The Status of Microwave Education in Italy

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Abstract— **After a short description of the engineering education system in Italy, and a brief historical account of the introduction of microwave courses in such studies, the paper illustrates the present situation of microwave education. Data are provided on schools where courses on microwaves and related disciplines are available, types of degrees, laboratories and computing facilities, and number of students. Typical syllabi in some universities are also discussed.**

I. The Engineering Education System in Italy

BEFORE describing the status of microwave education in Italy, it is worth taking a few moments to illustrate the engineering education system in Italy as compared to that in English-speaking countries.

The university education system in Italy depends on a centralized structure—the Ministry of University and Scientific and Technological Research. Engineering studies are provided only at Engineering Faculties of the universities, and are therefore under government control. Nonuniversity engineering schools having a shorter duration of studies are typically available in Europe (such as the German *Fachhochschulen* or the Swiss *HTL*) but were never allowed in Italy. Polytechnics, that are administratively independent from local universities, such as those of Milan (founded in 1863) and Turin (independent since 1906), are to be classified as universities.

In contrast with the English system, which is divided into undergraduate and graduate courses, since the foundation of the unified Italian State (1860) till a few years ago, the structure of engineering studies in Italy used to be unique, with only one graduation level (the *Laurea*, approximately equivalent to the Master's Degree). The Laurea degree nominally requires five years of education (although the majority of students take six to seven years to complete their studies), following thirteen years of education at primary and secondary schools. Since the 19th century, in fact, engineering studies were organized according to the model of the German *Technische Hochschulen*.

In recent years, two more degrees have been added to the Laurea. In 1985, a postgraduate program, the Dottorato di Ricerca (Research Doctorate, equivalent to the Ph.D.), has been established. Very recently, in 1990, a new law has established an undergraduate program (Diploma Universitario) of a duration of three years. Such a program, informally called "laurea breve" or short laurea, is just starting in many Italian universities. In addition to these degree programs, courses of specialization and for continuing education are organized at many universities.

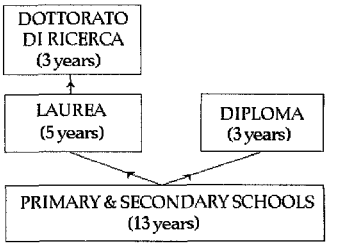

Fig. 1. Schematic of engineering degree programs in Italy.

A schematic of the engineering degree programs is shown in Fig. 1. After secondary school, the student can join either the Laurea or the Diploma Programs. The Dottorato can be entered after the Laurea degree. It should be mentioned that the Italian system is structured on a year, rather than semester, basis. Classes start mid-November and end mid-June. Nevertheless, in recent years, many universities have introduced the semester system, with classes usually extending from early October to mid-January and from mid-February to May. In all systems, each course consists of a minimum of approximately 80 lectures to a maximum of 120 (including exercises and laboratory experiments).

II. Microwave Education in Italy: A Bit of History, and the Difficulties of the EE Curricula

The centralization of the Italian education system is an inheritance of the Napoleonic school reform (1802) and was reinforced during the fascist period. It has, till now, put considerable constraints on the universities. To introduce changes in the curricula, as required by both scientific and technological advances, state laws had to be issued. Curricula and degrees are in fact regulated by law and must be uniform throughout the whole country, as the profession is regulated and protected by the state law [1].

Such a structure is one of the main reasons why delays in engineering curricula were often observed in the past. This is the case of microwave courses. In spite of the increasing production of microwave radio links and radars during the 1950's in Italy, microwave courses were introduced only in the 1960's, i.e., more than 20 years after the big development of microwave technology during World War II. This delay is, in many respects, a consequence of the delay in the introduction of the *industrial engineering* degree in addition to the traditional *civil engineering* degree. The former, in fact, was introduced in Italian universities only between 1926 and 1938, with the exception of the Polytechnic of

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TABLE I
GROWTH OF UNIVERSITIES, ENGINEERING FACULTIES AND ELECTRONIC ENGINEERING SCHOOLS IN ITALY

Year	Universities	Engineering Faculties	Electronic Eng. Schools
1980	45	19	13
1992	100	35	25

Milan (1863) and Turin (1879) which took advantage of their particular independence (later lost during the fascist period). The electrical engineering education thus suffered substantially from this delay, although the Polytechnics could already in 1887 introduce postgraduate courses for the specialization of mechanical graduates in electrical engineering and, a few years later, at the turn of the century, a complete electrical engineering degree (laurea). In most of the other universities, the latter started only in the 1930's.

Although electricity was first used for communication rather than for energy applications, dedicated courses on electrical and radio communications were introduced only very late, in the late 1950's. At the Polytechnic of Milan, however, some information on telegraphy and telephony was given before 1880 in a course on technological physics while the fundamentals of electromagnetic waves were given at the beginning of the 20th century in a general course on electricity. Maxwell's equations were generally introduced in all engineering schools at the beginning of the 1930's in the teaching of *Physics*.

Various events concurred to determine this delay. Till the 1960's, engineering education was considered to be a strictly unitary body. The mechanical engineer was viewed as a civil engineer with an additional specialization, and the electrical engineer as a further specialization of the mechanical engineer.

In a country lacking combustibles, energy transmission at a distance was recognized as a vital problem since the first years of its industrialization. The education system was therefore easily adapted (e.g., in the Polytechnics of Milan and Turin) to educate an electrical engineer specialized in energy applications. Faculty staffs used to identify industrial needs with mechanical engineering hardly recognized electrical communications as a part of engineering. Even today many consider conventional engineering (civil, mechanical, and energy engineering) to be the only *true* engineering.

Only in 1960 did a new law soundly modify the structure of the engineering education system, by relaxing the unitary structure and introducing various types of engineering degrees and, specifically, an *Electronic Engineering* degree (Laurea). This was separated from the *Electrotechnical Engineering* degree, essentially devoted to power application.

It was therefore possible to introduce microwave courses in the new Electronic Engineering degree. During the long period of elaboration of this reform, some universities (the two Polytechnics among them) and other institutions (such as the National Research Council together with the Ministries of Post and Defence) had anticipated the reform organizing postgraduate courses in radiocommunications and radar technology, where teaching of microwaves was first introduced. The first course on microwaves had been held in 1945 in Livorno in a postgraduate program for Navy officials. The course was given by Prof. Nello Carrara, a microwave pioneer of the 1930's, who first apparently used the word *microwave* in *Proc. IRE* [2], [3].

The first professors of telecommunications were typically people coming from radio research laboratories of the Navy, Air Force, or industry. They oriented their courses mainly toward radiocommunications and electronic circuits. Their research assistants later formed groups of researchers who were very active in applied electromagnetics in various Universities. They, in turn, formed the Faculty charged to teach electromagnetic fields and microwave technology during the 1960's.

After the reform of 1960, while basic electromagnetics was still being introduced in the general discipline of *Physics* during the second year of the degree course, a deeper knowledge of electromagnetic theory was given in the discipline of *Electromagnetic Fields*, taught in the fourth year. Further application-oriented courses such as *Microwaves* and *Antennas and Propagation* were given in the fifth year.

Up to 1969, almost all the disciplines for getting the Laurea degree were compulsory, half of them being fixed nationwide. In 1969, a law was issued giving the students a notable degree of freedom. A core of basic disciplines (15 out of 30) were still compulsory nationwide, but most of the rest could be selected by the student (subject to the Faculty approval) to create his or her own curriculum. A number of new disciplines began to be taught. The basic course of *Electromagnetic Fields* has been generally put at the third year, and *Microwaves* at the fourth year, to allow more application-oriented disciplines to be taught during the last year of the degree.

For some years, the Electronic Engineering degree was mainly oriented toward telecommunications, where electromagnetics was considered a basic discipline. This situation, however, has changed in the last twenty years. As a consequence of the law of 1969, engineering curricula changed significantly, and the traditional unitary structure of the engineering education system rapidly came to an end. The advent of new technologies and new specialties in the profession fostered the introduction of new disciplines (such as computer science, automatic controls, biomedical instrumentation, bioelectronics, etc.) in the degree. The role of electromagnetics as a basic discipline then became questionable.

A new law in 1989 has reorganized engineering studies, introducing a number of new degrees, among them a Laurea degree in *Telecommunication Engineering (Ingegneria delle Telecomunicazioni)* and a Laurea in *Computer Engineering (Ingegneria Informatica)*. In the present system, electromagnetic waves as well microwaves are taught both in the Electronic Engineering and in the Telecommunication Engineering curricula. In spite of the introduction of a number of new electromagnetic disciplines, the latter seem to be losing their importance, microwave courses are being left as optional, while increasing emphasis is given to digital communications, digital switching, digital networks, computer networks, computer science, digital signal processing. Recent trends in communication networks, where microwave radio links are losing their traditional role in network main trunks, contribute to this tendency.

TABLE II

ELECTROMAGNETIC COURSES IN THE ITALIAN UNIVERSITIES WITH NUMBER OF STUDENTS (WHEN AVAILABLE) AND GRADUATES IN ELECTRONICS ENGINEERING. DATA REFER TO 1991/1992 ACADEMIC YEAR

UNIVERSITY / DISCIPLINE	ANCONA	AQUILA	BARI	BENEVENTO	BOLOGNA	CAGLIARI	CATANIA	COSENZA	FERRARA	FIRENZE	GENOVA	MILANO	NAPOLI	PADOVA	PALERMO	PARMA	PAVIA	PERUGIA	PISA	ROMA-1	ROMA-2	SALERNO	TORINO	TRIESTE	VERCELLI
EM FIELDS I	160	100	250	•	450	30	•	50	•	•	250	130	250	100	180	60	95	150	220	500	•	•	350	•	42
EM FIELDS II																				15			20		
MICROWAVES	50		40		50			25		50	20	46	65	70	90		40	101		100	45	•	60	10	33
MICROWAVE MEASUREMENTS																				50					
MICROWAVE CIRCUIT DESIGN										•															
MICROWAVE ELECTRONICS																					•				
ANTENNAS &/OR PROPAGATION	30	30	40		100					•	30	75	• •	•			16	6		150	•	•	35 20	•	
REMOTE SENSING											60	•						•		106			120		
EM COMPATIBILITY	30									•										20			120		
BIOELECTROMAGN. INTERACTION																				20					
OPTICS												141	•							140		•			
OPTOELECTRONICS												133			45		30			40					
OPTICAL CIRCUITS & COMPONENTS	52														30	20	30						60		
OPTICAL SIGNAL PROCESSING					50						30														
N° of EE Graduates	150	12	50	•	250	-	•	•	-	180	150	660	200	250	60	15	70	10	160	250	30	•	259	35	•

• = Number not known

TABLE III

CONTENTS OF THE COURSES ON ELECTROMAGNETIC FIELDS IN VARIOUS UNIVERSITIES

UNIVERSITY / SUBJECT	ANCONA	AQUILA	BARI	BENEVENTO	BOLOGNA	COSENZA	FERRARA	FIRENZE	GENOVA	MILANO	NAPOLI	NAPOLI II UN	PADOVA	PALERMO	PARMA	PAVIA	PERUGIA	PISA	ROMA-1	ROMA-2	SALERNO	TORINO	TRIESTE	VERCELLI
MAXWELL'S EQNS. BASIC THEOREMS	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
RELATIVITY									•										•					
CONST. RELATIONS & MATERIALS	•	•	•	•	•	•	•			•	•	•		•	•		•		•		•	•	•	•
STATIC FIELDS			•		•		•	•	•	•				•			•							
PLANE WAVES	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
CYL./SPH. WAVES	•	•				•				•														
PROP. DISPERS. & ANISOTROP. MEDIA	•		•	•							•		•	•	•	•			•	•	•		•	•
TRANSM. LINES	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
WAVEGUIDES	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•		•
MICROSTRIPLINES	•	•	•		•		•								•				•	•		•		
DIELETRIC WAVEGUIDES	•	•	•		•		•						•		•				•	•		•		
DISTRIB. & LUMPED CIRCUITS	•		•		•		•		•	•			•							•		•	•	
CAVITIES	•			•	•	•	•	•			•	•						•	•		•			•
RADIATION FROM ELEMENT. SOURCES	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
ANTENNAS	•	•	•	•	•	•	•		•		•	•	•		•	•	•	•	•	•	•	•	•	•
FOUNDAMENTALS OF PROPAGATION			•						•			•												
GEOMETRICAL OPTICS			•	•						•			•		•	•					•	•		
NUMERICAL METHODS			•							•							•							

TABLE IV
CONTENTS OF THE COURSES ON MICROWAVES IN VARIOUS UNIVERSITIES

UNIVERSITY / SUBJECT	ANCONA	BARI	BOLOGNA	COSENZA	FIRENZE	GENOVA	MILANO	NAPOLI	PADOVA	PALERMO	PAVIA	PERUGIA	ROMA-1	ROMA-2	SALERNO	TORINO	TRIESTE	VERCELLI
REVIEW OF EM THEORY	•	•	•	•	•	•	•			•			•			•	•	•
METALLIC WAVEGUIDES	•	•	•		•	•	•	•	•	•		•	•	•		•	•	•
OPTICAL FIBERS & DIELECTRIC. WAVEG.	•	•	•		•	•	•	•	•				•	•	•	•	•	•
MICROSTRIPLINES	•	•	•	•	•	•	•		•			•	•	•	•	•	•	•
OPEN WAVEGUIDES	•	•						•						•			•	
DISTRIBUITED CIRCUITS	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•		•
FERRITES/ PLASMAS	•				•	•	•	•		•		•	•		•	•	•	•
JUNCTIONS & DISCONTINUITIES	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•
CAVITIES	•	•	•		•	•	•	•	•	•		•	•		•	•	•	•
PERIODIC STRUCTURES	•	•								•						•		•
GENERATORS AND ACTIVE CIRCUITS	•	•	•			•	•	•	•		•			•	•	•		•
NUMERICAL & ASYNTH. METODSS		•		•	•		•					•	•	•				
CAD		•		•			•					•	•					
MEASUREMENTS	•	•		•	•		•	•		•		•		•		•	•	•
ANTENNAS				•					•	•								
PROPAGATION									•	•								
NON CONVENTIONAL APPLICATIONS												•				•	•	•

TABLE V
CAD AND LABORATORY FACILITIES AND PH.D. PROGRAMS IN ITALIAN UNIVERSITIES

	CAD FACILITIES	LABS FACILITIES	PhD PROGRAM
ANCONA	Commercial packages	Network analyzer	Electromagnetics
BARI	Commercial packages	Network analyzer	Electronic Eng.
BOLOGNA			Electronic Eng.
COSENZA	Puff, CAD of arrays	Microwave bench	Computer and Telecomm. Eng.
FIRENZE	Puff, CAEME. In house softw.	Microwave bench, Network analyzer	Computer Science and Telecomm. Eng.
GENOVA	Commercial packages	Microwave bench,Network Analyzer, Anechoic Chamb., TEM Cell	Electronic and Comp. Eng.
MILANO	Commercial packages	Microwave bench, Network and spectrum analyzers	Electronic and Telecomm. Eng.
NAPOLI	♦	♦	Electronic Eng.
PADOVA	--	Spectrum Anal. , Radio link	Electronicsand Telecomm. Eng.
PALERMO	♦	♦	Electronic Eng.
PAVIA	Commercial packages	Network Analyzer	Information Technology
PERUGIA	Commercial packages	Network Analyzer	Electronic Eng.
ROMA 1	Commercial packages	Network Analyzer	Electronic Eng., Electromagn.&Elecrophysics
ROMA 2	Commercial packages	Network Analyzer	High Frequency Electronics
SALERNO	Commercial packages	Network Analyzer, Spectrum Analyzer	
TORINO	Commercial packages	Network Analyzer, Antenna Measuremets	Electronic Eng.
TRIESTE		Network Analyzer, Spectrum Analyzer	
VERCELLI	Commercial packages		

III. PRESENT STATUS OF MICROWAVE EDUCATION

As in many other countries, a great concern has also been felt in Italy about the declining interest of students toward electromagnetics. To investigate the reasons for that and single out possible remedies, a survey was promoted at the beginning of 1992. The results were presented at a meeting held in Rome on February 7, 1992, devoted to the Teaching of Electromagnetics in view of the application of the new law of 1989.

The meeting was, of course, far from being conclusive. Some ideas were, however, shared by all participants. The complicated mathematics associated with electromagnetics was recognized as the biggest obstacle for the teaching. Another

difficulty is that EM phenomena are scarcely intuitive, so that computer simulation (especially in time domain) should be largely employed. Finally, the teaching of electromagnetic compatibility, with its numerous implications on various fields including computers, should also be stressed in basic introductory courses.

The survey aimed at describing the status of the electromagnetic disciplines taught in Italian universities. The number of universities as well as Engineering Faculties and Electronic Engineering schools have increased dramatically from 1980 to 1992 as illustrated in Table I. In addition to Engineering schools with a long tradition, such as Bologna, Milan, Rome, Turin, etc., a number of new schools have been created in many relatively small cities, such as Benevento, Parma, Perugia, etc. Electronic Engineering graduates which were about 21% of total Engineering graduates in 1980–1985 rose to about 35% in 1990. Table I shows, however, that the total number of universities has had a larger increase (122%) than Engineering Schools (84%) and Electronic Engineering schools (85%).

The survey was also intended to find out the real contents of the disciplines, since it was felt that different subjects could be taught under the same titles in different universities. In spite of a number of differences between universities, however, a high degree of homogeneity exists as a result of the rigid traditional structure mentioned above.

The results of this survey have been reviewed, augmented, and updated (December 1992) and are presented here. As far as the disciplines are concerned, the data refer to the academic year 1992–1993. The data on the number of students, when available, refer to 1991–1992. Only the Laurea degree on Electronic Engineering has been considered, since those on Telecommunication Engineering are still too fragmentary.

Table II shows the disciplines with electromagnetic contents taught in Italian universities. When available, the approximate number of students for each course as well as the approximate number of graduates in Electronic Engineering are also quoted. The basic course of Electromagnetic Fields is taught in all 25 universities with a School of Electronic Engineering. Most universities (72%) also provide a course on *Microwaves*, the second traditional electromagnetic discipline. Another traditional discipline in the area of electromagnetics is *Antennas and Propagation*. Since the reform of 1989, this course has been replaced in most cases by either *Antennas* or *Propagation*; in two cases by both courses (University of Naples and Polytechnic of Turin). It can be noted that very few universities offer courses on *Optics* and related disciplines. Other gaps to be filled can be considered those of *Electromagnetic Compatibility* and *Remote Sensing* (both taught in only four universities).

Some universities, such as the Second University of Rome and the University of Florence, offer courses on *Microwave Electronics*. A somewhat similar course (*Electronic Devices II*, not quoted in the table) is taught at the Polytechnics of Turin and Milan. Such courses, however, are generally taught by teachers with an expertise in the area of electronic circuits and devices rather than in electromagnetics.

The contents of the basic course of *Electromagnetic Fields* is illustrated in Table III. This is the basic course on electromagnetics and is generally taught during the third year. It is compulsory for all Electronic Engineering as well as Telecommunication Engineering students (with a few exceptions such as the Polytechnic of Milan and the University of Padova).

A number of discrepancies are observed between courses at different universities. Most differences are due to some topics being treated in other courses. While Transmission Lines and Plane Waves are covered by all courses, Maxwell's Equations and the Basic Electromagnetic Theorems or the Constitutive Relations are in some cases omitted as they have been already treated in the preliminary course on *Physics* taught at the second year. Traditionally, the Electromagnetic Fields course (formerly called *Electromagnetic Fields and Circuits* till 1989) treated the Electrostatic Field, the Magnetostatic Field, and Electrodynamics. In recent years, most courses have concentrated on electrodynamics, guided waves, and fundamentals of radiation, leaving static fields to the course of *Physics*. In some other cases, topics such as waveguides and microstriplines are left to a subsequent course (typically *Microwaves*).

As far as the number of Students is concerned, it should be noted that the number of Electronic Engineering graduates increased dramatically in the last 12 years (from about 1500 during 1980–85, to 2500 in 1990, and 2700 in 1991), while the total number of Engineering graduates increased only slightly (from about 7000 in 1980 to 7250 in 1990).

It can be noted from Table II that the number of graduates is generally a fraction of the number of students attending the basic course on *Electromagnetic Fields*. This is mostly due to the increasing number of Electronic Engineering students, particularly for new established Faculties (e.g., Parma and Perugia) and, to a lesser extent, to students quitting school before graduation. The latter phenomenon, however, is a dramatic problem that occurs mostly during the first two years. It is one of the reasons for the push toward the institution of the Diploma degree. It is also observed that the Polytechnic of Milan has a somewhat peculiar situation with a quite low percentage of students attending the course of *Electromagnetic Fields*. This course, in fact, is optional for Electronic Engineering students specializing in Computer Science, Automatic Controls, or Bioengineering. The University of Padova is in a similar situation, although the Electromagnetic Fields course will become compulsory in the next years.

Table IV shows a comparison among all 18 courses on *Microwaves* taught at Italian universities. Here the scattering of the subjects is even more noticeable than for *Electromagnetic Fields*. The highest correlation is on subjects such as Metal Waveguides (14), Distributed Circuits (16), Junctions and Discontinuities (16), Cavities (14), Microstriplines (14), and Optical Fibers (14). Note that microwave systems are not covered. In addition, most courses are concentrated on passive circuits. Active circuits are usually left to electronic courses such as *Microwave Electronics* (where available).

For the same schools as in Table IV, additional information on the availability of Ph.D. programs in the area of Electromagnetics, as well as on CAD and labs facilities, is given in Table V. It is noted that almost all schools offer

commercial software packages and network analyzers (scalar or vector). A Ph.D. degree specifically on Electromagnetics exists only at the University of Ancona. In all other cases, Electromagnetics is a subsection of a more general Ph.D. degree such as Electronic Engineering, etc.

As a final remark, it should be mentioned that Engineering schools usually receive modest financial support from the Ministry of University to equip student laboratories. Similarly, industry support is lacking, also because Italy does not have as strong microwave industries as the U.S. As a consequence, the education has the tendency to stress more theoretical rather than practical aspects. Nevertheless, the quality of the education is rather high and comparable to that of other advanced countries. This is partly due to a system which, by tradition, still aims to a broad spectrum education, rather than to a high degree of specialization.

IV. Conclusions

Historically, Electronic Engineering studies have evolved in Italy with some delays and subject to many constraints due to a rigid central system. This has produced a considerable delay in the teaching of electromagnetics and specifically of microwaves. This situation has somewhat changed in the last 20 years, thanks to new laws that have substantially relaxed the constraints and allowed the introduction of new types and levels of degrees. In spite of a number of structural and economical problems, the quality of microwave education in Italy is comparable to that of most advanced countries. The problems with microwave education, such as the lack of interest of students toward such disciplines, is felt in Italy as in other countries such as the U.S. A more extensive use of computer simulation of EM fields, and stressing the teaching of electromagnetic compatibility, are viewed as first remedies against this trend.

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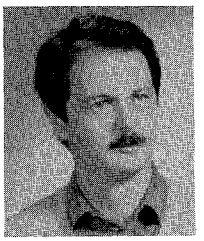
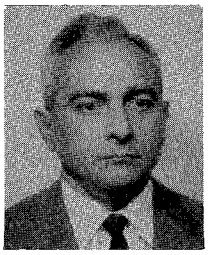


Roberto Sorrentino (M'77–SM'84–F'90) received the Doctor degree in electronic engineering from the University of Rome "La Sapienza," Rome, Italy, in 1971.

In 1971 he joined the Department of Electronics of the same University, where he became an Assistant Professor of Microwaves in 1974. He was also *Professore Incaricato* at the University of Catania (1975–76), at the University of Ancona (1976–77), and at the University of Rome "La Sapienza" (1977–1982), where he then was an Associate Professor from 1982 to 1986. In 1983 and 1986 he was appointed as a Research Fellow at the University of Texas at Austin. From 1986 to 1990 he was a Professor at the Second University of Rome "Tor Vergata." Since November 1990 he has been a Professor at University of Perugia, Perugia, Italy. His research activities have been concerned with electromagnetic wave propagation in anisotropic media, interaction of electromagnetic fields with biological tissues, and mainly with the analysis and design of microwaves and millimeter-wave passive circuits. He has contributed to the planar-circuit approach for the analysis of microstrip circuits and to the development of numerical techniques for the modeling of components in planar and quasi-planar configurations.

Dr. Sorrentino is a member of the editorial boards of the IEEE *Transactions on Microwave Theory and Techniques*, the *International Journal on Numerical Modeling*, and the *International Journal of Microwave and Millimeter-Wave Computer-Aided Engineering*.



Giovanni B. Stracca received the Dr. Ing. degree in electrical engineering from the University of Rome in 1949.

He worked at F.I. Magneti Marelli (1949–1960) and the GTE Telecomunicazioni S.p.A. (1961–1968), where he conducted, as Head of the Microwave Laboratory, R&D work on microwave devices for microwave radio links, long-distance circular waveguide systems, and satellite communication systems. In 1966 he was appointed Director of the Research Laboratories of GTE Telecomunicazioni S.p.A. From 1968 to 1974 he was with the Istituto di Elettrotecnica ed Elettronica of the University of Trieste, as Full Professor of Radiotecnica, and from 1974 with the Politecnico di Milano, where he is currently Full Professor of Microonde (*Microwaves*) in the Dipartimento di Elettronica e dell'Informazione. From 1984 to 1987 he was Vice Rector of Politecnico di Milano