State-of-the-Art and Development of Microwave Electronics Education at the Faculty of Engineering of Messina

Alina Caddemi

***Abstract* – In the present paper the author outlines the most peculiar aspects of the growth of the microwave electronics field of study at the Faculty of Engineering of the University of Messina, Italy. Details are given on the related courses and the resource management up to the development of a complete laboratory and educational activities within the frame work of the Bologna process implementation.**

Keywords – **Education, Microwave Electronics, Academic Activities, Course Management**

I. INTRODUCTION

Education in the field of microwave electronics in the engineering faculty sites of the South Italy is not exhaustively covered, mainly due to historical reasons and to the lack of industries in this area able to offer to the young engineers an adequate job opportunity.

Nevertheless, basic knowledge and training in EHF (*extra high frequency*) electronics is nowadays required for building a sound electronic and telecommunication engineer background that can compete with university education levels offered in other parts of our country and in most advanced European countries.

Based upon these considerations, we have strongly worked since 1998 towards developing leading course contents and laboratory activities at the Faculty of Engineering of the University of Messina (*ENG-UniME*). This Faculty is one among the youngest in the Italian country and the first electronic engineers graduated in 1994.

We first introduced microwave electronics concepts within the framework of existing courses, namely the courses of Optoelectronics and Solid-State Electronic Devices. Then we slowly began to support *laurea* (i.e. graduation) thesis focused upon theoretical studies and computer-aided simulation and/or design in this field. It was quite difficult to start from the ground level, mainly because no lab instrumentation was available at that time for instructor training and student practising.

From 2000, the implementation of the Bologna process started all over the Italian country. Therefore, the academic organization was changed and new courses could be included. We requested two main courses be introduced: Microwave Circuits and Components (*CCMIC* acronym) and Microwave Electronics (*ELEMIC* acronym).

Alina Caddemi is with the Dipartimento di Fisica della Materia e Ingegneria Elettronica, Università degli Studi di Messina, Salita Sperone 31, S.Agata 98166 Messina, Italy,
E-mail: caddemi@ingegneria.unime.it

In what follows, we will present the main topics treated in both CCMIC and ELEMIC classes, the organization, growth and management of the Microwave Measurement and Circuit Laboratory (*M^2C Lab*), the most interesting experimental graduation thesis developed since 2000.

Finally, we will briefly describe two interesting extra-curricula educational experiences realized in 2003-2004 and in 2007-2008 aimed at developing expert engineer figures in the field of either Microwave Systems for Advanced Telecommunications (*STEMIT* project) and Mechatronics for Advanced Production Environments (*MECAP* project).

II. CCMIC CLASS AT ENG-UNIME

The aim of this course is to give basic knowledge on guided wave propagation starting directly from the Maxwell's equations but avoiding long analytical treatment of the subject. We spend about 40 hours on theory and 20 hours on exercising over a total of 60 hours. A special concern is devoted to microstrip lines and components, including software practising. We are using Microwave Office™ (MWO) by Applied Wave Research which is quite user-friendly and yet is a very complete package for several microwave applications.

The main topics covered by the course are:
Guided propagation – Two-port parameters - Microstrip lines and components - Waveguide components and systems - Resonant circuits and cavities - Antennas for wireless telecom systems - CAD of microstrip components.

In the framework of this course, we also organize seminars held by people of the microwave industry or by academic researchers from other Italian universities.

We have mid-term and final written tests and the students are free to add a short thesis work based on computer design/simulation to get a higher score.

III. ELEMIC CLASS AT ENG-UNIME

The aim of this course is to give advanced knowledge on solid-state transistors for linear/non linear microwave applications, circuit modelling procedures, scattering and noise parameter measurements. Instead, we work on a basic knowledge level as far as microwave amplifier design is concerned.

The main topics covered by the course are:
HMICs and MMICs – Passive components – Advanced microwave transistors – Modeling procedures – Characterization techniques – Noise figure and gain – Noise figure and noise parameter measurement techniques – Microwave amplifiers design.

Again, we spend about 40 hours on theory and 20 hours on lab and software practice over a total of 60 hours. Experimental activity is performed with the teacher and/or the instructor and the students are free to try their own measurements with the network analyzer and the spectrum analyzer on packaged devices/modules. The MWO software is employed for noise and scattering parameter simulation by circuit model analysis. The element *tuning* capability of this software is often exploited to show the students how each circuit element affects the performance of a given scattering or noise parameter.

Microwave circuit design topics are restricted to the basics of low-noise and linear CAD techniques. The students learns how to carry out the standard design of a simple amplifier stage and to analyze the layout of an existing project. Those who are interested in this topic, can study and analyze it in details by developing a specific master thesis work.

As far as student's evaluation is concerned, the same observations as CCMIC course apply.

The educational references for both courses are:

- D.M. Pozar *Microwave Engineering*, (3rd Ed.) John Wiley & Sons, Inc.
- R. Sorrentino, G. Bianchi, *Ingegneria delle microonde e radiofrequenze, McGraw-Hill*
- G. Gonzalez, *Microwave Transistor Amplifiers: Analysis and Design*, Prentice-Hall Ed., 1984.
- G. Ghione, M. Pirola, *Elettronica delle Microonde*, OTTO Ed. Torino, 2002.
- Notes written by the teacher and/or instructors
- Industry data sheets
- Instrument manuals

We spend part of the exercise time to study and compare industry data sheets of components and instruments because we think that technical material plays a fundamental role in the education process of a young engineer.

IV. The Microwave Measurement and Circuit Laboratory at ENG-UniME

The M^2CLab has grown slowly over a ten years period due to the difficulties encountered in acquiring funds. As it is well known, microwave instrumentation is not cheap and we first started in 2001 with a refurbished vector network analyzer 8753E by Agilent Technologies (frequency range 30 KHz – 6 GHz). We then built by ourselves a probe station for on-wafer measurements with temperature controlling features using a thermoelectric cooler, supported also by the work of a graduating student that presented the first results of the testing system in his thesis dissertation.

Successively, we had financial support to either buy a cryogenic He chamber (based on a proprietary design) for low-noise microwave circuit characterization and to lease a new vector network analyzer 8364A by Agilent Technologies (frequency range 45 MHz – 50 GHz) that was successively bought by adding a small amount a money.

The most recent instruments were a spectrum analyzer N9020 by Agilent Technologies (frequency range 20 Hz – 26.5 GHz), a noise figure analyzer NP8975 by Agilent Technologies (frequency range 10 MHz – 26.5 GHz) and a Cascade Microtech M150 probe station for on wafer testing.

Experimental activities in M^2CLab include: trained measurements of components and circuits, application of linear/noise modelling procedures, instructor-assisted self-training in the use of spectrum analyzer, vector network analyzer and noise figure analyzer.

The laboratory is equipped for small seminars (8-10 persons) and also with instrumentation for basic electronic measurements and board realization.

At present, we do not have availability of internal technician support, therefore we take care of either management and maintainance of all the instrumentation.

V. Development of Graduation Thesis

During the last 10 years, the most interesting topics covered in the development of master thesis have been:

Noise figure measurement of a low noise amplifier with a Spectrum Analyzer
Design and realization of an on-wafer station with a thermal chamber
Design o fan LNA for cryogenic applications
Design of HTS microwave filters
Circuit modelling procedure by direct extraction
Neural network modelling of HEMTs
Testing of a cryogenic system for microwave applications
HEMT Modeling from cryogenic measurements
Cryogenic characterization and modeling of a transistor test fixture
Non linear modeling of microwave HEMTs
Noise parameter modeling by evolutionary algorithm
CAD of microstrip structures by EM-ANN techniques
Digital radio system for radio astronomy applications
Design of advanced microstrip components
Noise characterization and modeling of pseudomorphic HEMTs
Design of microwave power amplifiers with GaN HEMTs

In addition, many thesis have been focused on developing software for system automation and data processing to be employed in the measurement activities that we carry out currently.

Finally, we had several thesis carried out in cooperation with industries and research centers such as Infineon in Munchen (DE), Galileo Avionica in Palermo (IT), Selex Communications in Catania (IT), INAF Radio Astronomy Observatory in Noto (IT), ST Microelectronics in Catania (IT).

VI. Other Educational Experiences: the STEMIT and the MECAP projects

We had also very interesting experiences by organizing and managing two educational projects co-financed by the European Communities. These were extra-curricula courses having one year duration and aimed at developing a

specialized knowledge in the field of microwave systems and mechatronics. The general structure of this projects was based on a six-months period for classes and a three-months period for an industry stage and thesis preparation.

The first project was "Microwave Systems for Advanced Telecommunications (*STEMIT*)" and every activity was financed, including a fellowship for the students involved. It addressed young persons having a master degree in either Electronic or Telecommunication Engineering or Physics, and it was organized in 2003-2004. Most of the students participating at that project found a better level job thanks to the knowledge acquired and to the stage performed after classes.

The second project was "Mechatronics for Advanced Production Environments (*MECAP*)" and every activity was co-financed (our University had to fund 10% of the total budget), but the students involved had no financial support. It addressed young persons having a first level (bachelor) degree in either Electronic or Telecommunication or Industrial Engineering, and it was organized in 2007-2008.

Both courses ended with the preparation and presentation of a final dissertation concerning a project developed during the stage. The students then were appointed by the title of either "Expert in Microwave Systems for Advanced Telecommunications" for STEMIT participants or "Expert in Mechatronics for Advanced Production Environments" for MECAP participants.

The most interesting and student's enjoyed aspects of this educational experiences were the high degree of interaction with the industry world and the application-oriented style of the topics treated during the class semester.

ACKNOWLEDGMENT

We acknowledge the European Commission for grant under project Tempus CD_JEP-41112-2006 (RS), the Italian Ministry of University Education and Research (MIUR) and the European Social Fund (FSE) for funding the STEMIT project under P.O.N. 2000-2006 (Asse III, Misura III.4), the Regional Department of Education and FSE for funding the MECAP project (Cod.1999:IT.16.1.PO.011/3.07/9.2.14/0332) under P.O.R. Sicilia 2000-2006 (Asse III – Risorse Umane Misura 3.07 – az. C), the Politecnico of Mediterraneo consortium for funding part of the laboratory instrumentation.