

# THE LABORATORY OF WIRELESS AND MOBILE COMMUNICATIONS

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## Abstract

*The paper presents the basic information about establishing of the laboratory for Mobile Communications on the Dept. of Radio Electronics, Brno University of Technology. This information allows to experts from the practice to obtain the general notion about the extent of theoretical knowledge and practical experiences of our students in this field. This information can be also useful for the specialists from universities comparing simple their pedagogical activity in this field respecting the activity in another institute.*

## Keywords

Wireless and mobile communications, education

## 1. Introduction

In the last years, mobile communications have shown strong expansion both abroad and in the Czech republic. We can say that the mobile communications will dominantly participate in the transfer of information between two subjects anywhere on the globe in near future. New digital systems being used in mobile radio communications are operated upon quite new principles and use the latest technology development.

Universities have to follow all new trends in the field of mobile communications including their mediating to students of both graduate and post-graduate study programs. Therefore, the Faculty of Electrical Engineering and Computer Science of Brno University of Technology has introduced a new optional course "Wireless and Mobile Communications" under recommendation of the Specialization Board of "Electronics and Communications". After the following approving by the Scientific Board of the faculty, the new course was introduced in the teaching process for Master Study within 3 hours of lectures and 2 hours of laboratory exercises per week. On the Institute of Radio Electronics, this course is lectured since 1997 and is

very popular among students. The same course is lectured also for foreign students in English language since the academic year 1999/2000. For students of doctoral Study, the course named "Selected Topics of Wireless and Mobile Communications" has been opened in the academic year 1999/2000 within 3 hours of lectures per week.

## 2. Contents of the course

Good understanding of mobile communication systems is conditioned by some theoretical knowledge of students. These theoretical fundamentals can be obtained mainly in obligatory courses "Theory of Communication", "Data Communication" and "High Frequency and Microwave Techniques". Passing these obligatory courses, students of 4<sup>th</sup> class can choose the course "Wireless and Mobile Communications" the content structure of which can be described in following items:

- The distribution of frequency spectrum, the distribution of radio communication systems, general circuit diagram of radio communication system, basic relations.
- Signal processing in radio communication systems (source encoding, channel encoding, interleaving, digital modulations).
- The basic philosophy of the function of radio communication systems.
- The spurious effects affecting signals and possibilities to limit it (equalization, diversity reception, etc.).
- Radio telephone systems (NMT 450, GSM 900, GSM 1800, including GPRS, HSCSD and EDGE, IS-95).
- Cordless telephony systems (CT2, DECT).
- Radio paging (RDS, ERMES).
- Data communication systems (MOBITEX).
- Advanced radio communication systems (Universal Mobile Telecommunication System UMTS, Universal Bluetooth System).

Finishing this course, students of 5<sup>th</sup> class can select from offer of optional courses, which continue in and/or complete the previous one: "Radio Receivers and Transmitters", "Radio Relay and Satellite Communication", "Radio Communication Design" or "Signal processors".

The theoretical knowledge has to be completed by the corresponding practical form of teaching, which include even the individual development of students. Thanks to the faculty cooperation with several Czech telecommunication companies, first of all with RadioMobil and Wirelesscom

Praha (which is ensured by reciprocal advantage contracts), the students can see, within the excursions, the operation of latest technology being used in today's modern mobile systems. Moreover, the popular excursions had to be completed by some form of laboratory measuring and individual work of students.

### 3. Laboratory of mobile communications

In order to set up the laboratory of mobile communications, a project "The Laboratory for practical training of the Mobile Communication Problems" was proposed. The project was approved in selective searching process within the subvention of two million crowns from the Czech Ministry of Education. The project was aimed to building-up the laboratory and to creating a set of modern laboratory experimental tasks in the branch of wireless and mobile communications. The conception of project is in coincidence with the world trend of technical universities to enhance both the practical and the individual work of students.

Building-up the laboratory was a sophisticated task, that could not be fully covered by financial funds granted by the Ministry. Therefore, the laboratory was financed even by the Institute of Radio Electronics together with the help of Faculty of Electrical Engineering and Computer Science. The establishing of laboratory is a part of the research program "Research of Electronic Communication Systems and Technologies" (CEZ: MSM 26200011, VUT: CZ 400011).

Building-up the laboratory, cooperation with several companies was entered. The company RadioMobil supported us not only with material in costs of several million crowns but too by consultations concerning the contents of laboratory experiments, including the ensuring of needful software together with delivered computers, the printout of printed lectures for course "Wireless and Mobile Communications" etc. All the above activities enabled to built-up the laboratory having both unique measuring equipment and possibilities to solve modern laboratory tasks.

The following measuring equipment was purchased:

- Digital radio communication tester CTS 65 R&S with accessories (436 330 Kč)
- Digital radio communication tester CMD 53 R&S with accessories (741 730 Kč)
- Spectrum analyser R 3132 R&S (509 290 Kč)

Simultaneously, several special books of Artech House were ordered.

Thanks to the help RadioMobil, the base station BTS of GSM system, produced by Motorola, was installed in the laboratory together with two antenna systems (one is the diversity system). BTS has two HF power stages (two radio duplex channels) with maximum output power 50 W

in each. The useful output power is limited in following circuits, so that radiated power in any place in laboratory and in neighbourhood does not exceed the health limits. The control of the base station (the change of settings) needs to connect the station to controller BTS of Paegas network. In regard to distance 1.5 km to the nearest controller BSC, the connection of both subsystems was done using an optical cable connecting both buildings within academic metropolitan net.



Fig. 1 Photograph of the base station MOTOROLA in the Laboratory of wireless and mobile communications.

For the laboratory exercises, following 8 experiments were prepared and realized:

1. The check of mobile station Motorola for GSM system: verification of synchronizing functions, up-dating of received data, setting-up of both the incoming and outgoing calls, control of high frequency output power, measuring of PEP (Peak Envelope Power) and the test of echo.
2. The check of mobile station Ericsson for system GSM (or DECT) - auto-test for check of all functions of data terminal, measuring the tolerance diagram of time slot - power ramping function.
3. The synthesiser with undirected coherent synthesis: the laboratory aid with Motorola integrated circuit. The checking of output signal frequency stability, measuring of phase noise of the output signal. Interleaving on PC demonstration.

4. The identification of basic capabilities of Ericsson's TEMS routine. The tracking of both the call processing and call decay in GSM network using program TEMS.
5. Check of mobile station Motorola for GSM system - measuring of both the frequency and phase error, analysis of high dynamic bursts, quick spectra measuring during switching terminal and modulation, narrow-band signal spectrum analysis and the testing of SIM card.
6. The check of mobile station Ericsson for system GSM: the analysis of demodulated signal, the check of timing and its accuracy and error rate measuring of BER.
7. The check of MS Nokia for system GSM - the check of HF blocks frequency characteristics, the display and determination of single bursts in signalling channels FCCH (frequency synchronization), SCH (time synchronizing) and BCCH (important data for MS).
8. The observation of mobile station during hand over transfer using TEMS routine. The data transmission in GSM network using modems - determination of transmission rate and error rate BER.

In September 2000, the visiting day was organized by the Institute of Radio Electronics in order for interested scientific, research, technical and academic workers. Visiting day was aimed to present results of both the Institute of Radio Electronics and single workers. Also the established „Laboratory of Wireless and Mobile Communications and High Frequency Technique“ was presented.

## 4. Conclusion

Teaching the course "Wireless and mobile communications", where laboratory will be dominant exploited, will begin in summer term of the academic year 2000/01. In the course, 51 students are registered. Simultaneously, teaching "Selected topics of wireless and mobile communications" for doctoral study will be carried out.

Exploitation of the laboratory and also the measuring laboratory equipment is planned also in courses "HF and Microwave Techniques" (obligatory course, 120 students per year), "Radio Receivers and a Transmitters" (optional course, 30 students per year) and in "Radio Relay and Satellite Communications" (optional course, 30 students per year). The exploitation of laboratory is planned also for a newly prepared specialization "Electronics and Communication Techniques" and "Teleinformatics" for bachelor study and "Electronics and Radio Communication" and "Telecommunication and Informatics Techniques" for master study.

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**Stanislav HANUS** was born in Brno, Czech Republic, in 1950. He received the Ing. (MSc.) degree and CSc. (PhD.) degree from the Brno University of Technology. He is associate professor at the Department of Radio Electronics, Faculty of Electrical Engineering and Computer Science in Brno. His research is concentrated on Wireless and Mobile Communications.