**EE601: Numerical techniques for RF Circuit Modelling**

## Module Details

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| **Short Title:** | Numerical techniques for RF Circuit Modelling APPROVED |
| **Full Title:** | Numerical techniques for RF Circuit Modelling |

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| **Module Code:** | EE601 | **NFQ Level:** | 9 | **ECTS Credits:** | 5 |

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| **Valid From:** | Academic Session - 2011/12 ( September 2011 ) |
| **Administrator:** | Noel Murphy |
| **Module Coordinator:** | Marissa Condon |

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| **Description:** | Simulation of RF circuits is essential for the design and analysis of state of the art wireless and high speed RF systems. To keep pace with the rapid and exponential development of RF systems, novel and advanced numerical techniques have had to be introduced and incorporated into commercial software packages. This course provides an in-depth study of the key numerical methodologies that are required to analyse and simulate cutting-edge electronic systems. The course shall be delivered in one block lasting a week. This module is being developed under the Telecommunications Graduate Initiative (TGI) as part of which it has the course code TGI_M01. In 2012, the module will be delivered by Professor Wil Schilders of the Technical University of Eindhoven in the Netherlands. In addition to his outstanding academic credentials, Prof. Schilders has significant industrial experience. He has worked for 30 years in the electronics industry at Phillips and NXP Semiconductors. |

**Learning Outcomes:**

*On successful completion of this module the learner will be able to*

1. Describe and apply several direct and iterative methods for solving large sets of linear equations.
2. Derive, apply, compare and extend various methods for solving differential algebraic equations. Explain the associated concept of 'index'.
3. Describe and illustrate methods for finding solutions to oscillator equations when they are both unperturbed and perturbed by external signals.
4. Derive, apply, compare and extend techniques for model order reduction, nonlinear circuit simulation and macro-modelling.
5. Explain how the underlying mathematical approaches can be applied to systems in various engineering sectors and beyond.
6. Identify and critique current research activities relating to the area of RF circuit modelling.

**Pre-requisite learning**

***Module Recommendations***

*This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*

No recommendations listed

***Requirements***

*This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*

As this is an advanced level module in telecommunications, it shall be assumed that participants have an appropriate background in mathematics and circuit theory. A basic knowledge of programming in C and MATLAB is also expected.

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## Module Content & Assessment

### Indicative Content

- **Linear Algebra**
  Gaussian elimination. Steepest descent methods. Conjugate gradients. Preconditioning techniques. Indefinite systems. Vector extrapolation methods.
- **Differential Algebraic Equations**
  General introduction and examples. Various concepts of "index". Consistency of initial conditions. Projector methods and splitting.
- **Simulation of Oscillators**
  Autonomous differential equations. Periodic steady state solutions. Floquet eigenvectors. Theory of phase noise.
- **Nonlinear system simulation**
  Newton's method. Modifications: damping, nonlinear variable transformation, continuation methods.
- **Model order reduction**
  Overview of basic techniques. Krylov-based methods for linear problems. Passivity and stability preservation. Brief overview of methods for nonlinear problems.
- **Macro-modelling/behavioural modelling**
  Basic techniques. Vector fitting. Adaptive methods.

| **Assessment Breakdown** | **%** |
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| Course Work | 100% |
| End of Semester Formal Examination | 0% |

**Coursework Breakdown**

| *Type* | *Description* | *Outcome addressed* | *% of total* | *Assessment Date* |
|---|---|---|---|---|
| Assignment | Coursework assignments | 1,2,3,4,5,6 | 50 | n/a |
| In Class Test | There will be a 3-hour test at the end of the week examining all aspects of the course | 1,2,3,4,5,6 | 50 | n/a |

**DCU reserves the right to alter the nature and timings of assessment**

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## Module Workload & Resources

| Workload | Full-time hours per semester | |
|---|---|---|
| *Type* | *Description* | *Hours* |
| Lecture | Block release classroom sessions | 15 |
| Tutorial | Block release tutorial sessions | 5 |
| Assignment | Application of the course material and independent study time | 80 |
| Independent learning time | Students will be given a comprehensive reading list comprising recent and classic papers well in advance of the week of lectures so that they can start to work on the course material | 22 |
| Examination | In-class test | 3 |
| | Total Workload | 125.00 |

**Resources**

*Essential Book Resources*

- **S. Selberherr 1984, *Analysis and simulation of semiconductor devices*, Springer**
- **W.H.A. Schilders 2012, *Numerical methods for semiconductor device simulation*, Springer**
- **W.H.A. Schilders and E.J.W. ter Maten 2005, *Handbook of Numerical Analysis*, Elsevier**

*Supplementary / Recommended Book Resources*

- **M.C. Jeruchim, P. Balaban, K.S. Shanmugan 2000, *Simulation of communications systems*, Kluwer Academic/Plenum Publishers**
- **W. H. Tranter, K. S. Shanmugan, T. S. Rappaport, K. L. Kosbar 2003, *Principles of Communication Systems Simulation with Wireless Applications*, Prentice Hall**

## Module Managers & Teachers

**Module Coordinators**

| *Semester* | *Staff Member* | *Staff Number* |
|---|---|---|
| Semester 1 | Marissa Condon | 75059878 |
| Semester 2 | N/A | N/A |
| Autumn | N/A | N/A |

**Module Teachers**

| *Staff Member* | *Staff Number* |
|---|---|
| No Teacher Staff Assigned | |