The Department

Chair of the Department:
J.S. Wight

Departmental Supervisor of Graduate Studies:
N.G. Tarr

Programs of study and research leading to the master’s and Ph.D. degrees in electrical engineering are offered through the Ottawa-Carleton Institute for Electrical Engineering. The institute, established in 1983, combines the resources of Carleton University and the University of Ottawa. For further information, including admission and program requirements, see page 119.

The Department of Electronics is concerned with the fields of applied and physical electronics. Effort is strongest in two broad areas. One of these encompasses solid-state devices and integrated circuits, the other communications and microwaves. Specific areas of specialization include:

Solid State Devices
Fundamental semiconductor device physics; device design and novel device structures; device modeling for CAD; new fabrication processes; submicron and quantum effect devices; photovoltaics; semiconductor sensors and transducers

Integrated Circuit Engineering
Design and development of linear and digital integrated circuits; fabrication processes and test techniques; MOS, bipolar and BiCMOS ICs; VLSI; computer-aided circuit design

Analog Signal Processing
Switched-capacitor filters, transversal filters, operational amplifiers and radio frequency functions in analog signal processing applications, particularly for integrated circuit realization

Circuits
Active filters; linear and nonlinear circuit design; computer-aided circuit design; phase-locked circuits; carriers and clock synchronizers; mixers, modulators and demodulators

Microwave Electronics
Microwave amplifiers, oscillators, modulators, frequency converters, phase-shifters; use of FET and bipolar transistors, Schottky barrier, varactor, step recovery and PIN diodes; design using finline, microstrip, stripline, coax, and waveguide; monolithic microwave ICs in GaAs; miniature hybrid microwave ICs

Communications and Radar Electronics
Circuits for terrestrial and satellite communications; circuit implementation of digital modulation techniques; antenna and array design; communication channel characterization; optical communications circuits; radar transmitter and receiver design

Biomedical Electronics
Cochlear prosthesis

Computer-Aided Circuit Design
Development of hierarchical simulators for mixed analog/digital circuits; analysis and design of switched-capacitor networks; analysis and design of high speed circuits; optimization techniques; synthesis of VLSI circuits using both algorithmic and knowledge-based approaches; analysis and simulations of communications systems; layout synthesis and module generation

Photonic Devices
Waveguides and holographic optical elements for optical interconnects; electro-optic modulators and switches; waveguides for sensing applications.

NSERC/BNR Chair in CAD
The joint Natural Sciences and Engineering Research Council/Bell Northern Research Chairs in Computer-Aided Design are currently held by Dr. Michel Nakhla and Dr. Q.J. Zhang. This is part of a planned expansion of the department in the area of CAD for VLSI.

Ottawa-Carleton Centre for Communications Research
The newly formed Ottawa-Carleton Centre for Communications Research (OCCCR) is a multidisciplinary interdepartmental research group comprising faculty members, full-time research staff, postdoctoral fellows, visiting researchers, graduate students, and support staff from both Carleton University and the University of Ottawa. It is part of the Centre of Excellence “TRIO” (Telecommunications Research Institute of Ontario). Current research areas of the centre with major participation from the department are: integrated services digital networks, mobile and portable wireless networks, and VLSI in communications.

Micronet
The department is a member, along with seven other Canadian universities and several major industrial organizations, of Micronet, the federally-sponsored network on Microelectronic Devices, Circuits and Systems for ULSI (ultra-large scale integration). Within the department Micronet sup-
ports research on: device structures, modeling and fabrication processes for submicron CMOS and BiCMOS IC’s; high-speed filters, phase detectors, A-to-D converters, frequency synthesizers and other circuit elements for silicon IC’s operating at radio frequencies; analysis and optimization of interconnects for high-speed IC’s; and automated generation of custom cells for VLSI design.

The department’s integrated circuits testing instrumentation supports automated testing for both analog and digital circuit implementations. Low noise test beds and instruments such as spectrum analyzers, lock-in amplifier, signal generators, digital data generators and analyzer are linked together with controlling computers facilitating characterization and testing of high-performance analog and digital circuits.

The department has up-to-date facilities for circuit development and measurement at frequencies ranging from dc to 22 GHz. There are also facilities for work at optical frequencies. Thin-film microwave integrated circuits can be fabricated in house; there is provision for the fabrication of GaAs MMIC’s through foundry services. Special purpose microwave equipment includes automated network analyzers, spectrum analyzers and frequency synthesizers, and a complete microwave link analyzer. Data generators and error-detection equipment is available for work on digital communications. Software, such as SUPERCOMPACT and TOUCHSTONE, is available for the computer-aided design and layout of microwave integrated circuits.

The research laboratories maintain extensive collaboration with government and industrial research and development agencies in the Ottawa area.

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**Graduate Courses**

The courses offered by the Department of Electronics are as follows:

- **Engineering 97.551F1 (ELG6351)**
  Passive Microwave Circuits
  Review of EM theory for guided waves; transmission lines and waveguides. Propagation in ferrites. Characteristics of planar transmission lines, both single and coupled; stripline, micro-strip, coplanar lines; slotline. Representation of discontinuities in transmission lines and wave-guides. Scattering-matrix characterization of microwave junctions and discontinuities. Micro-wave network analysis. Design theory (including CAD), characteristics, and use of microwave components such as impedance transformers, filters, hybrids, directional couplers, isolators and circulators with particular emphasis on their realization in microwave integrated circuits.
  B.A. Syrett.

- **Engineering 97.555F1 (ELG6355)**
  Passive Circuit Theory
  General description of networks, leading to matrix

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*F,W,S indicates term of offering. Courses offered in the fall and winter will be followed by T.*

The number following the letter indicates the credit weight of the course: 1 denotes a half-course credit, 2 denotes a full-course credit, etc.

- Engineering 97.556 (ELG6356) Simulation and Optimization of Electronic Circuits
  Q.J. Zhang.

- Engineering 97.557W1 (ELG6357) Active Circuit Theory
  Prerequisite: Engineering 97.555 or equivalent.
  P.D. van der Puije.

- Engineering 97.558F1 (ELG6358) Computer Methods for Analysis and Design of VLSI Circuits
  M.S. Nakhla.

- Engineering 97.559F1 (ELG6359) Integrated Circuit Technology
  Survey of technology used in silicon VLSI integrated circuit fabrication. Crystal growth and crystal defects, oxidation, diffusion, ion implantation and annealing, gettering, chemical vapor deposition, etching, materials for metallization and contacting, and photolithography. Structures and fabrication techniques required for submicron devices. Applications in advanced CMOS and BiCMOS processes.
  N.G. Tarr.

- Engineering 97.562W1 (ELG6362) Microwave Semiconductor Devices and Applications
  Survey of basic semiconductor physics, PN junctions and Schottky barriers. Discussion of basic principles of operation, characteristics and applications of varactor diodes (tuning, parametric amplifiers, frequency multipliers), p-i-n diodes (switches, limiters, attenuators, phase shifters), IMPATT and Gunn diodes (negative resistance amplifiers and oscillators), micro-wave bipolar transistors and MESFET’s (amplifiers and oscillators). Design theory (including CAD) of amplifier matching networks. Discussion of microwave device/circuit fabrication technology (discrete, hybrid, monolithic).
  B.A. Syrett.

- Engineering 97.564W1 (ELG6364) Radar Systems
  Fundamentals; range equation, minimum detectable signal, radar cross-section, pulse repetition frequency, range ambiguities. Classes of Radar; CW, FM-CW, MTI, tracking, air surveillance, SSR, PAR, MLS, SAR, SLAR, OTH, 3D and bistatic radars. Radar subsystems; transmitters, antennas, receivers, processors, displays, detection criteria; CFAR receivers, noise, clutter, precipitation. Waveform design; ambiguity functions, pulse compression. Propagation characteristics; Earth’s curvature, refraction, diffraction, attenuation.
  J.S. Wight.

- Engineering 97.565W1 (ELG6365) Optical Fiber Communications
  Transmission characteristics of and design considerations for multi-mode and single-mode optical fiber waveguides; materials, structures, and device
properties of light-emitting diodes and laser light sources; photo-diodes, avalanche detectors; repeater design; coupling devices for fibers; noise generation and measurements; inter-modulation, cross-modulation, and non-linearity characterization; analog systems, digital systems, system design accounting for component signal degradation; data bus systems. Mitch Gallant, David Kahn, Jan Glinski and Paul Vella.

- **Engineering 97.566F1 (ELG6366)**
  Phase-Locked Loops and Receiver Synchronizers
  Phase-locked loops; components, fundamentals, stability, transient response, sinusoidal operation, noise performance, tracking, acquisition and optimization. Receiver synchronizers: carrier synchronizers including squaring loop, Costas loop, and remodulator for BPSK, QPSK BER performance; clock synchronizers including early/late gate, in-phase/midphase, and delay line multiplier; direct sequence spread spectrum code synchro-nizers including single dwell and multiple dwell serial PN acquisition, delay locked loop and Tau-Dither loop PN tracking; frequency hopped spread spectrum time and frequency synchronization.
  J.S. Wight.

- **Engineering 97.567F1 (ELG6367)**
  Antennas and Arrays
  P.J. Wood.

- **Engineering 97.568 (ELG6368)**
  Fourier Optics
  R.G. Harrison.

- **Engineering 97.569W1 (ELG6369)**
  Nonlinear Microwave Devices and Effects
  Technology of discrete and integrated nonlinear devices and circuits (MMICs) up to submillimeter frequencies. Device modeling: varistor and varactor devices including Schottky, tunnel and resonant-tunneling diodes; cryogenic devices including Josephson junctions, super-Schottky diodes, and SIS quasiparticle tunnel junctions; active devices including GaAs and InP MESFETs, HBTs and HEMTs. Gunn and optical effects in MESFETs. Simulation of nonlinear microwave circuits: analytical methods for global insight (algebraic harmonic balance, Volterra series, Ritz-Galerkin); numerical methods for design (integration and extrapolation, shooting methods, generalized power-series analysis (GPSA), numerical harmonic balance, and the almost-periodic Fourier transform (APFT). Multi-valued solutions, jump phenomena and hysteresis, bifurcations and chaotic behavior. Practical examples of passive and active circuits illustrating theoretical aspects: detectors, mixers, modulators, frequency multipliers, frequency dividers.
  R.G. Harrison.
linear recursions, memory efficient linear generators, statistical properties of M sequences, Galois field connections, nonlinear feed forward logic, DS and FH multiple access design. Code synchronizers; single dwell and multiple dwell serial PN acquisition for DS, delay locked loop and Tau-Dither loop PN tracking for DS, time and frequency synchronization for FH.

J.S. Wight.

- Engineering 97.571F1 (ELG6371)
  Optical and Microwave Remote Sensing Instrumentation
  Introduction to airborne and remote sensing for environmental monitoring. Interaction of optical and microwave radiation with the Earth’s surface and its impact on sensing and instrumentation design and operation. Airborne platform motion compensation schemes and their application to geometric correction of airborne imagery. Passive and active electro-optical sensors. Radar systems: clutter measurement; scatterometers, real aperture strip mapping radar (SLAR); synthetic aperture strip mapping radars (SAR).
  C.E. Livingstone and members of the department.

- Engineering 97.577 (ELG6377)
  Microelectronic Sensors
  This course is concerned with the fabrication and physical principles of operation of microelectronic sensors. A large variety of sensors will be studied and the basic fabrication methods used in their production reviewed. The devices discussed will include optical sensors, fiber optic sensors, magnetic sensors, temperature sensors and, briefly, chemical sensors. A substantial portion of the course will be devoted to micro-mechanical sensors.
  T.J. Smy.

- Engineering 97.578 (ELG6378)
  ASIC’s in Telecommunications
  The definition of Application Specific Integrated Circuits is given along with current ASIC technology trends. CMOS and BiCMOS fabrication technologies are compared for their potential use in communications circuits. Circuit building blocks such as amplifiers, switched-capacitor filters and analog to digital converters are overviewed in the context of their communications applications. An overview of vendor technologies is followed by application examples such as line drivers, pulse shaping and equalization circuits, high-speed data transmission over twisted pair copper cables and mobile radio components and implementation issues. Students are required to submit a related literature study and design a communications integrated circuit component using a standard cell library environment.
  T.A. Kwasniewski.

- Engineering 97.579W1 (ELG6379)
  Advanced Topics in Electromagnetics
  Recent and advanced topics in electromagnetics, antennas, radar systems, microwave devices and circuits, or optoelectronics. The subject material will vary from year to year according to research interests in the department and/or expertise provided by visiting scholars or sessional lecturers.

- Engineering 97.580F1 (ELG6380)
  Theory of Semiconductor Devices

- Engineering 97.581 (ELG6381)
  Electronic Circuit Reliability
  D.V. Sulway.

- Engineering 97.582W1 (ELG6382)
  Surface-Controlled Semiconductor Devices
  Basic theory of the MOS capacitor structure; charge and capacitance relationships; characterization of practical structures. MOSFET theory: classical 1-D analysis, Pao-Sah model, charge-sheet model, saturation region analysis. Small-geometry devices, scaling theory. Dynamic behavior of MOSFETs: quasi-static models, capacitance characterization. Metal-semiconductor devices; Schottky diode structures and MESFETs. Device modeling for CAD.
**Prerequisite:** Engineering 97.580 or equivalent.

- **Engineering 97.583F1 (ELG6383)**
  Silicon Compilers: Automated IC Synthesis
  A number of topics related to computer analysis and synthesis of integrated circuits will be discussed. These topics will include automatic PLA/FSM (programmable logic array)/(finite state machines) compilers, silicon compilers and automatic test plan generators (ATPG).
  **Prerequisite:** Engineering 97.476 or equivalent.

- **Engineering 97.587W1 (ELG6387)**
  **Microprocessor Electronics**
  This course introduces the student to the analysis and design of a microprocessor-based system, integrating the three design aspects: signal representation and processing, hardware and software. Topics discussed are stochastic processes, digital signal representation (as applied to a microprocessor system design), conversion and arithmetic errors, real-time applications software support, micro-architecture of VLSI systems, innovative modern micro- and DSP-processors, bit slices, A/D and D/A converters, controller chips. Students will be given design examples and prepare their own micro-computer system designs.
  **Prerequisite:** Engineering 97.476 or equivalent.

- **Engineering 97.591F2, W2, S2**
  **Engineering Project II**
  A one-term course, carrying full-course credit, for students pursuing the course work M.Eng program or the cooperative M.Eng. program. An engineering study, analysis and/or design project under the supervision of a faculty member. Results will be given in the form of a written report and presented orally. This course may be repeated for credit.

- **Engineering 97.596F1, W1, S1**
  **Directed Studies**
  Various possibilities exist for pursuing directed studies on topics approved by a course supervisor,
including the above listed course topics where they are not offered on a formal basis.

- Engineering 97.599F4, W4, S4
  M.Eng. Thesis

- Engineering 97.699F, W, S
  Ph.D. Thesis