filters, discrete wavelet transform, synthesis and analysis of wavelet systems, and applications in signal processing and control systems.

303567 Machine Learning Theory**3(3-0-6)**

Types of machine learning, linear discriminants, neural networks, multi-layer perceptron and radial basis functions, support vector machines, decision trees, learning in probabilistics, Bayes classifier, unsupervised learning, dimensional reduction, and least-square optimization.

303571 Stochastic Signals and Systems 1**3(3-0-6)**

Random variables and stochastic processes, probability distribution and probability density functions, stationary and non-stationary random processes, white and colour noises, analysis of random signals, power and spectral density, and time and frequency response of linear systems to random signals using both classical transforms.

303572 Stochastic Signals and Systems 2**3(3-0-6)**

Direction and estimation theory, smoothing theory, Wiener filters, discrete-time Kalman filters, maximum likelihood method, continuous-time stochastic dynamical systems, linear stochastic differential equations, stationary Gauss-Markov process, and modeling of stochastic dynamical systems.

303573 Theory of Optical Fibres and Optical Communications**3(3-0-6)**

Ray propagation and impulse response in step index multimode fibres, ray propagation, light propagation and bandwidth in step-index single mode fibres, graded-index single mode fibres, bending and micro bending losses in fibres, launching efficiencies in multimode and single mode fibres, power budgets and dispersion budgets in fibre systems, and optical fibre components.

303574 Communication Systems Design**3(2-2-5)**

Physical concepts in communications systems, carrier-to-noise ratio in communication systems; noise processes, polarisation topics, atmospheric propagation, receiver components, antennas; system calculations, and case studies.

303575 Microwave Circuits: Theory and Techniques**3(3-0-6)**

Transmission line theory, the Smith chart and matching networks, the measurement and use of scattering parameters, passive component design for micro-strip circuits, noise properties of two-port networks, the characterization and use of microwave transistors and diodes, and microwave subsystems.

303576 Radio Wave Propagation**3(3-0-6)**

A study of the following topics: antennas located over a flat earth, antennas located over a spherical earth, the field in the diffraction zone, midpath-obstacle diffraction loss, surface-wave propagation, ionospheric propagation, microwave and millimetre-wave propagation, scattering by rain, tropospheric scatter propagation, and extremely low to low frequency propagation.

303577 Cellular Radio and Wireless Communications**3(2-2-5)**

Modern communication systems, cellular mobile communication systems, theory and design of high capacity wireless communication systems, radio propagation-loss model, mobile fading channels, modulation and coding in mobile communication systems, equalization and channel diversity, and concepts of spread spectrum (SS) communication.

303578 Advanced Digital System Communication**3(2-2-5)**

The theory, design, and analysis of modern digital communication systems; representation of signals in digital form and optimal non-uniform quantisation; design and analysis of digital modulation formats and receivers using signal-space techniques; combining error correction techniques with digital modulation; viterbi algorithm for maximum likelihood sequence estimation; and design and analysis of spread-spectrum communication systems.

303580 Information Theory**3(3-0-6)**

The transmission of information over noisy channels, measures of information and transmission channel capacity, use of codes to improve the reliability of transmission, mathematical theories of information, transmission at rates above channel capacity, linear codes, error detecting and code correction, and Hamming codes.

303581 Electromagnetic Theory**3(3-0-6)**

A study of the following: time-varying and time-harmonic electromagnetic fields, electrical properties of matter, wave equation and its solution, wave propagation and polarization, reflection and transmission, auxiliary vector potentials, electromagnetic theories and principles, rectangular cross-section wave guides and cavities, and cross-section wave guides and cavities.

303582 Finite Element Method for Electrical Engineering**3(3-0-6)**

Boundary values problems, electromagnetic problems, the variational method, the method of weighted residuals, one-dimensional analysis, two dimensional analysis, three dimensional analysis, eigenvalue problems, and vector finite element method.

303583 Numerical Methods in Electromagnetics**3(2-2-5)**

The principles of electromagnetic fields, computational methods in electromagnetic, the finite difference method, the variation method, the method of weighted residuals, the finite element method, and the boundary element method.

303584 Queuing Theory and its Applications**3(3-0-6)**

Systems of flows, a study of some important random processes, birth date queuing systems, Markovian queuing systems, queuing systems with general service distribution, and priority queuing.

303585 Coding Theory**3(3-0-6)**

The use of codes to improve the reliability of transmission over noisy channels, algebraic structure of codes including error detection and code correction, BCH codes, Reed Solomon codes, convolution codes, and codes for checking arithmetic operations.

303586 Antenna Theory**3(3-0-6)**

A study of the fundamental parameters of antennas, radiation integrals and auxiliary potential functions, linear wire antennas, loop antennas, arrays, antenna synthesis and continuous sources, smart antennas, and antenna measurements.

303592 Research Methodology in Science and Technology**3(3-0-6)**

Research definition, characteristics, and goals; types of research and research processes; research problem determination; variables and hypotheses; data collection and analysis; research proposal and report writing; research evaluation; research applications; ethical considerations; and research techniques for science and technology.

303611 Electrical Machine Dynamics**3(2-2-5)**

Mathematical models of DC current, synchronous and induction machines, transient phenomena analysis in individual machines, the effects of self and mutual inductancies in AC machines, and applications of numerical and analytical methods for electrical machines.

303612 Analysis and Model Synthesis for Photovoltaic Systems 3(2-2-5)

Configurations of photovoltaic systems; electrical characteristic analysis of photovoltaic system components, such as solar array, battery, and power converters in transient and steady states; development of mathematical models for photovoltaic system components; and computer based analysis of photovoltaic system components.

303621 Energy Policy and Planning project**3(2-2-5)**

Energy planning, energy policies and economics, government energy policies, economic analysis, energy project identification and development, cost concepts and cost-benefit analysis, project evaluation and decision making, investing in and financing energy projects, and case studies.

303622 Methods of Energy Analysis**3(2-2-5)**

Energy productivity and efficiency analysis, performance benchmarking, regression analysis, econometric models and energy forecasts, energy-economy modeling, energy balances, energy input-output analysis, energy-economy impact models, and the relationships between economic, environmental, and social factors.

303623 Energy Price Theory and its Applications**3(2-2-5)**

Theories of consumers, producers and markets, price elasticity of demand, production and cost functions, pricing of exhaustible and renewable energy resources, energy resource and energy pricing considerations and their implications, and case studies.

303631 Mixed Signal System Design and Implementation 3(2-2-5)

The design and implementation of mixed signal systems using programmable device, a study of programmable device architecture, arithmetic circuits, memory and memory interfacing, circuit implementation using JTAG boundary scan, bus system architecture, analogue to digital conversion methods, the implementation of real systems by using field-programmable gate array (FPGA), and applications in specific integrated circuits (ASIC) or system-on-a-chip (SOC).

303632 Advanced Biomedical Electronics 3(2-2-5)

The theory and design of electronic systems of rehabilitation engineering and assistive technology, literature reviews, and projects for biomedical electronics.

303641 Radio Frequency Circuit Design and CAD 3(2-2-5)

Transistor parameters and the design of amplifiers at high frequency, matching networks, impedance matching with microstrip line and stub, Smith's chart and its use for matching networks and design of amplifiers, bias stability, scattering parameters and its use for oscillator design and stability determining, and CAD for radio frequency circuit design.

303642 Serial Communication Architectures of Electronic Circuits 3(2-2-5)

Embedded system design in programmable devices; a study of serial communication architecture of electronic circuits, such as universal serial bus (USB); controller area networks (CAN); serial advanced technology attachment (SATA) and modern communication technology; discussions and presentations for advantages and drawbacks of interesting serial communications architectures.

303651 System Identification and Learning Theory**3(2-2-5)**

Linear time-invariant and time-varying systems models; parameter estimation methods; convergence and consistency; recursive identification methods; model structure, selection, and model validation; linear discriminants; support vector machines; decision trees; Bayes' classifier; unsupervised learning; dimensionality reduction; and least square optimization.

303652 Iterative Learning Control**3(2-2-5)**

D type iterative learning control (ILC) for dynamic processes, robust optimal design for the first order linear type ILC, analysis of higher order linear type ILC, linear and non-linear ILC design for multiple input and multiple output (MIMO) dynamic systems, non-linear type ILC scheme, monotonic convergence of ILC, and ILC design for iteration-varying models of uncertainty.

303653 Non-Linear Systems and Adaptive Control**3(2-2-5)**

Introduction to non-linear systems with fundamental properties, phase plane analysis, stability analysis, Lyapunov stability and input-output stability, perturbation theory, analysis of feedback systems, Popov criterion, small gain theorem, basics of differential geometry, feedback linearization, geometric non-linear control, non-linear controller design, self-tuning control, model-reference adaptive control, and adaptive predictive control and its applications.

303661 Random Processes**3(2-2-5)**

An introduction to the concepts of random variables, functions of random variables and random processes, study of the spectra properties of random processes and of the response of linear systems to random inputs, introduction to linear mean square estimation, and applications in signal processing and control systems.

303662 Detection and Estimation Theory**3(2-2-5)**

Fundamentals of signal detection and estimation, formulation of maximum likelihood, multidimensional probability theory, signal and noise problems, Kalman filter structure, and applications in signal processing and control systems.

303671 Spectral Estimation and Modeling**3(2-2-5)**

Processing and modeling of discrete-time signals, random time series, autocorrelation and cross-correlation sequences and their generation, filtering of random sequences, Wiener filters, matched filters, modeling assumption errors, one-step predictors, rational modeling of random sequences, and parametric and non-parametric spectral estimation.

303672 Radar System Analysis and Design**3(2-2-5)**

Theory and practice of radar systems used for detection, location, and tracking of targets; the measurement of range and velocity; pulse compression; design of radar transmitters, and receivers and antennas.

303673 Spread Spectrum Communications**3(2-2-5)**

Study of direct sequence and frequency hopping methods, synchronization, resistance to jamming, low probability of detection, spreading codes and their generation, system performance, rake receivers, code division multiple access (CDMA), and cellular CDMA applications.

303681 Optical Networks**3(2-2-5)**

Introduction to optical networks, propagation of signals in optical fibres, components of optical networks, generation of optical networks, broadcast and select networks, wavelength routing, photonic switching, wavelength converters, and single hop and multi-hop networks.

303682 Finite Element Method for Electromagnetics 3(2-2-5)

Variational principles for electromagnetics, eigenvalue problems, vector finite elements, absorbing boundary conditions, finite element-boundary integral methods, finite elements and eigen-function expansion, and finite element analysis in the time domain.

303683 Antenna Analysis and Design 3(2-2-5)

Integral equations, moment method, travelling wave antennas, broadband antennas, horn antennas, microstrip antennas, and reflector antennas antenna design.

303690 Special Topics in Advanced Electrical Engineering 3(2-2-5)

Study and discussion of topics that are relevant and up to date with technological advances in electrical engineering.

303691 Seminar 1 1(0-2-1)

Practicing how to search and analyse data, and giving an oral presentation of research or an article of current interest in electrical engineering.

303692 Seminar 2 1(0-2-1)

Conducting a presentation and discussion of a research topic of interest in theoretical or applied electrical engineering.

303693 Seminar 3 1(0-2-1)

Conducting a presentation and discussion of current research in the field of electrical engineering relevant to the proposed dissertation research.

303694 Seminar 4 1(0-2-1)

Practicing how to write and present research in electrical engineering.

303695 Dissertation 1, Option 2.1 6 Credits

Undertaking a literature review of basic knowledge and research relevant to the topic, creating guidelines, frameworks, and hypotheses for the proposed research, and submitting a summary literature review report and progress report to the program advisor.

303696 Dissertation 2, Option 2.1**6 Credits**

Researching and compiling further information relevant to the research and within the frameworks and guidelines, and submitting a summary research report and progress report to the program advisor.

303697 Dissertation 3, Option 2.1**6 Credits**

Establishing research assumptions, frameworks, and guidelines; preparing a dissertation proposal; and submitting a summary report of the research and progress to the program advisor.

303698 Dissertation 4, Option 2.1**9 Credits**

Reviewing the research, making any improvements or modifications necessary based on expert opinions, writing a research article for publication in a national or international journal, and presenting a summary report of the research and a progress report to the program advisor.

303699 Dissertation 5, Option 2.1**9 Credits**

Writing a final dissertation, passing the dissertation defense, and submitting the dissertation to the Graduate School.

303791 Dissertation 1, Option 2.2**6 Credits**

Conducting a literature review in various databases and research articles on fundamental knowledge on topics of interest and writing a progress report for presentation to the program advisor.

303792 Dissertation 2, Option 2.2**6 Credits**

Conducting further research, compiling further information for the consideration of a dissertation research project, and submitting a summary research report and progress report to the program advisor.

303793 Dissertation 3, Option 2.2**9 Credits**

Setting up research hypotheses and conducting research within the frameworks and guidelines, and submitting a summary report and a progress report to the program committee.

303794 Dissertation 4, Option 2.2**9 Credits**

Conducting research within allocated guidelines and framework; dissertation proposal; summary report of research and dissertation progress report to present to the advisor.

303795 Dissertation 5, Option 2.2**9 Credits**

Conducting a review of the research, writing an article for publication in a national or international journal, making any improvements or modifications to the research results based on expert opinions, and presenting a summary of the dissertation results to the program committee.

303796 Dissertation 6, Option 2.2**9 Credits**

Writing a complete dissertation, passing a dissertation defense, and presenting the dissertation to the Graduate School.