US-China Education Review A 10 (2012) 868-874
Earlier title: US-China Education Review, ISSN 1548-6613

Remote Access to Wireless Communications Systems Laboratory—New Technology Approach*

Nadezhda Kafadarova, Sotir Sotirov, Mihail Milev
Plovdiv University "Paisii Hilendarski", Plovdiv, Bulgaria

Technology nowadays enables the remote access to laboratory equipment and instruments via Internet. This is especially useful in engineering education, where students can conduct laboratory experiment remotely. Such remote laboratory access can enable student to use expensive laboratory equipment, which is not usually available to students. In this paper, we present a method of creating a Web-based Remote Laboratory Experimentation in the master degree course "Wireless Communications Systems" which is part of "ICS (Information and Communication Systems)" and "Investment Management in Telecommunications" curriculums. This is done within the RIPLECS Project (Retrieved from http://riplecs.dipseil.net/) and the NI2011 FF005 Research Project "Implementation of Project-Based Learning in an Interdisciplinary Master Program".

Keywords: remote access, remote laboratory, wireless telecommunications, EASCB (external antenna-switching controller board)

Introduction

Web-based course management and delivery software are becoming common in many areas of education, but the facilities provided by such systems do not support practical laboratory work (Dervis, Atilla, & Gökhan, 2003).

The accelerated pace at which both the computing and telecommunications worlds are advancing along with their ever increasing availability is creating a new relationship between the teaching process and the way students are learning, thus revolutionizing the way this process is carried out altogether. Experimental work is a vital component of science and engineering teaching at all levels.

Remote Laboratory

The increasing use of multimedia packages or "virtual science" has much to offer in terms of teaching scientific facts and principles, but does not generally focus on the process of scientific enquiry or engineering practice. However, the real and practical experience cannot be excluded from this process since it would have a negative impact on the learning process. Likewise, collaborative work and at-a-distance projects are beginning

* **Acknowledgements:** This paper is supported by RIPLECS Project No. 517836-LLP-1-2011-1-ES-ERASMUS-ESMO, and NI2011 FF005-Project.

Nadezhda Kafadarova, Ph.D., Department of ECIT (Electronics, Communication and Information Technologies), Plovdiv University "Paisii Hilendarski".

Sotir Sotirov, M.Sc., Department of ECIT (Electronics, Communication and Information Technologies), Plovdiv University "Paisii Hilendarski".

Mihail Milev, B.Sc., Department of ECIT (Electronics, Communication and Information Technologies), Plovdiv University "Paisii Hilendarski".

to pay more attention to the engineering world. With the integration of telecommunication technologies and computer science with virtual instrumentation, real, remote laboratories can be developed and accessed through Internet in real time, ensuring a richer collaborative experience for the student while avoiding some of the growing limitations of traditional laboratories, such as the lack of enough work area, expensive instrumentation, lack of personnel, time assigned to a laboratory, and their availability in non-working office hours (Zorica, Jan, & Andrew, 2003).

Wireless Communications

Wireless communications is, by any measure, the fastest growing segment of the communication industry. Cellular systems have experienced exponential growth over the last decade and there are currently around two billion users worldwide. In addition, the explosive growth of wireless systems coupled with the proliferation of laptop computers indicates a bright future of wireless networks, both as stand-alone-systems and as part of the larger network infrastructure.

Antennas are essential components of all equipment for wireless communications. They are instruments for transmitting and receiving waves. Antennas are used in systems, such as radio broadcasting, communications receivers, radar, cell phones, and satellite communications. Parameters used to test the performance of an antenna are radiation pattern, directivity, gain, polarization, impedance, and bandwidth. As radiation pattern and gain are considered as basic parameters of an antenna, they are most commonly studied in student’s tutorials.

Architecture of Remote Laboratory for Wireless Telecommunications

The overall objective of the RIPLECS Project is to develop a remote laboratory for wireless communications, where students at remote sites can perform actual experiments using actual hardware equipment and tools concurrently.

The main purpose of NI2011 FF005 Project is to investigate experimentally the effect of performance-cantered platform for the design, composition, and reuse of open course learning materials by means of development of an interdisciplinary curriculum in investment management in telecommunications for a joint master degree. This project is being developed within the research project competition “Research 2011/2012” of the “Research and development” division of Plovdiv University. The keywords for the project are: DIPSEIL (Distributed Internet-based Performance Support Environment for Individualized Learning) (Retrieved from http://www.dipseil.net/), master program, education, and interdisciplinary education (Kafadarova, Stoyanova-Petrova, Mileva, & Raikova, 2011).

The course “Wireless Communication Systems” gives students an overview of the characteristics of different types of antennas used in wireless communications and the wave propagation in mobile communication.

The course “Wireless Communication Systems” is divided into two main educational parts: The first part gives students knowledge about the characteristics of different types of antennas used in wireless communications. The second part is connected with the wave propagation in mobile communications. The students have to fulfil practical tasks, connected with understanding the basic functions of the antennas as well as mobile communication propagation characteristics. There are seven antennas which must be changed in the system automatically without participation of an operator. In this paper, the authors describe their idea of how the automatic change is done. The proposed method is by means of an EASCB (external antenna-switching controller board). This automated system provides rapid installation of the correct antenna for the appropriate application and experiment, allowing the teacher not to be in the laboratory during each experiment. The creation of that innovative automated system for antenna change is the main part of the Wireless Communications Remote Lab.

The practical part consists of several assignments dealing with understanding the basic functions of the antennas as well as mobile communication propagation characteristics experiments.

The system configuration is shown in Figure 1.

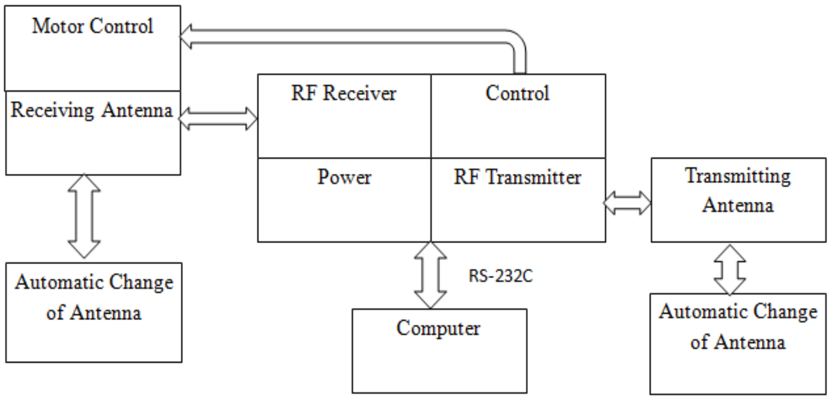

Figure 1. System configuration.

The different types of antennas are changed in the system automatically without participation of an operator. This automatic change is made by means of an EASCB (external antenna-switching controller board). This automated system provides rapid installation of the correct antenna for the appropriate application and experiment, allowing the teacher not to be in the laboratory during each experiment. The innovative automated system for antenna change is the main part of the Wireless Communications Remote Lab.

Under the normal circumstance, wave characteristics are hard to measure and analyze due to the nature of wave being so much dependent on surrounding environment and fluctuating. Therefore, the educational training system has a built in hardware circuit which creates a wave environment, offering a practical experience on wave environment. In other words, by means of that educational system, emulation on real wave environment is possible, so that students are able to understand and analyze the wave environment correctly.

Educational Objectives and Performance-Based Learning

The learning goals of the course are, firstly, to measure the radiation patterns of various types of antennas to get a clear picture on their radiation characteristics. Secondly, wave characteristics experiment in mobile communication is carried out to identify fading, time delay characteristics, voltage standing wave, Doppler's frequency, etc.. It is done using WATS-2002 (Wave Propagation and Antenna Experiments of Man & Tel Co., Ltd.) equipment.

The subject matter is divided into educational objectives. These objectives are learnt in a performance-based manner.

The basic elements and devices used in the task experiments are shown in Figure 2.

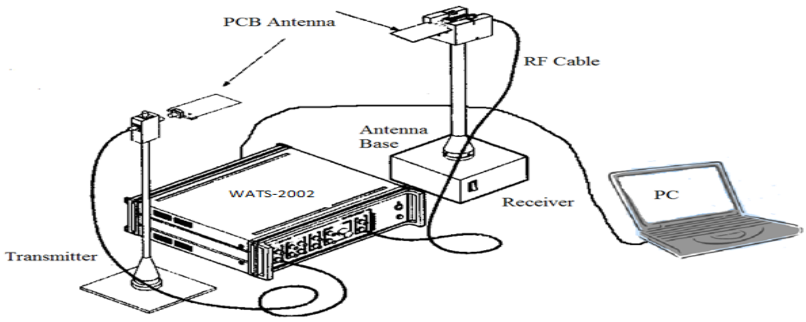

Figure 2. Basic components of the experimental setup.

Antenna Characteristics

In this section, the students learn the basic characteristics of Dipole, Yagi, Monopole, Loop, Inverted F, Ceramic chip, and Patch and Array antennas. They gain experience in measuring the radiation pattern of E plane and H plane. An example of a radiation pattern of a half wavelength Dipole antenna is shown in Figure 3.

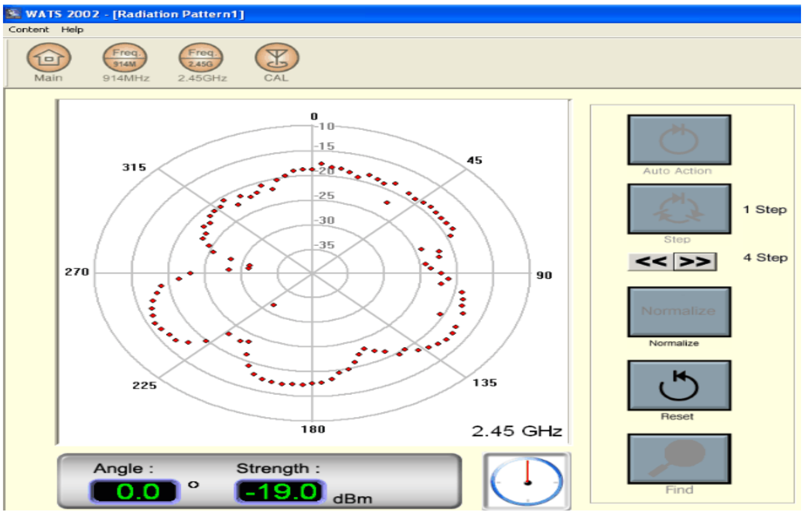

Figure 3. Radiation pattern measuring experiment screen.

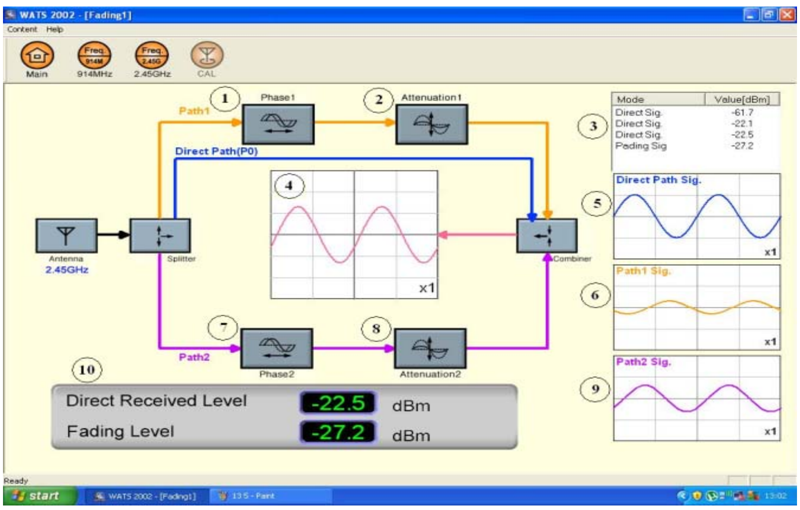

Figure 4. Multi-path fading experiment screen.

Mobile Communication Propagation

In this section, the students are taught to understand the characteristics of wave propagation in mobile communications and identify fading, phase delay characteristics, standing wave, Doppler frequency, etc.. A multi-path fading experiment screen is shown in Figure 4.

EASCB (External Antenna-Witching Controller Board)

Current Technical Situation

As already mentioned in the previous chapter, we would like to automate the swapping of the antennas on the given telecommunications kit—WATS-2002. The kit has two outputs—one for 900 MHz bandwidth and one for 2.4 GHz bandwidth. It also has the corresponding inputs—900 MHz and 2.4 GHz. The transmission channel is built from 10 output antennas and 7 receiving antennas. At a single time only one antenna may transmit and one may receive data. Figure 5 shows an example situation, where one of the antennas is emitting at 900 MHz and one is receiving at the same bandwidth.

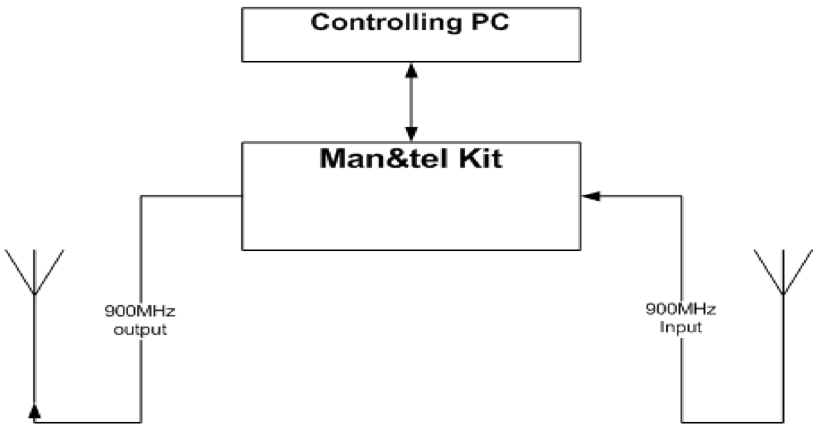

Figure 5. 900 MHz transmission and reception.

The kit does not support simultaneous sending and receiving over the two bandwidths. Only one of them can be selected during exercise.

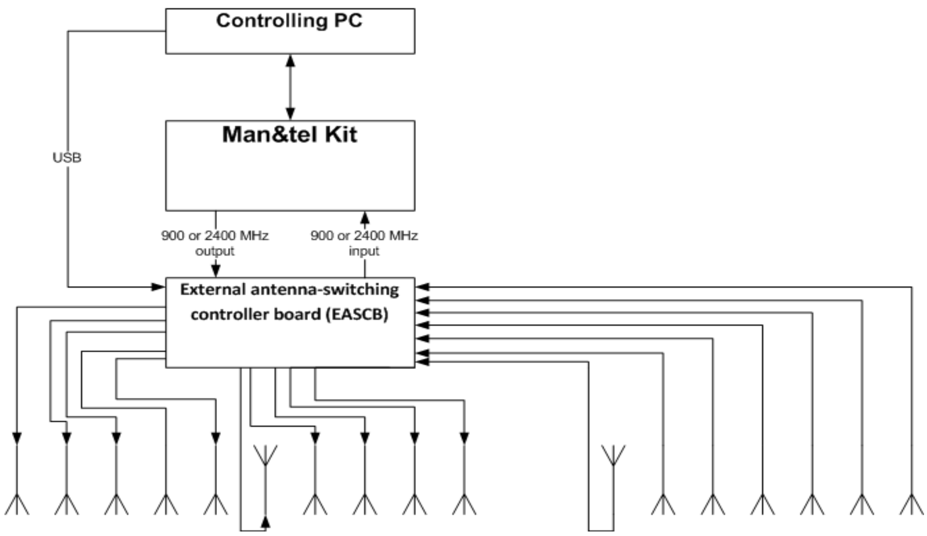

Figure 6. Plan of the EASCB system, the antennas pointing to the top are the transmitting/receiving ones.

Because of the different types of tasks we have to fulfill with the kit, it is very often needed to switch between antennas—This means a technically educated person must be next to the kit and manually disconnect and connect antennas, taking care that no interference or overpowering takes place. We would like to automate this process, because of two reasons: (1) make the configuration of the kit remotely accessible and easier to do; and (2) make sure that the above mentioned problems—interference and overpowering, do not appear. Figure 6 shows the idea of the automation process and how the final solution for the external controller should look like.

Problems Occurring With High-Frequency Signals

Dealing with such high frequencies is not an easy task, because of several problems: (1) high-frequency signals flowing through cables cause magnetic fields around the cables and closely situated devices—the so-called magnetic induction; (2) high-frequency signals can be very easily attenuated; (3) keeping signal integrity of high-frequency signals is very hard and if not done properly could cause data distortion or complete loss; and (4) standing-wave problems will make the signal to noise ratio—SNR, smaller.

All of these are problems, that the kit has already overcome, but adding a new external node can bring them back and will make fulfilling tasks harder, if not impossible. We must address these problems and make sure that we overcome them.

Possible Solutions

Our main goal now is to propose the best solution to overcome the problems with the system as mentioned above. We have considered some possible solutions, such as using analog relays, transistors, or high-frequency analog switch and/or analog multiplexer. After a detailed study of the advantages and disadvantages of these elements, we have come to the conclusion that the only possible solution that is left is to search for high-frequency analog switch and/or analog multiplexer. It should be able to let pass frequencies around 2.4 GHz with 0 dB or not less than -2−2.5 dB.

After an extensive search and comparison we decided to stop on the chip ADG904 by Analog Devices©. It is offered in two versions—ADG904 and ADG904R. The second version does not have the 50 Ohm termination at all inputs/outputs. This will cause the development of a standing wave, thus reducing the SNR. That is why we decided on the standard ADG904—absorptive version. It is a 4:1 MUX/SPT4 chip, which means we can use it either as a one-input, four-output device; or in reverse, four-input, one-output. In order to meet our requirements we will have to use four such multiplexers.

The next thing we have to consider is how to control the multiplexers. An easy way seems to be via direct PC (personal computer) parallel or serial port. For each multiplexer, we need three signal lines, so for four multiplexers we will need 12 total connections. Modern computers (especially laptops) do not have parallel or serial ports. They only have USB (universal serial bus). The USB cable has four connections, two of which are fixed—power line and ground line, leaving only two for communication.

We decided to use an USB chip, which will be controlled via USB connection, and on the other side, it will control the multiplexers. The cheapest and easiest to employ is PIC 18F4550—by Microchip©. It costs around 5€ (depends on the dealer) and is easy and cheap to program. It also comes in DIP (dual inline package) package, making it easy to solder and use on a circuit board. It has an integrated USB interface and is very easy to configure on the destination machine as a HID (human interface design) device.

Conclusions

The idea of implementation of a remote access experimental laboratory for “Wireless Communication Systems” has being presented. The future work in this area will concentrate on realization of the EASCB and extending the range of experiments available in the system and on implementing help systems for the more complex experiments detailed in the experimental roadmap.

References

Dervis, Z. D., Atilla, B., & Gökhan, Ö. (2003). A novel approach to remote laboratories. In *The 33rd Frontiers in Education Conference (FIE2003)* (Vol. 1, pp. T3E-8-T3E-12).

Zorica, N., Jan, M., & Andrew, N. (2003). Remote laboratories versus virtual and real laboratories. In *The 33rd Frontiers in Education Conference (FIE2003)* (Vol. 1, pp. T3E-1-T3E-6).