MICROWAVE EDUCATION AFTER THE UNIFICATION OF GERMANY - AN EXAMPLE: GERHARD-MERCATOR-UNIVERSITY DUISBURG

Adalbert Beyer, Klaus Solbach and Arnold Ziermann

Gerhard-Mercator-University Duisburg, Dept. of Electrical Engineering (FB9), Bismarckstrasse 81, D-47057 Duisburg, Germany, Tel.: (+49) 203-379-4217, Fax: (+49) 203-379-3218, Email: a.beyer@uni-duisburg.de

Abstract -The expansion of the wireless and mobile communication techniques has rendered possible the opening of numerous new fields of activities not only at lower microwave (0.9 GHz, 1.8 GHz), but also at millimeter-wave frequency (66 GHz) bands. These areas became very important factors at the international market of communication. With the rapid changes of these techniques there arise a lot of new demands both in the industry and in the university area. This paper describes activities within a University in order to show how the demands connected with the new technologies can be fulfilled.

I. INTRODUCTION

The Department of Electrical Engineering of the Gerhard-Mercator-University Duisburg was founded in 1972. During the period from 1972 to 1990, the university - and certainly also the Department of Electrical Engineering - undergone a significant expansion in scope and size. Today, there are 1,700 students enrolled studying electrical engineering including some 200 graduate students. The research involvement has increased steadily over the past 25 years to an annual dollar level of over $ 5,000,000 (average of 5 years between 1990 - 1995) for the more than 30 faculty members in the department [1, 2, 3].

The courses in electrical and electronic engineering are set up by undergraduate studies of two years and postgraduate studies of 1.5 in the more application oriented branch, or 2.5 years in the more theoretical oriented branch, respectively.
The more application oriented branch offers studies in

- microelectronics/power engineering and
- microelectronics/communication engineering.

The more theoretical branch offers studies in

- power engineering and
- communications engineering.

It should be mentioned, however, that there is a special study for communication engineering, in which the education takes place bilingual: in English and in German. Within both directions, between several special courses can be chosen. The remainder of this paper will focus on the microwave-, millimeter-wave and optoelectronics activities within the Department of Electrical Engineering.

II. ACADEMIC PROGRAM IN THE PERIOD 1972 - 1990

The undergraduate academic program at the Department has always maintained strong course requirements in traditional basic areas. For instance, one full year (two semesters) of the Theory of Electromagnetism is required in order to continue the study in the area of High Frequency Techniques. In the period under

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consideration, for students in the last three semesters a few **compulsory** microwave courses were offered, such as

- Radiofrequency Engineering (1 semester)
- Radiofrequency Engineering and Microwave Techniques (3 semesters)
- Introduction to Optical Waveguides (1 semester).

Parallel to these, the students could take additional **elective** courses. Of these courses, there were three in **traditional electromagnetic topics** like:

- Introduction to Microwave Techniques (1 semester)
- Introduction to Antenna Theory (2 semesters)
- Selected Topics of Microwave Engineering (2 semesters)

and three in **numerical electromagnetics** such as

- Computer Oriented Field Theory (Electrostatics) (2 semesters)
- Computer Oriented Field Theory (Waves) (2 semesters)
- Introduction in the Theory Rapidly Changeable Electromagnetic Fields (2 semesters)

The popularity of these senior level electromagnetic courses was at an all time high at the Department. For example, the compulsory courses have had total enrollments of 120, and the elective ones up to 30, respectively. Four Faculty Members and several senior scientific assistants and scientific assistants were actively involved in electromagnetics teaching; at the same time strong research groups with excellent international reputation were active in the fields of microwave- and millimeterwave integrated circuits theory and techniques.. It turned out that research and teaching were interdependent because only through active participation of students by way of diploma thesis work etc. research could be done efficiently and also could young graduates be recruited with the necessary foreknowledge and "bias" to become efficient junior researchers. Clearly, Duisburg was one of the larger microwave oriented department in (West)Germany.

On the other hand, in East Germany, then known internationally as the German Democratic Republic, the teaching of RF/ microwave courses at some universities was much less supported by advanced research activities, mainly due to the lack of funding and the lack of industrial and economical basis in this sector.

III. Academic Program in the Period 1990 - 1997

The rapid changes in the telecommunications (e.g. glass-fibre communication) and microwave-millimeter-wave markets - not least as the consequence of the breakdown of the eastern-block and unification of Germany - have made it necessary to change the areas of the education and of the research within the university by novel strategies and methods. Furthermore, after the unification of Germany the downsizing of the military industry has reduced the chances for young engineers in getting jobs. It was strongly connected with a decreasing number of freshmen at the Engineering Departments in Germany. For instance, the Department of Electrical Engineering in Duisburg has lost more than 40% freshmen during the period between 1992 - 1996. This leads to a loss of a large part of the financial support both in the area of education and in research. It was and is a big challenge for the Department - and especially for the Faculty Members dealing with Electromagnetics - to face against these negative developments. The market success of new technologies like the wireless and mobile communication helps to overcome these difficulties. However, new industries need young engineers of new types. They should have

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founded theoretical backgrounds and practical knowledge of these new technologies.

The Department of Electrical Engineering in Duisburg has made a lot of efforts to match its activities to the requirement of the new technologies in the area of education and in research as well. New topics of education were implemented into the education of electromagnetics.

In the period mentioned above, for students in the last three semesters - after extensive revision of the topics of courses - the traditional **compulsory** microwave courses were a bit shortened. Hence, the following courses are offered:

- Radiofrequency Engineering and Microwave Techniques (2 semesters for students specializing in RF/ microwave studies)
- Radiofrequency Engineering (1 semester for all students of communications engineering).

This course emphasizes fundamental principles of RF technology, e.g. frequency dependence of concentrated circuit elements, matching circuits, waves and impedance transformation in transmission lines, as was recommended by a joint industry-academia work group.

Additionally, an advanced **compulsory** course dealing with microwave electronic circuits was introduced, which is entitled:

- Radiofrequency Electronics (3 semesters).

Furthermore, from 1990 activities in optoelectronics were forced by implementing a new Faculty Member. Following from this, a **compulsory** course on

- Optical Communication Technology is offered.

As already mentioned, the students could take additional **elective** courses. Of these courses, there are three in **traditional electromagnetic topics** like:

- Introduction to Microwave Techniques (1 semester)
- Introduction to Antenna Theory (1 semester)
- Selected Topics of Microwave Engineering (1 semester)

and two in **numerical electromagnetics** such as

- Computer Oriented Field Theory (2 semesters)
- Introduction in the Theory of Rapidly Changeable Electromagnetic Fields (2 semesters)

In order to make the communications engineering branch more attractive, and at the same time to fulfill the demands of the new technologies, two new topics for **elective** courses were developed. There is the topic involved with **mobile and wireless communication techniques** such as:

- Mobile Communications (2 semesters)
- Wave Propagation (2 semesters)

Another topic leads into the special areas of the **Optoelectronics:**

- Optical Signal Processing (1 semester)
- Optoelectronic Networks (1 semester).

All these courses are generally survey in nature. Emphasis is placed on fundamental physical understanding and concepts as a significant design content.

As already mentioned, in the past the decreasing number of freshmen was a big problem. Now, following the renovation of the education concepts and contents, a slight increasing number of student can be observed. The popularity of these senior level electromagnetic courses is increasing again at the Department. For example, the compulsory courses have had total

enrollments of 60, and the elective ones up to 15, respectively. Four Faculty Members and several senior scientific assistants and scientific assistants as well as Ph.D students are actively engaged in electromagnetics teaching and research. The Department of Electrical Engineering in Duisburg tries - also under the rapidly changed boundary conditions - to hold its position to be one of the larger microwave oriented faculty in the united Germany.

IV. OUTLOOK

Recent discussions among industry, academia, engineering societies, government and the public have revealed that engineering education is challenged to put more weight on the capabilities which are important for the success of the individual engineer as well as the whole economy within a changing world of global competition at an increasing pace and on an increasing level of complexity. Focussing on the Microwave Education, this goal requires more attention to the **application** of fundamental microwave techniques, which traditionally the young engineer learns to know only after graduation from university. While real applications will remain for industry, the education of students needs to improve the understanding of systems based on radiofrequency techniques. This comprises the understanding of at least the fundamental principles of radiofrequency communications-, sensor- and industrial-systems in order to gain the ability of playing a role in a typical team effort concerning marketing, design, development and production of competitive new system applications. To make this possible, the borders of individual disciplines have to be crossed and the interfaces between RF, the digital domain, signal processing and systems engineering have to be addressed; a first example is the lecture on Mobile Communications, see section III., which covers the system aspects from the air interface to the software problem.

In order to allow more time on system aspects to be spent without increasing the total duration (indeed, a reduction seems to be needed due to the relative high average age of German engineering graduates), traditional areas of teaching have to be shortened. This does not result necessarily in a dangerous weakening of fundamentals, if teaching can be done more effectively. Although this still has to be proven, more orientation towards general principles, as opposed to specific, dedicated solutions, may reduce time effort of learning because language, tools and principles can be used that are common to many disciplines of electrical engineering and thus are known to the student from other courses (e.g. equivalent circuits, system block description, Fourier- and Laplace-techniques and conformal mapping are used extensively in information theory, control theory and general electrical engineering)

At the same time, more research work at university level has to be oriented towards interdisciplinary problems, to improve the value of academic research for society but also in order to become part of the enlarged scope of teaching and students' thesis work.

V. REFERENCES

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