DOKUZ EYLÜL UNIVERSITY

THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

DEPARTMENT OF ELECTRICAL AND ELECRONICS ENGINEERING

Ph.D. QUALIFYING EXAMINATION GUIDEBOOK

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Ph.D. QUALIFYING EXAMINATION RULES AND PROCEDURES

The following summarizes the rules and procedures for the Doctoral Qualifying Examination ("qualifying exam" hereafter) that the Ph.D. students of DEU EEE should abide by when they are preparing for the qualifying exam. These guidelines have been approved by the DEU EEE Ph.D. QUALIFYING COMMITTE.

1- The qualifying exam is given twice a year at the end of the fall and spring semesters.

2- A Ph. D. student must take the Ph.D. qualifying exam by the end of his/her fifth semester. Students who fail the qualifying exam are asked to take the exam again the following semester.

3- Students who are going to take Ph.D. qualifying exam must apply to their advisor for the qualifying exam no later than the end of the related semester in written form indicating their specialization area.

4- Each Ph.D. qualifying exam consists of three sections: Background Subjects (30%), Core Subjects (40%) and Special Subjects (30%).

5- Qualifying exam is held in two parts: Written and oral. In both parts, students are responsible for the background, core, and special subjects of a specialization area.

6- For the written qualifying exam, the Ph.D. pass level is set at 75%.

7- The intent of the oral exam is to determine whether the student knows more EEE knowledge than displayed on the written part. Pass level is 75% for the oral exam also.

8- Ph.D. Qualifying Examination Committee submits their decision on the exam to the Ph.D. Qualifying Committee.

9- Possible results for the exam: Pass, Conditional Pass, or Fail.

10- The final decision on the exam is given by the Ph.D. Qualifying Committee.

11- Detailed information, rules and regulations can be found in code of conduct of DEU FBE. (https://fbe.deu.edu.tr/wp-content/uploads/2021/03/Fbe_Uygulama_Esaslari_.pdf)

The background, core, and special subjects of possible specialization areas including the related courses are given in the following parts of this guidebook. (The content of the questions in the "special subject" part of the qualifying exam is not limited to those listed in the following. The questions might be in other areas depending on the thesis topic of the student. The suitability of the questions is subject to the approval of Ph.D. Qualifying Committee.)

“CIRCUITS AND SYSTEMS” Area for Ph.D. Qualifying Exam

Background Subjects:

Linear Algebra and Differential Equations: Differential equation models, solution techniques for linear, separable and exact equations, modeling examples, stability of equilibrium solutions, numerical methods, matrices, matrix notation of linear systems of algebraic equations, Gaussian elimination, subspaces and bases, determinants, general properties, linear systems with constant coefficients, eigenvalues, eigenvectors and characteristic equation, fundamental set of solutions, fundamental matrices and matrix exponential, nonhomogeneous linear systems, the phase plane, constant coefficient equations, homogeneous and nonhomogeneous equations, linear independence of solutions, characteristic equation, superposition principle, reduction of order, undetermined coefficients, variation of parameters, Laplace transforms and their properties, initial-value problems, delta or impulse function and Heaviside or step function, linearization of a nonlinear system, phase plane analysis and stability.

Circuit Theory: Circuit variables, circuit elements, simple resistive circuits, circuit analysis techniques, operational amplifier, inductance, capacitance and mutual inductance, response of 1st order circuits, response of 2nd order circuits, sinusoidal steady-state analysis, power calculations, 3-phase circuits, circuit analysis in Laplace domain, passive filters, active filters, Fourier series and Fourier transform, two-port circuits.

Signal Processing: Signal classification, continuous-time and discrete-time signals and systems, sampling and reconstruction, Fourier series and Fourier transform, Laplace transform, LTI systems, Z-transform.

Related Courses: EED 2311, EED 2411, EED 1012, EED 2010, EED 1008, MAT 2505, EEE 5503

Core Subjects:

Circuit Theory: Circuit analysis, circuit theorem, passivity, stability, characterization of one-port and multi-port RLCM circuits, synthesis of one-port-two-port LC, RC, and RL circuits, synthesis of one-port RLCM circuits.

System Theory: Dynamical systems, linearization of a nonlinear system, phase plane analysis and stability, controllability, observability, linear system realizations, state feedback design.

Passive, Active and Digital Filters: Active RC filters, infinite impulse response (IIR) and finite impulse response (FIR) digital filters.

Related Courses: EEE 5503, EEE 5502, EEE 5071, EEE 5121, EEE 5069, EEE 5090, EEE 5102

Special Subjects (The content of the questions in the “special subject” part of the qualifying exam is not limited to those listed in the following. The questions might be in other areas depending on the thesis topic of the student. The suitability of the questions is subject to the approval of Ph.D. Qualifying Committee.):

Multiresolution Signal Analysis: Fundamentals of signal decompositions, filter banks, wavelets, algorithms and complexity, subband coding.

Related Course: EEE 5067

System Identification and Modeling: The mathematical foundations of system identification, nonparametric techniques, parameterizations and model structures, parameter estimation, nonlinear modeling of static and dynamic processes using neural networks.

Related Course: EEE 5019

Optimization: Optimization theory, constrained and unconstrained optimization methods, application to systems.

Related Course: EEE 5090

Nonlinear Dynamics and Chaos: Analytical methods of nonlinear systems, Lyapunov methods, Lp stability, reachability and detectability.

Related Course: EEE 5102

Neural Networks and Fuzzy Systems: Fundamental models of neural networks for signal processing, filtering, spectral estimation, signal detection, signal reconstruction, adaptive extraction of principal and minor components, neural networks for system identification, neural networks for signal compression.

Related Courses: EEE 5029, EEE 5030, EEE 5072

“ELECTRONICS” Area for Ph.D. Qualifying Exam

Background Subjects:

Linear Algebra and Differential Equations: Differential equation models, solution techniques for linear, separable and exact equations, modeling examples, stability of equilibrium solutions, numerical methods, matrices, matrix notation of linear systems of algebraic equations, Gaussian elimination, subspaces and bases, determinants, general properties, linear systems with constant coefficients, eigenvalues, eigenvectors and characteristic equation, fundamental set of solutions, fundamental matrices and matrix exponential, nonhomogeneous linear systems, the phase plane, constant coefficient equations, homogeneous and nonhomogeneous equations, linear independence of solutions, characteristic equation, superposition principle, reduction of order, undetermined coefficients, variation of parameters, Laplace transforms and their properties, initial-value problems, delta or impulse function and Heaviside or step function, linearization of a nonlinear system, phase plane analysis and stability.

Circuit Theory: Circuit variables, circuit elements, simple resistive circuits, circuit analysis techniques, operational amplifier, inductance, capacitance and mutual inductance, response of 1st order circuits, response of 2nd order circuits, sinusoidal steady-state analysis, power calculations, 3-phase circuits, circuit analysis in Laplace domain, passive filters, active filters, Fourier series and Fourier transform, two-port circuits.

Signal Processing: Signal classification, continuous-time and discrete-time signals and systems, sampling and reconstruction, Fourier series and Fourier transform, Laplace transform, LTI systems, Z-transform.

Related Courses: EED 2311, EED 2411, EED 1012, EED 2010, EED 1008, MAT 2505, EEE 5503

Core Subjects:

Electronic Circuits: Diode characteristics, diode applications, bipolar junction transistor (BJT) characteristics, DC biasing of BJTs, field effect transistor (FET) characteristics, DC biasing of FETs, basic amplifier fundamentals, BJT amplifiers, FET amplifiers, differential amplifiers, multistage amplifiers.

Analog Electronics: Operational amplifiers (op-amps), op-amp applications, non-ideal effects in opamps, power amplifiers, basic filter types, active filters, oscillator theory, sinusoidal oscillators, relaxation oscillators.

Digital Electronics: Analog-to-Digital converters (ADC), Digital-to-Analog converters (DAC), phase locked loops (PLLs), static and dynamic properties of logic gates, transistor-transistor logic (TTL), CMOS logic circuits, semiconductor memories, multivibrators, Schmitt triggers.

Related Courses: EED 2005, EED 2006, EED 3003, EEE5004, EEE 5086, EEE 5089

Special Subjects (The content of the questions in the “special subject” part of the qualifying exam is not limited to those listed in the following. The questions might be in other areas depending on the thesis topic of the student. The suitability of the questions is subject to the approval of Ph.D. Qualifying Committee.):

Data Converters: Principles of DAC and ADC, scaled DAC, high resolution scaled DAC, parallel-encoded ADC, counter-ramp ADC, successive-approximation ADC, integrated circuit ADC, feedback ADC, algorithmic converters, ramp function converters, fast ADC, switched-current data converters, sigma-delta ADC, delta-sigma DAC.

Related Course: EEE 5089

Analog IC Design: Linear op-amp applications, non-linear op-amp applications, analog integrated filters, signal generators and oscillators, ADC and DAC, analog signal conditioning circuits, current-mode circuits, operational transconductance amplifier, OTA applications, current conveyors, current feedback op-amps, CFOA applications, translinear circuits, log-domain signal processing.

Related Course: EEE 5004

Integrated Sensors: Temperature sensors and temperature sensitivity, MOS photodiode and CCD imagers, non-visible imaging arrays, special technologies for integrated sensors, bulk micromachining, surface micro-machining, wafer-to-wafer bonding, electroforming process and LIGA, mechanical sensors, silicon as a mechanical material, stress and strain, bulk piezoresistive pressure sensors, capacitive pressure sensors and their readout using oscillators and integrators, force transducers and tactile imagers, accelerometers, microactuators and integrated sensing systems, fundamental microactuator drive mechanisms, system functions for integrated microsystems.

Related Course: EEE 5082

VLSI Design: Semiconductor physics fundamentals, physical operation of electronics devices, integrated circuits design processes, integrated circuit realization of passive devices, analog integrated circuits, MOS digital integrated circuits, integrated transmitter-receivers, hardware description languages (HDLs), VHDL, VERILOG, nano-scale integration.

Related Course: EEE 5086

Filter Design: Network functions, frequency and impedance normalization, types of filters, approximation, passive network synthesis, synthesis of double-resistance-terminated lossless ladder networks, amplifiers and fundamental active building blocks, op-amp-, OTA-, CCII-based integrators, gyrators and immittance converters, second-order filters, single-amplifier active RC biquads, multiple amplifier RC biquads, OTA-based filters, high-order filter realizations, multiple-loop feedback realizations, LC ladder simulations, high-frequency filter realizations, transconductance filters, log-domain filters, switched-capacitor filters, delay equalizers.

Related Course: EEE 5121

“CONTROL SYSTEMS” Area for Ph.D. Qualifying Exam

Background Subjects:

Linear Algebra and Differential Equations: Differential equation models, solution techniques for linear, separable and exact equations, modeling examples, stability of equilibrium solutions, numerical methods, matrices, matrix notation of linear systems of algebraic equations, Gaussian elimination, subspaces and bases, determinants, general properties, linear systems with constant coefficients, eigenvalues, eigenvectors and characteristic equation, fundamental set of solutions, fundamental matrices and matrix exponential, nonhomogeneous linear systems, the phase plane, constant coefficient equations, homogeneous and nonhomogeneous equations, linear independence of solutions, characteristic equation, superposition principle, reduction of order, undetermined coefficients, variation of parameters, Laplace transforms and their properties, initial-value problems, delta or impulse function and Heaviside or step function, linearization of a nonlinear system, phase plane analysis and stability.

Circuit Theory: Circuit variables, circuit elements, simple resistive circuits, circuit analysis techniques, operational amplifier, inductance, capacitance and mutual inductance, response of 1st order circuits, response of 2nd order circuits, sinusoidal steady-state analysis, power calculations, 3-phase circuits, circuit analysis in Laplace domain, passive filters, active filters, Fourier series and Fourier transform, two-port circuits.

Signal Processing: Signal classification, continuous-time and discrete-time signals and systems, sampling and reconstruction, Fourier series and Fourier transform, Laplace transform, LTI systems, Z-transform.

Related Courses: EED 2311, EED 2411, EED 1012, EED 2010, EED 1008, MAT 2505, EEE 5503

Core Subjects:

Linear System Analysis: Stability, controllability and observability of linear systems, minimal realizations, poles and zeros of MIMO systems, linear quadratic control.

Digital Control Systems: Sampling of continuous-time signals, computer-oriented mathematical models: discrete-time systems, analysis and design of discrete-time systems, state-space design methods, pole-placement design based on input-output models.

Optimization: Mathematical optimization theory, linear and nonlinear programming, gradient and Newton’s method based optimization algorithms, convex optimization, Lagrange multiplier theory, applications to signal processing, control theory, system identification.

Related Courses: EEE 5502, EED 4301, EED 4303, EEE 5090

Special Subjects (The content of the questions in the “special subject” part of the qualifying exam is not limited to those listed in the following. The questions might be in other areas depending on the thesis topic of the student. The suitability of the questions is subject to the approval of Ph.D. Qualifying Committee.):

Optimal Control: Optimization by vector space methods, static optimization with and without constraints, calculus of variations, optimal control of discrete-time and continuous-time systems, linear quadratic regulator, steady-state closed loop control and tracking control, dynamic programming of discrete-time and continuous-time systems, robust control, H design.

Related Course: EEE 5104

System Identification: The mathematical foundations of system identification, non-parametric techniques, parameterizations and model structures, parameter estimation, nonlinear modeling of static and dynamic processes using neural networks.

Related Course: EEE 5109

Artificial Neural Networks: Fundamental models of neural networks for signal processing, filtering, spectral estimation, signal detection, signal reconstruction, adaptive extraction of principal and minor components, neural networks for system identification, neural networks for signal compression.

Related Courses: EEE 5029, EEE 5030

Machine Perception: Bayes decision theory, parameter estimation and supervised learning, nonparametric techniques, linear discriminant functions, unsupervised learning and clustering, scene analysis, image representation, image transforms, image enhancement, image restoration, video processing, computer vision.

Related Courses: EEE 5073, EEE 5033, EEE 5034

“TELECOMMUNICATIONS” Area for Ph.D. Qualifying Exam

Background Subjects:

Linear Algebra and Differential Equations: Differential equation models, solution techniques for linear, separable and exact equations, modeling examples, stability of equilibrium solutions, numerical methods, matrices, matrix notation of linear systems of algebraic equations, Gaussian elimination, subspaces and bases, determinants, general properties, linear systems with constant coefficients, eigenvalues, eigenvectors and characteristic equation, fundamental set of solutions, fundamental matrices and matrix exponential, nonhomogeneous linear systems, the phase plane, constant coefficient equations, homogeneous and nonhomogeneous equations, linear independence of solutions, characteristic equation, superposition principle, reduction of order, undetermined coefficients, variation of parameters, Laplace transforms and their properties, initial-value problems, delta or impulse function and Heaviside or step function, linearization of a nonlinear system, phase plane analysis and stability.

Circuit Theory: Circuit variables, circuit elements, simple resistive circuits, circuit analysis techniques, operational amplifier, inductance, capacitance and mutual inductance, response of 1st order circuits, response of 2nd order circuits, sinusoidal steady-state analysis, power calculations, 3-phase circuits, circuit analysis in Laplace domain, passive filters, active filters, Fourier series and Fourier transform, two-port circuits.

Signal Processing: Signal classification, continuous-time and discrete-time signals and systems, sampling and reconstruction, Fourier series and Fourier transform, Laplace transform, LTI systems, Z-transform.

Related Courses: EED 2311, EED 2411, EED 1012, EED 2010, EED 1008, MAT 2505, EEE 5503

Core Subjects:

Signal Processing: Continuous-time and discrete-time signals and systems, sampling and reconstruction, LTI systems, Laplace transform and Z-transform, Fourier analysis of signals, Fourier series, Fourier transform, DTFT, DFT and FFT, FIR and IIR filter structures and design techniques.

Probability and Random Processes: Basic probability, random variables, probability density and distribution functions, expected value and moments, conditional and joint probability, correlation and covariance, stationarity and ergodicity, autocorrelation function and power spectral density, transmission of random signals through LTI systems, white Gaussian noise characterization, Gaussian random processes, Poisson random processes.

Analog Communications: Amplitude and angle modulation methods (AM, DSB-SC, SSB, VSB, QAM, PM, FM), basic systems: FDM, superheterodyne receiver, phased-locked loops, modulators and demodulators, noise analysis of analog receivers.

Digital Communications: Source coding, sampling, quantization, PCM, DPCM, DM, baseband pulse transmission, passband transmission, modulation of digital signals: ASK, PSK, FSK, QAM, orthogonal signaling, constellation diagrams, error performance analysis, equalizers, optimal sequence detection: Viterbi algorithm.

Detection, Estimation and Modulation Theory: Bayes and Neyman-Pearson tests, binary and Mary hypothesis testing, GLRT and Rao tests, minimum variance unbiased estimation, best linear unbiased estimators, maximum likelihood, least squares, Karhunen-Loeve expansion, detection and estimation of signal parameters in white and colored noise.

Basic Information and Coding Theory: Mutual information and entropy, channel capacity, source and channel coding theorems, block and convolutional codes.

Related Courses: EED 3014, EED 4101, EEE 5035, EEE 5036, EEE 5075, EEE 5084, EEE 5087

Special Subjects (The content of the questions in the "special subject" part of the qualifying exam is not limited to those listed in the following. The questions might be in other areas depending on the thesis topic of the student. The suitability of the questions is subject to the approval of Ph.D. Qualifying Committee.):

Communication Systems Design: Line-of-sight microwave radio links, multi-hop radio networks, GSM mobile network design, channel noise.

Related Course: EEE 5027

Image Processing: Image representation, image transforms, image enhancement, image restoration, computer vision, image compression.

Related Courses: EEE 5033, EEE 5034

Artificial Neural Networks: Computer models of a neuron, supervised and unsupervised learning, Hopfield nets, perceptrons, backpropagation learning algorithms, self organization and memories, applications of neural networks.

Related Courses: EEE 5029, EEE 5030

Pattern Recognition: Machine perception, parameter estimation and supervised learning, nonparametric techniques, linear discriminant functions, unsupervised learning and clustering, scene analysis.

Related Courses: EEE 5073, EEE 5072

Time-Frequency Analysis and Wavelets: Time-frequency distributions, STFT and Wigner distribution, Cohen's class of distributions, wavelets and multiresolution analysis, filter banks, image compression via wavelets, denoising.

Related Courses: EEE 5055, EEE 5067

Adaptive Signal Processing: Wiener filter, steepest gradient descent algorithm, LMS algorithm, method of least squares, RLS algorithm, Kalman and extended Kalman filters, filter structures and algorithms for real-time processing, applications of adaptive filtering.

Related Courses: EEE 5066, EEE 5069

Modern Spectral Estimation: Classical spectral estimation, periodogram and Blackman-Tukey method, modern spectral estimation methods, MA, AR, and ARMA modeling and estimation of model parameters, minimum variance unbiased estimation, MUSIC and Pisarenko methods.

Related Courses: EEE 5087, EEE 5103

“ELECTRICAL MACHINES AND POWER ELECTRONICS” Area for Ph.D. Qualifying Exam

Background Subjects:

Linear Algebra and Differential Equations: Differential equation models, solution techniques for linear, separable and exact equations, modeling examples, stability of equilibrium solutions, numerical methods, matrices, matrix notation of linear systems of algebraic equations, Gaussian elimination, subspaces and bases, determinants, general properties, linear systems with constant coefficients, eigenvalues, eigenvectors and characteristic equation, fundamental set of solutions, fundamental matrices and matrix exponential, nonhomogeneous linear systems, the phase plane, constant coefficient equations, homogeneous and nonhomogeneous equations, linear independence of solutions, characteristic equation, superposition principle, reduction of order, undetermined coefficients, variation of parameters, Laplace transforms and their properties, initial-value problems, delta or impulse function and Heaviside or step function, linearization of a nonlinear system, phase plane analysis and stability.

Circuit Theory: Circuit variables, circuit elements, simple resistive circuits, circuit analysis techniques, operational amplifier, inductance, capacitance and mutual inductance, response of 1st order circuits, response of 2nd order circuits, sinusoidal steady-state analysis, power calculations, 3-phase circuits, circuit analysis in Laplace domain, passive filters, active filters, Fourier series and Fourier transform, two-port circuits.

Signal Processing: Signal classification, continuous-time and discrete-time signals and systems, sampling and reconstruction, Fourier series and Fourier transform, Laplace transform, LTI systems, Z-transform.

Related Courses: EED 2311, EED 2411, EED 1012, EED 2010, EED 1008, MAT 2505, EEE 5503

Core Subjects:

Electromechanical Energy Conversion: Magnetic circuits, stored energy, losses, principles of electromechanical energy conversion, single and multiple excited electromechanical systems, direct current machines, rotating magnetic fields, induction and synchronous machines, sizing of electromechanical energy conversion devices, the relationship between losses and size, steady-state analysis of electrical machines, dynamic behavior of electrical machines.

Electrical Drives: DC and AC motor speed control systems and their performance, power electronic converters in electric motor drives, steady-state and transient model of the motor drives and controller design.

Power Electronics: Solid state power devices, characteristics and protection of power semiconductors, thermal design for cooling of solid state devices, natural commutation, rectifiers, current harmonics, power definitions for distorted waveforms, inverter voltage control, choppers and resonant converters, unity power factor PWM rectifiers.

Generalized Machine Theory: Matrix equations of electrical machines, transformations between reference frames for analysis and modeling of electrical machines and drive circuits, analysis of transient, steady-state, balanced and unbalanced operation of electrical machines, linearization of non-linear models of machines around an operating point, simplified models, applications.

Related Courses: EED 3001, EED 3002, EEE 5001, EEE 5064, EED 4201, EED 4206, EEE 5065

Special Subjects (The content of the questions in the “special subject” part of the qualifying exam is not limited to those listed in the following. The questions might be in other areas depending on the thesis topic of the student. The suitability of the questions is subject to the approval of Ph.D. Qualifying Committee.):

Special Topics in Power Electronics: Switch mode power supplies, buck, boost and buck-boost converters, current controllers, modulation techniques, reactive power control with ac-dc converters, harmonic elimination, resonant inverters and resonant DC link circuits.

Related Course: EEE 5064

Electrical Aspects of Wind Energy Conversion Systems: Wind power systems, wind speed and energy, wind statistics, wind turbines and characteristics, wind generators and drives, wind power applications, modeling of wind power systems.

Related Course: EEE 5032

Electrical Power System Quality: The theory and applications of electrical power system quality, the effect of power quality problems on industry and on electrical and electronics equipments, active power filters, static reactive power compensation units (SVC, TCR, and STATCOM).

Related Course: EEE 5101

“ELECTROMAGNETIC FIELDS AND MICROWAVES” Area for Ph.D. Qualifying Exam

Background Subjects:

Linear Algebra and Differential Equations: Differential equation models, solution techniques for linear, separable and exact equations, modeling examples, stability of equilibrium solutions, numerical methods, matrices, matrix notation of linear systems of algebraic equations, Gaussian elimination, subspaces and bases, determinants, general properties, linear systems with constant coefficients, eigenvalues, eigenvectors and characteristic equation, fundamental set of solutions, fundamental matrices and matrix exponential, nonhomogeneous linear systems, the phase plane, constant coefficient equations, homogeneous and nonhomogeneous equations, linear independence of solutions, characteristic equation, superposition principle, reduction of order, undetermined coefficients, variation of parameters, Laplace transforms and their properties, initial-value problems, delta or impulse function and Heaviside or step function, linearization of a nonlinear system, phase plane analysis and stability.

Circuit Theory: Circuit variables, circuit elements, simple resistive circuits, circuit analysis techniques, operational amplifier, inductance, capacitance and mutual inductance, response of 1st order circuits, response of 2nd order circuits, sinusoidal steady-state analysis, power calculations, 3-phase circuits, circuit analysis in Laplace domain, passive filters, active filters, Fourier series and Fourier transform, two-port circuits.

Signal Processing: Signal classification, continuous-time and discrete-time signals and systems, sampling and reconstruction, Fourier series and Fourier transform, Laplace transform, LTI systems, Z-transform.

Related Courses: EED 2311, EED 2411, EED 1012, EED 2010, EED 1008, MAT 2505, EEE 5503

Core Subjects:

Electromagnetic Theory: Fundamental concepts and theorems, static electric and magnetic fields.

Electromagnetic Waves: Plane wave functions, cylindrical wave functions, spherical wave functions, wave transformations.

Antennas and Propagation: Antenna parameters, linear antennas, antenna arrays, radiation from slot and aperture antennas, elements of ground wave, tropospheric and ionospheric propagation.

Microwaves: Transmission lines, field and distributed circuit analysis, propagation in waveguiding structures, impedance transformation and broadband matching techniques, matrix representation of microwave networks, generalized scattering parameters, active and nonlinear microwave systems, microwave equivalent circuits.

Numerical Methods: Numerical solution of matrix equations and matrix eigenvalue problems, method of moments, finite difference and finite elements methods, variational methods, spectral domain approach.

Telecommunications: Analog transmission, modulation techniques, superheterodyne receivers, frequency division multiplexing, sampling process, digital transmission, noise.

Related Courses: EED 2008, EED 3007, EEE 5092, EEE 5113, EEE 5111, EEE 6003, EEE 5026, EEE 5092

Special Subjects (The content of the questions in the "special subject" part of the qualifying exam is not limited to those listed in the following. The questions might be in other areas depending on the thesis topic of the student. The suitability of the questions is subject to the approval of Ph.D. Qualifying Committee.):

Communications System Design: Line-of-sight microwave radio links, multi-hop radio networks, GSM mobile network design, channel noise.

Related Course: EEE 5027

Numerical Methods: Numerical solution of matrix equations and matrix eigenvalue problems, method of moments, finite difference and finite elements methods, variational methods, spectral domain approach.

Related Courses: EEE 5021, EEE 5022

Antennas and Propagation for Wireless Communication: Propagation mechanism, wireless systems and antennas.

Related Course: EEE 5113