Development of a Wireless Communications Course for Electronics Engineering Technology (EET) Curriculum

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Abstract

Wireless communications is one of the most rapidly developing segments of the telecommunications industry. All segments of the wireless industry - cellular, personal communication services (PCS), paging, and specialized mobile radio (SMR) - are expected to grow at double-digit rates. In 1993, wireless services accounted for only $40 billion or 9% of the $640 billion telecommunications market, but by the year 2000, wireless is expected to control $200 billion or 18%, of an expected $1.1 trillion telecommunications market [1].

This phenomenal growth in wireless communications has put new demands on engineering technology curricula. Industry seeks graduates with appropriate background and training in wireless technologies. Electronics engineering technology (EET) graduates are not only expected to understand the theory of state-of-the-art wireless technologies, but also to exhibit hands-on analytical and problem solving skills.

To address these changing industrial needs, it is imperative that new courses in wireless technologies be developed and incorporated into the Electronics Engineering Technology program. To help achieve this goal, a survey was conducted in the wireless industry to determine the required level of training for EET graduates. This paper describes a proposed wireless technology lecture/laboratory course implementing the future trends identified through feedback from the wireless industry.

Introduction

"It is dangerous to put limits on wireless."
- Guglielmo Marconi (1932) [2]

Nearly a century ago, Marconi transmitted the first radio signals. Fifty years later, AT&T's Bell Laboratories invented cellular technology. Today, cellular industry is probably the world's fastest growing major industry, with the cellular technology playing a pivotal role in how people communicate around the world [3]. In 1983, less than 10 countries had cellular systems. By 1993, there were approximately 140 countries with cellular service. In 1993, the North American cellular market grew 43 percent to 16 million and western Europe grew 47 percent to 8.8 million. By contrast, eastern Europe grew 129 percent, while Malaysia grew by 64 percent, Argentina by 220 percent, and China by 300 percent.

According to wireless consulting firm EMCI's report on world cellular markets, there will be 53.6 million subscribers worldwide by 1996. The U.S. will account for approximately 45 percent, Western Europe 25 percent; Asia will almost catch with Western Europe; and Latin America, Africa, Eastern Europe, the Middle East and the Caribbean will account for 5 percent. In developed countries, cellular technology is a valuable productivity tool that has rapidly evolved into a personal communication service. In developing countries, cellular technology is providing access to telecommunications that is not possible, in many cases, with existing landline infrastructure. EMCI believes that cellular growth will continue to be strong over the next few years, reaching nearly 90 million subscribers by 1998 [4].

The speed of developments in the wireless industry is phenomenal. For example, it took cellular phone manufacturers eight hours to make a cellular phone in 1988; 30 minutes in 1992. Today it takes a mere 12 minutes, and this is a telephone containing computer capacity of between 30 million and 40 million instructions per second, equivalent to the power of mainframes of only a few years ago [5].

Impetus for new curricula

The half-life of an engineer's technical skills - how long it takes for half of everything an engineer knows about his or her field to become obsolete - is becoming strikingly short. According to the National University Continuing Education Association, for mechanical engineers it is 7.5 years; electrical engineers, 5 years; software engineers, a mere 2.5 years [6]. These estimates were devised almost a decade ago; considering the rapid pace of technological growth, those numbers are surely even smaller today.

The rapid growth in wireless technology coupled with the shortened "half-life" of engineers, has created a shortage of qualified RF and microwave engineers during the past two years [7]. To address this shortcoming a number of colleges and universities have revised existing curricula and offered new courses in the areas of microwave techniques, RF circuits, and communications systems.

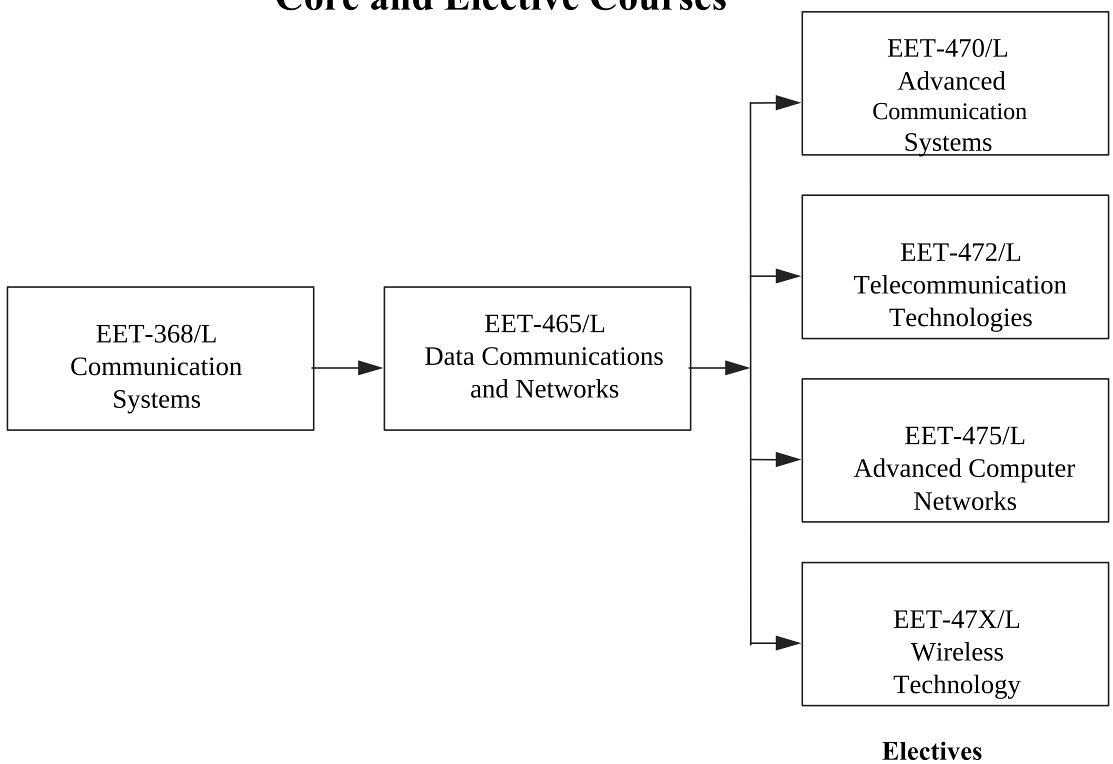
Development of a wireless course

Rapid technological growth has put new demands on engineering technology curricula. Industry seeks graduates with appropriate background and training in wireless technology. Electronics Engineering Technology (EET) graduates are not only expected to understand the theory of start-of-the-art telecommunications networks such as wireless technology, but also exhibit hands-on lab experience and skills with RF equipment and tools. To address these changing industrial needs, it is imperative that a wireless technology course be incorporated in the DeVry's Electronics Engineering Technology (EET) curricula. The new course should provide the graduates with knowledge of current wireless technologies, identify the emerging technologies and standards, and more importantly develop hands-on skills with RF equipment to implement and service wireless systems.

Electronic Communications Course Sequence

At DeVry, the EET electronic communications course sequence consists of two core and several elective courses (Figure 1). The first core course in the sequence, EET-368 (Communication Systems), introduces students to fundamental concepts and theories of electronic communications systems with emphasis on analog communication sub-systems, and provides a foundation for other communications courses. The course begins with basic concepts of a typical communication system block diagram (transmitter, channel and receivers). During the course, the domains of signal analysis, signal impairments, and signal processing by various sub-systems are covered by exploring Fourier transform, noise, analog & digital modulation and demodulation techniques, transmission lines and antennas. The second core course, EET-465 (Data Communications and Networks), covers concepts of digital data communications and computer networks by exploring information theory, telephone system, modems, protocols, and software/hardware aspects of local area networks (LANs). The proposed wireless technology course will be offered as an elective in conjunction with other electives: Telecommunication Technologies, Advanced Computer Networks and Advanced Communication Systems. "Telecommunication Technologies" focuses on public switched telephone networks; "Advanced Computer Networks" addresses the design and implementation of enterprise networks; and "Advanced Communications Systems" explores the areas of lightwave technology, satellite and wireless systems.

Figure 1. EET Communications Course Sequence
Core and Elective Courses



Industry survey

A survey was conducted in the wireless industry to determine the required cognitive level of training for EET graduates and to seek input regarding scope of the proposed course. Following is a summary of the competencies required of the engineers and technologists based on the results of the survey.

- Knowledge of the important underlying technologies
    - Modulation schemes- analog and digital
    - Coding schemes -protocols
    - Antennas
- Design and analysis of wireless systems
    - Hardware and software
    - Peripherals
- RF tests
    - Transmitter performance
    - Receiver performance
        - Tests versus major equipment

Troubleshooting at the networks level

- Environmental and social issues
    - Antenna location and aesthetics
    - Battery disposal
    - Health concerns
    - Communication for safety

The contents of the proposed course support the above competencies; further, the cognitive level of coverage was based on the faculty's interpretation of the results from the industry survey. Figure 2 depicts the wireless technologies/services employers would like to be covered in the proposed course. Figure 3 identifies the level of competencies developed. Figure 4 illustrates the desired modulation schemes. Figure 5 shows desired techniques/methods for implementing the laboratory course, and figure 6 gives the type of equipment used to test performance of wireless systems and the level of proficiency desired in graduates. The following sections describe the contents of the wireless course:

Theory course

Historical perspective

Emerging Technologies

Wireless services
- Value Added Services
- Carrier
- Cable
- Cellular
- Paging
- SMR
- Satellite

Wireless Systems
- Hardware/Software
- Peripherals/Components
- Microwave/Satellite

Analog cellular systems
- Cell Types
- Mobile Switching
- FDA
- Frequency Planning

Digital cellular systems
GSM
TDMA
CDMA

Satellite systems
LEOs
MEOs

PCS
Architecture
TDMA-AMPS systems
CDMA-AMPS systems
GSM - based systems

Digital Modulation Schemes
Speech encoding
FSK
PSK
QPSK
MSK
CPM
QAM

Wireless Regulations
U.S.
International

Future Trends

Laboratory course

The laboratory projects include both systems and subsystems level experiments. However, knowledge of the various tests for cellular equipment and the interpretation of the results are probably the most valuable skills to be developed in this course for engineering technologists. This laboratory thus focuses on wireless testing methods.

Design projects

1. Using software tools for basic commercial cell site design
2. Designing a frequency plan using a commercial frequency planning tool

Experiments on Cellular Testing

1. Transmitter Tests: Frequency, Hum and Noise, Distortion, Audio, Isolation, and Power
2. Receiver Tests: SINAD (signal strength compared to noise and distortion), Sensitivity,
3. Diversity, Audio Balance, Supervisory Audio Tone (SAT), AM Rejection, Signal Strength Indicator Frequency (SSI), Frequency Response, etc.
3. Digital Tests: Monitoring select lines, Power Steps, Bit Error Rate, Adjacent channel Selectivity, Intermodulation Immunity, Spurious Response Immunity, etc.

In addition to laboratory experiments/projects, the other strategies include visiting a commercial cell site, and serving a cell site internship. The internship projects would provide students an opportunity to manage/engineer a cell site and to perform various tests and engineering measurements. The laboratory work will also be supplemented with the use of videos covering various facets of wireless measurements/analysis that are difficult to duplicate in laboratories.

Conclusion

The exponential growth of wireless technology over the past decade has created a critical shortage of RF engineers/technologists. The proposed wireless technology course will not only provide the theoretical foundation of the state-of-the-art wireless technologies for EET graduates but will also enable them to develop required hands-on analytical and problem solving skills, thus enabling EET graduates to become better prepared for challenges of a rapidly changing wireless industry.

References

1. Parker, Tammy. "The Wireless Future," Convergence, October 1995, p. 33.
2. Mangir, Tulin E. "Wireless via Satellite: Systems for Personal/Mobile Communication and Computation," Applied Microwave & Wireless, January/February 1997, p.24.
3. Sheth, Jagdish N. and Sisodia, Rajendra S. "Cellular Communications: The First Decade," Worldwide Wireless Review, 1995, p.3.
4. Sheth, Jagdish N. and Sisodia, Rajendra S, "Cellular Communications: What's Ahead," 1994-95 Annual Review of Communications, p.802.
5. Quigley, Paul. "Watchword For The Future-Global Mobile Communications," Financial Times, March 16, 1994, Survey of Information and Communications Technology (14); Page VIII.
6. Smerdon, Ernest T. "It takes a Lifetime," ASEE Prism, December 1996, p. 56
7. Electronic Engineering Times, December 9, 1996, p. 102.

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AMIN KARIM is the curriculum manager of the EET programs for fourteen DeVry campuses in the United States and Canada. Before joining DeVry in 1991, he served as a faculty member, as a department chair, and as a dean of engineering technology programs. He received his MSEE from Texas A & M University and completed all required coursework for the Ph.D from the University of Wisconsin. He has worked as an engineer for more than twelve years.

Figure 2. Which technologies/services should be covered in the proposed course?

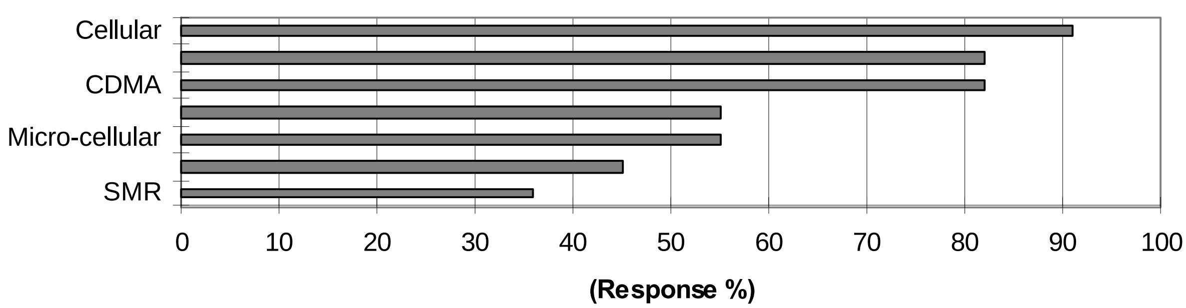

Figure 3. What should be the level of coverage of wireless technologies?

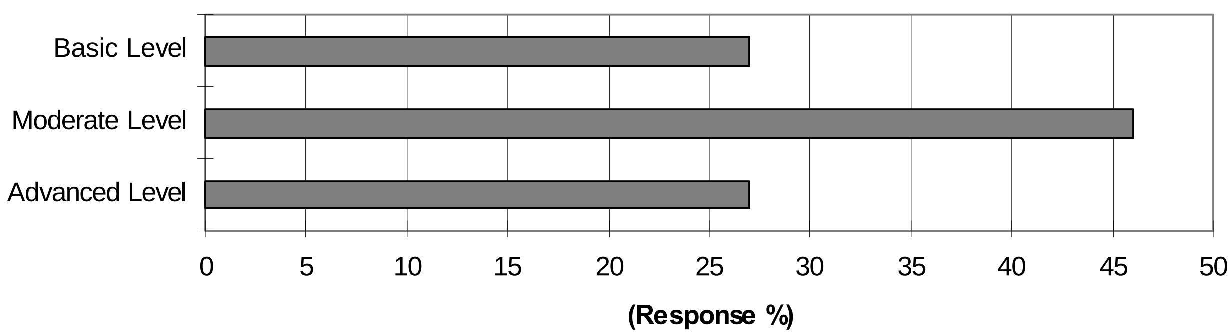

Figure 4. Which modulation schemes should be covered?

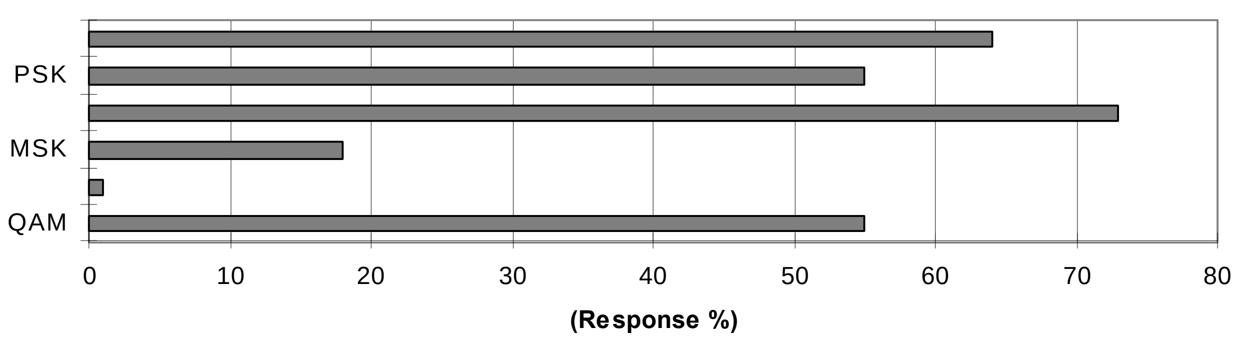

Figure 5. Which techniques/methods are most appropriate for implementing the related lab course?

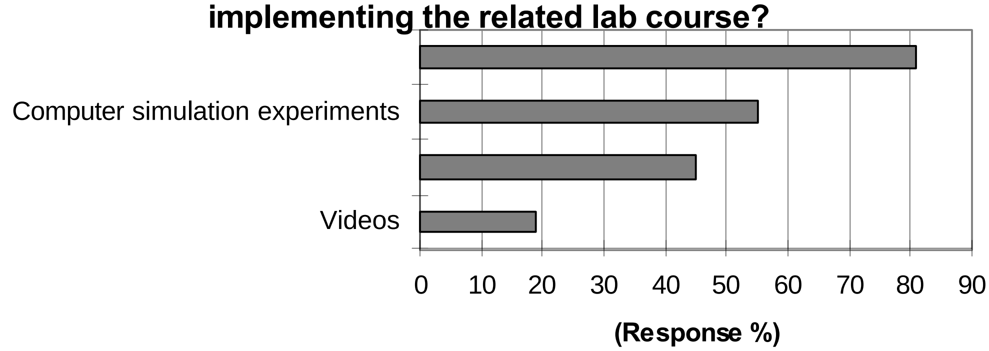

Figure 6. Which of the following RF equipment's operation and understanding is important to the job preformance of EET graduates?