Remote Access to Wireless Communications Systems Laboratory - New Technology Approach

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1. Introduction

Web-based course management and delivery software is becoming common in many areas of education but the facilities provided by such systems do not support practical laboratory work [1].

The accelerated pace at which both the computing and telecommunications worlds are advancing, along with their ever increasing availability, are 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.

1.1 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 in the learning process. Likewise, collaborative work and at-a-distance projects are beginning to have more attention in 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 [2].

1.2 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 indicate 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.

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

Following is the system configuration as shown on the figure below.

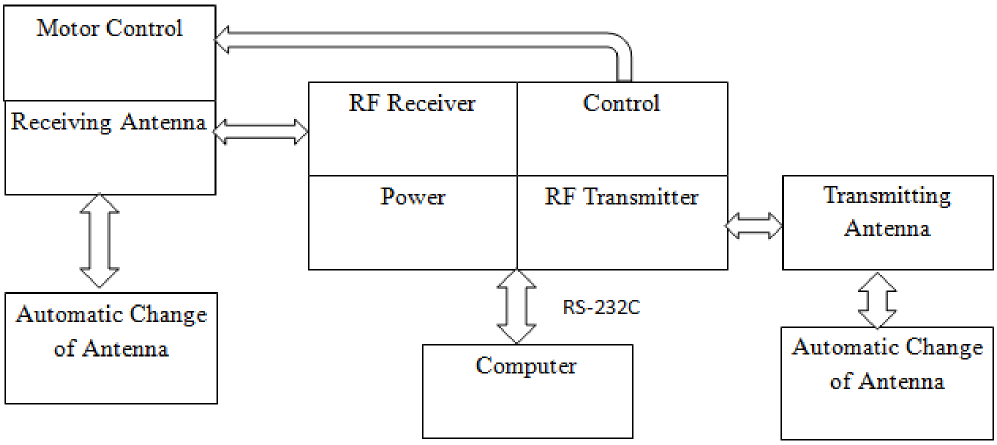

Fig.1 System Configuration

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 external antenna-switching controller board (EASCB). 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.

2.1 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 are carried out to identify fading, time delay characteristics, voltage standing wave, Doppler's frequency and etc. It is done using WATS-2002 equipment [3].
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 on fig.2.

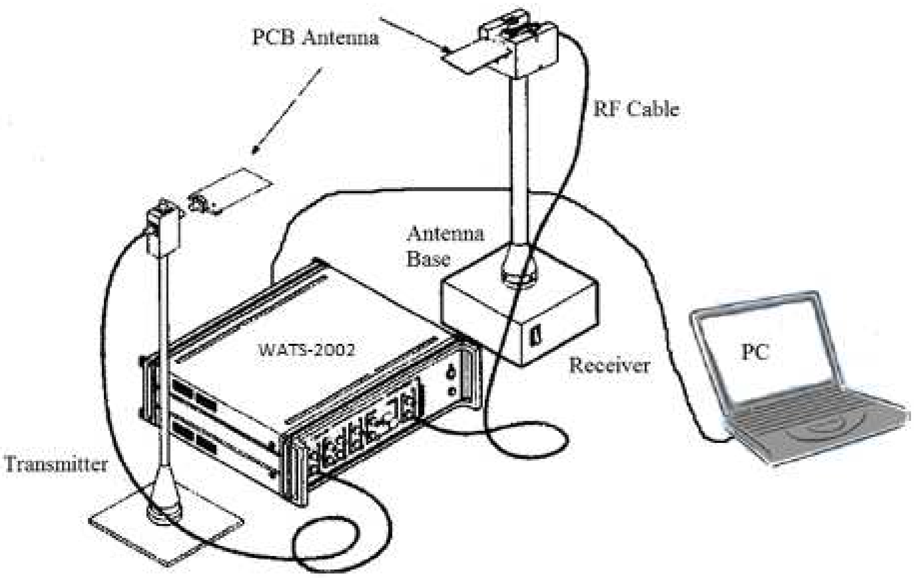

Fig.2 Basic components of the experimental setup

2.2 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 on Fig.3.

2.3 Mobile Communication Propagation

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

Fig.3 Radiation pattern measuring experiment screen

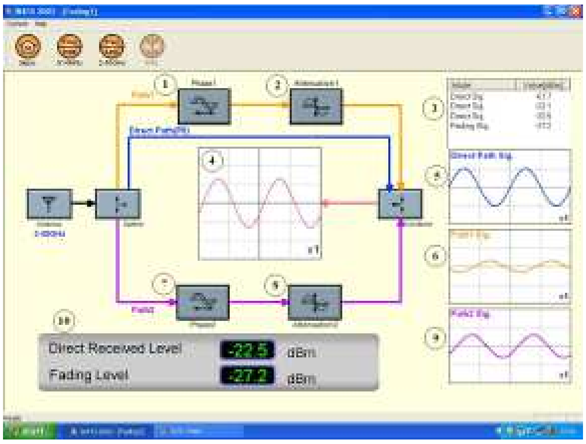

Fig.4 Multi-path fading experiment screen

3 External antenna-switching controller board (EASCB)

3.1 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 of Man&Tel Co.,Ltd. The kit has two outputs – one for 900MHz bandwidth and one for 2.4GHz bandwidth. It also has the corresponding inputs – 900MHz and 2.4GHz. 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 900MHz and one is receiving at the same bandwidth.

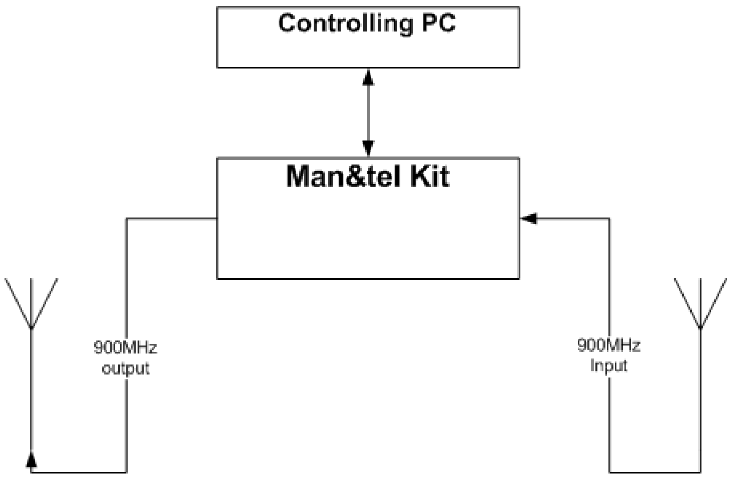

Fig.5 900MHz transmission and reception

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

Because of the different type 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; 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.

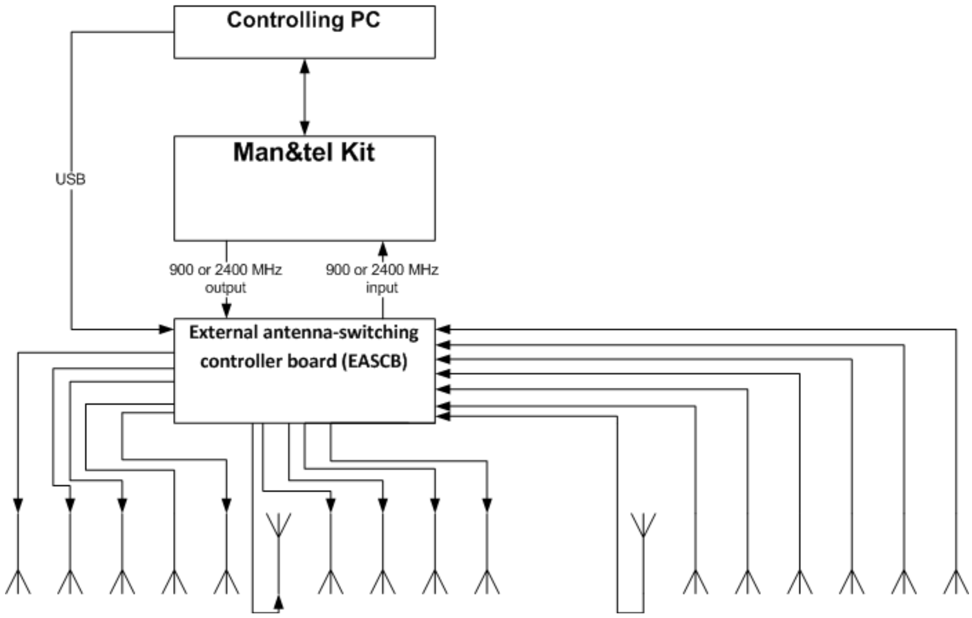

Fig.6 Plan of the EASCB system, the antennas pointing to the top are the transmitting/receiving ones

3.2 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; 4) standing-wave problems which 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.

3.3 Possible solutions

Our main goal now is to propose the best solution to overcome the problems with the system, 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 2.4GHz with 0dB or not less than -2 - -2.5dB.

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 50Ohm termination at all inputs/outputs. This will cause the development of a standing wave, thus reducing the signal to noise ratio. That is why we decided on the standard ADG904 – absorptive, version. It is a 4:1MUX/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 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. 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 it on the other side 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.

4 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 External antenna-switching controller board (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.

Acknowledgements

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