A Wireless Course Sequence Design Using Global Wireless Education Consortium (GWEC) Curriculum Modules and Industry Tools

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Abstract

The phenomenal growth in wireless communications coupled with fast changing technologies during the last decade has put new demands on engineering technology curricula. Industry seeks graduates with appropriate background and training. The engineering and engineering technology graduates are not only expected to understand the theory behind 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 are developed, implemented, and kept current. However, design and implementation of such a course or sequence of courses requires considerable investment of time and financial resources. Keeping these courses current with respect to the fast pace of technological advances in the field is another challenge for faculty.

College and university professors can address these challenges by using the Global Wireless Educational Consortium (GWEC) wireless curriculum modules. These modules, designed through a collaborative effort of academia and industry and totaling 46 modules at present, are revised regularly to maintain currency. Furthermore, industry members provide instructional tools to GWEC academic affiliates. This paper describes the revision and enhancement process of wireless technology lecture/laboratory courses by incorporating existing GWEC modules and industry tools at DeVry University, Dupage campus.

I. Introduction

According to research analysts, Yankee Group, the worldwide wireless penetration will double over next five years --- reaching 21 percent of the world's population by 2006, or a total of 1.3 billion subscribers. Currently, wireless penetration amounts to 10.6 percent of Earth's 6 billion people.

It is estimated that wireless subscribers in the Asia-Pacific region will number 575 million by 2005, topping Europe as the largest mobile communications market. It is expected that the region's wireless market will grow at a compound annual rate of 20 percent in the next five years. Thus, wireless penetration in Asia Pacific will rise from a minuscule 6.93 percent in 2000 to 15.60 percent in 2005 [1].

In the United States, despite the present economic outlook, there is persistent growth in the wireless industry, and it can be gauged by the following figures released by the Cellular Telecommunications and Internet Association (CTIA)[2]:

- Cell sites are up 15.2% year over year (Figure 1)
- Subscribers grew 13.65% year over year (Figure 2)
- Direct Carrier employment is up by 0.3% year over year
- Total billable MOUs minutes are up 48% year over year - (300 billion wireless minutes used in the first half of 2002)

Figure 1: Number of Cell Sites
Source: CTIA

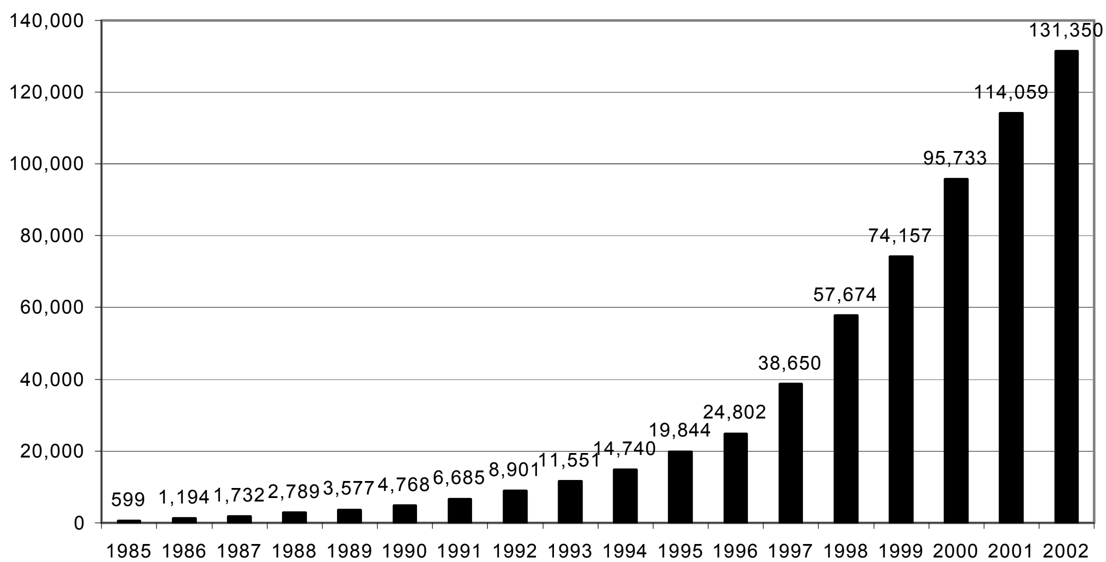
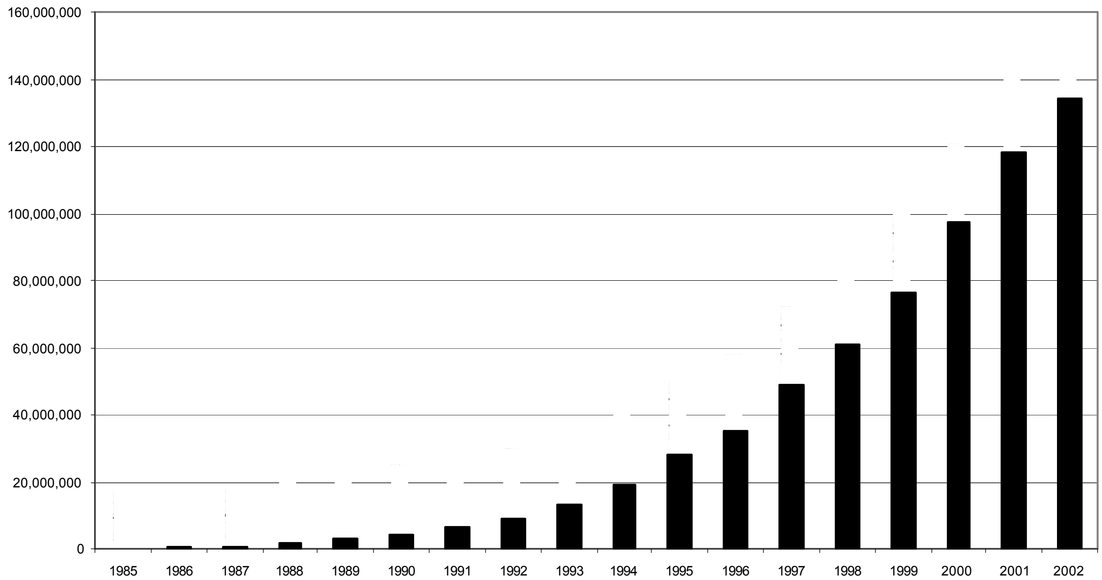


Figure 2: Estimated Subscribers -- June to June
Source: CTIA



II. Impetus for new curricula

Academic perspective

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. These estimates were devised almost a decade ago; considering the rapid pace of technological growth, those numbers are surely even smaller today [3].

The rapid growth in wireless technology, in the past decade, coupled with the shortened “half-life” of engineers, has created a demand for qualified RF and microwave engineers. Industry seeks graduates with appropriate background and training. The engineering and engineering technology graduates are not only expected to understand the theory behind state-of-the-art wireless technologies, but also to exhibit hands-on analytical and problem solving skills.

To address this new demand, a number of colleges and universities already have or are in the process of revising existing curricula and offering new courses in the area wireless communications. However, development of new courses and revision of existing courses takes considerable time and resources. Keeping courses technical current with respect to the fast pace of technological advances is a major challenge for the faculty.

College and university professors can address these challenges by using the Global Wireless Educational Consortium (GWEC) wireless curriculum modules. These modules, designed through a collaborative effort of academia and industry and totaling 46 modules

(Table 1) at present, are revised regularly to maintain currency. Furthermore, industry members provide instructional tools to GWEC academic affiliates.

Industry Perspective

The recent global economic situation has put some new demands on the wireless industry. The ability to adapt to change rapidly is a fundamental necessity of the wireless industry today. The quantity and magnitude of the forces affecting the wireless industry are unprecedented. As market penetration for basic wireless telecommunications services reaches saturation and as the industry matures, the economic indicators used to gauge success or failure have changed virtually overnight. Where adding new customers and growing revenue were once the premier indicators of success, profitability now occupies center stage in the wireless industry. When coupled with the recent dramatic changes in the global economic situation, these forces pose serious challenges to our industry's workforce. For the first time, the wireless industry is seeing reductions in the telecommunications workforce.

Fundamental to meeting these challenges is industry's ability to adapt the capabilities and attitudes of industry's existing *and future* workforce so they are equipped to meet new challenges. This adaptation will require the technical people of the industry to rethink the way they perform their work. Instead of locating cell sites where they provide the greatest capabilities from a Radio Frequency (RF) engineering point-of-view, for example, the engineers must now consider the economic ramifications of cell site locations. This requires substantial additions to the workforce's knowledge base and practical skill sets. And while the rate of increase of new people being hired into the wireless industry has leveled out due to the global economic situation, the industry is still hiring engineering and technical graduates to help meet its challenges. Since fewer people are currently being hired, it is all the more important to the individual companies that those who are hired are thoroughly equipped to enter the wireless workforce and immediately provide value. It is, therefore, vitally important that today's graduates have a full understanding of industry's expectations for their individual performance.

The Global Wireless Education Consortium (GWEC) was established in 1997 to provide a vehicle for exactly this sort of adaptation. Industry's participation in GWEC not only shows recognition of the need for highly-qualified workers but also that industry bears the responsibility for helping academia understand their needs and, most importantly, can significantly contribute to academia's success by providing information and resources that are largely unavailable to academia through other avenues. Industry provides a wide range of support to academia, through GWEC, to meet this responsibility. Industry generated technical training materials are provided to GWEC for use by academic members, as is industry research and analysis of workers skills and knowledge via job descriptions, certification requirements, skill standards, and task and skill analysis. GWEC member companies have made an unprecedented contribution of educational materials available to GWEC. And the member companies help academia stay up to date with the latest trends, both technically and economically, by connecting industry workers with academic faculty in annual workshops, informal meetings, and through local connections between companies and schools, all through the guidance and leadership of

GWEC. Many industry workers are also now teaching as adjunct faculty in many of the member schools. Industry supports GWEC because GWEC provides industry with what they need to succeed.

III. What is GWEC?

With the emergence of wireless technology and its myriad applications, business leaders have increasingly sought to employ college and university graduates with basic wireless knowledge and skill. The demand for qualified engineers, technicians and information technology (IT) specialists with a wireless background is considerable and expected to grow.

In 1997, a model was created in the United States that has positively affected the workforce for wireless technology companies. Through the Global Wireless Education Consortium (GWEC; www.gwec.org), a collaboration of industry and academe, colleges and universities throughout the world are preparing students in greater number who, collectively, represent a higher quality technology workforce for the future.

An important undertaking by GWEC is the development of a basic wireless curriculum based upon numerous, distinct, theoretical Points of Knowledge (POK) and Learning Requirements. The curriculum is designed in modular form to allow for maximum flexibility, with material and expert input from industrial representatives and academic faculty alike. The product – 46 discrete, two-part teaching and learning modules (Table 1) – is available to GWEC industry members and education partners for inclusion and/or incorporation into current curricula. Modules cover such broad topics as radio transmission, switch architecture, transmission and trunking, frequency reuse and planning, air interface, regulatory standards and conventions, and others. Laboratory exercises are an important part of the curriculum as well.

The POKs characterize the required information and experience content for two-year and four-year wireless-focused curriculums. An Industry Resource Guide illustrates, for each POK, how the various wireless professions (telecommunications engineer, wireless systems engineer, cell site technician, wireless switch engineer, etc.) use that knowledge in their work.

As the wireless industry evolves, curriculum materials are being updated and expanded. Both currency and relevancy are key factors in the design of the GWEC curriculum modules. Additionally, woven into the material and practical application exercises are several other core components: critical thinking, problem solving, communication, and teamwork. In terms of importance, these "soft skills" are on par with theoretical knowledge and application.

GWEC represents an innovative win-win model that works. Educators are kept abreast of the latest in wireless technology through interaction with industry leaders and through an annual Faculty Workshop. They are provided with – and indeed, helped create – a basic wireless curriculum that may be utilized by instructors to augment and/or enhance current course offerings. An extensive set of resources is also posted online for academic access and use. Students attending GWEC member schools worldwide may apply for Practical Work Experiences or internships with GWEC member companies (Table 2), preparing them further for challenging jobs in the wireless arena upon graduation. And companies benefit too, by realizing a reduction in recruitment costs and a greater pool of wireless talent from which to hire.

Table 1. GWEC Wireless Curriculum Modules

No.	Module Acronym	Concentration	Module Title
1	RT-RFT	Radio Transmission	RF Theory
2	RT-RFTT	Radio Transmission	RF Troubleshooting Techniques
3	RT-RFA	Radio Transmission	RF Antenna
4	RT-RFP	Radio Transmission	RF Propagation
5	RT-RFSP	Radio Transmission	RF System Planning
6	S-BDC	Switch	Basic Data Communications
7	S-BSS1	Switch	Basic Switching Systems 1
8	S-BSS2	Switch	Basic Switching Systems 2 – Digital Switching
9	S-DCS	Switch	Digital Cross-connect Systems
10	S-SPC	Switch	Stored Program Control
11	S-PSTN	Switch	Public Switched Telephone Network
12	S-BDN	Switch	Basic Data Networks
13	S-OSI	Switch	Open Systems Interconnect Model
14	S-ATM	Switch	Asynchronous Transfer Mode
15	TT-CTE	Transmission & Trunking	Concepts of Traffic Engineering
16	TT-LCP	Transmission & Trunking	Line Coding Protocols
17	TT-SI	Transmission & Trunking	Systems Integration
18	TT-BDT	Transmission & Trunking	Basic Digital Telephony
19	TT-CP	Transmission & Trunking	Circuit Provisioning
20	TT-TRANS	Transmission & Trunking	Transmission Theory
21	TT-NSI	Transmission & Trunking	Network Synchronization

22	TT-MULT	Transmission & Trunking	Multiplexing
23	TT-FOT	Transmission & Trunking	Fiber Optics Transmission
24	TT-SAT	Transmission & Trunking	Satellite Transmission
25	TT-SS7	Transmission & Trunking	Signaling System 7
26	TT-TCPIP	Transmission & Trunking	Transmission Control Protocol/Internet Protocol
27	TT-X25	Transmission & Trunking	Transmission & Trunking – X.25
28	FRP-RAC	Frequency Reuse & planning	Radio Architecture
29	FRP-CCC	Frequency Reuse & planning	Cellular Coverage Concepts
30	FRP-AC	Frequency Reuse & planning	Amplifier Chain
31	AI-MOD	Air Interface	Modulation
32	AI-AMPS	Air Interface	Advanced Mobile Phone Service
33	AI-BRT	Air Interface	Baseband Radio Transmission
34	AI-CDMA	Air Interface	Code Division Multiple Access
35	AI-TDMA	Air Interface	Time Division Multiple Access
36	AI-GSM	Air Interface	Global System for Mobile Communications
37	AI-3GES	Air Interface	Third Generation Emerging Standards
38	DVC	Digital Vocoding	Digital Vocoding & Techniques
39	PP&B	Power Plant	Power Plant & Batteries
40	TMTE	Test & Measurements	Test and Measurement Tools and Equipment
41	RSC-RR	Regulatory, Standards and Conventions	Rules & Regulations
42	RSC-WTS/TIA-41	Regulatory, Standards and Conventions	Wireless Communication Standards: Understanding TIA-41
43	RSC-SSO	Regulatory, Standards and Conventions	Standards Setting Organizations

44	HS-PHS	Health & Safety	Personal Health & Safety
45	HS-EMC	Health & Safety	Introduction to Electromagnetic Compatibility
46	PROF-AFF	Professional Affiliations	Professional Affiliations

Table 2. GWEC Industry Members and Education Partners

GWEC Industry Members	GWEC Education Partners
AT&T Wireless Services, Award Solutions, Cingular Wireless, EDS PLM Solutions, Emona Instruments, Ericsson, Flextronics Networks Services, IEEE, Motorola, Movilnet, Nokia, Sprint PCS, Telcordia Technologies, Verizon Wireless.	65 colleges and universities worldwide, including schools in the U.S. and Puerto Rico, Canada, Finland, Spain, Mexico, Brazil, China, Hong Kong, and India.

IV. Incorporation of GWEC modules in EET communication sequence: A case study at DeVry University-Dupage

At Dupage campus of DeVry University, the communication sequence of the Electronics Engineering Technology (EET) program consists of two core courses and a number of electives (Figure 3). Various GWEC curriculum modules have been incorporated (Table 3) into the communications sequence to:

(a) enhance the course content
(b) maintain the currency of the curriculum
(c) add the GWEC's points of knowledge (POK) and learning requirements
(d) deliver a wireless course sequence in an embedded form

Each GWEC curriculum module contains an Instructor Guide and a Powerpoint presentation. The Instructors Guide provides an overview of the learning objectives; the PowerPoint presentation contains detailed slides and material content for lecture notes.

Laboratory Tools

The following two lab tools can be used to support the lab component of the GWEC module-based courses:

1. Telecommunication Instructional Modeling System (TIMS) by Emona Industries.
2. Active Learning Suites (ALS) Simulation software by ATeL.

TIMS Description

Today's telecommunication texts use the "block diagram" as the standard notation to describe the implementation of mathematical equations, modulation and coding schemes.

The individual blocks that make up such diagrams represent basic electronic circuit functions such as oscillators, filters, adders, multipliers, etc. The TIMS system is made up of various plug-in (adder, multiplier, phase shifter, sequence generator, audio oscillator and twin pulse generator, PCM encoder, line-code encoder, CDMA decoder, error counting utilities, noise generator) and fixed modules (master oscillator, buffer amplifiers, LPF and frequency counter [4]. Figure 4 shows an example of TIMS modular approach to implement an experiment.

Active Learning Suites Description:
Active Learning Suites (ALS) is an interactive online learning system developed by ATeL, Advance Tool for e-Learning. It includes Simulations, Virtual Experiments, Interactive Lessons, Problem Solving Tutor, scriptable and animated Instructor's Assistant, assessment, authoring and ancillary tools. ALS's simulations and virtual experiments allow learners to simulate an authentic task that is similar to or identical with those tasks they are required to do in their workplace. Figure 5 (a) & (b) illustrate the ALS simulation suites for wireless and telephony modules [5]. Table 4 lists the characteristics of TIMS with ALS.

Figure 3 EET Communications Course Sequence Core and Elective Courses

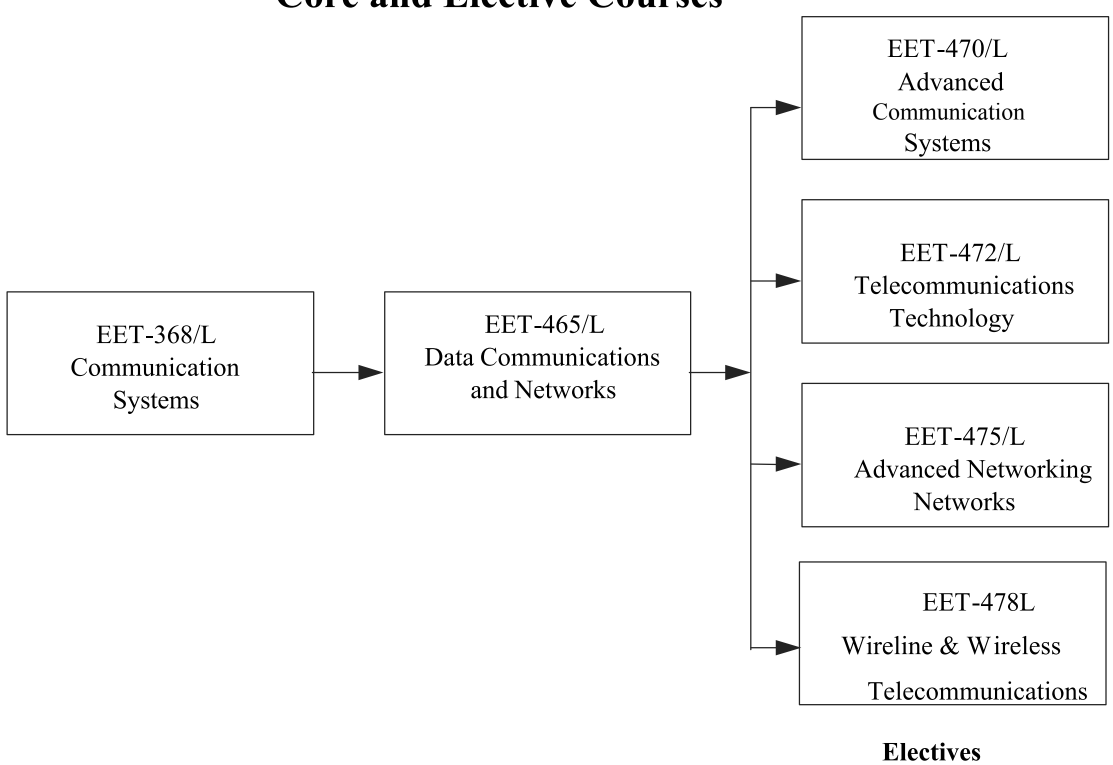


Table 3. Incorporation of GWEC wireless modules into EET communication sequence

Communication Sequence Course #	**Course Description**	**GWEC Module incorporation as enhancement or revision element**
EET-368 Communication Systems	Course covers basic communications systems at the circuit and subsystem levels. Topics include signal analysis, signal impairments, analog and digital modulation and multiplexing schemes.	• AI-MOD: Modulation • TT-MULT: Multiplexing • TT-TRANS: Transmission Theory • HS-EMC: Introduction to Electromagnetic Compatibility
EET-465 Data Communications and Networking	Course covers concepts of digital and computer networks by exploring the areas of information theory, telephone system, modems, computer network architecture, protocols, and LANs and WANs.	• S-BDC: Basic Data Communications • S-BSS1&2: Basic Switching Systems 1 &2 • S-PSTN: Public Switched Telephone Network • S-BDN: Basic Data Networks • S-OSI: Open System Interconnect Model
EET-470 Advanced Communication Systems	Course covers advance topics like fiber optic communication, cellular and personal communication systems (PCS), satellite & microwave systems, transmission lines and antennas.	• TT-FOT: Fiber Optic Transmission • TT-SAT: Satellite Transmission • RT- RFT: RF Theory • RT- RFA: RF Antenna • RT-RFP: RF Propagation • RF-RFTT: RF Troubleshooting Techniques • RF-RFSP: RF System Planning • FRP-CCC: cellular Coverage Concepts

EET-475 Advanced Networking	Course examines protocols and design issues in the physical, data link, network and transport layers of OSI model for LANs and WANs. Other topics include fiber optic and wireless networks.	• TT-TCPIP: Transmission Control Protocol/Internet Protocol • S-ATM: Asynchronous Transfer Mode • AI- AMPS: Advanced Mobile Phone Service • AI-CDMA: Code Division Multiple Access • AI-TDMA: Time Division Multiple Access • AI-GSM: Global System for Mobile Communication • AI- 3GES: Third Generation Emerging Standards

Table 4. Characteristics of TIMS and ALS

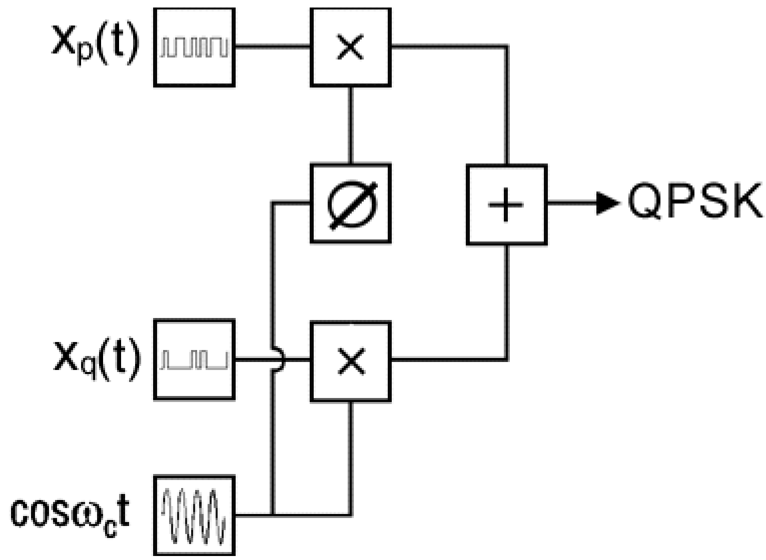
Lab Tool/System	**Characteristics**	**Advantages**	**Limitations/drawback**
Telecommunication Instructional Modeling System (TIMS)	Provides capability to set up 70 experiments in the areas of analog and digital communications	• Provides hands on experience at system level • Provides exposure to a wide range of topics	• Does not provide a hands on experience at chip level • Cost for Basic trainer modules: $9400 (for a typical work station)
Active Learning Suites (*ALS*)	Provides simulation and virtual experiments in the areas of wireless, telephony and fiber optics	• Provides a system level picture • Provides exposure to wireless, Fiber optic and PSTN technologies	• Does not provide a hands on experience at chip level • Cost for license

Figure 4. Implementation of a concept/equation using TIMS modules

Step 1: Write the mathematical equation

$$y(t) = x_p(t)\cos\omega_c t + x_q(t)\sin\omega_c t$$

Step 2: Draw the block diagram



Step 3: Construct the system using TIM's modules

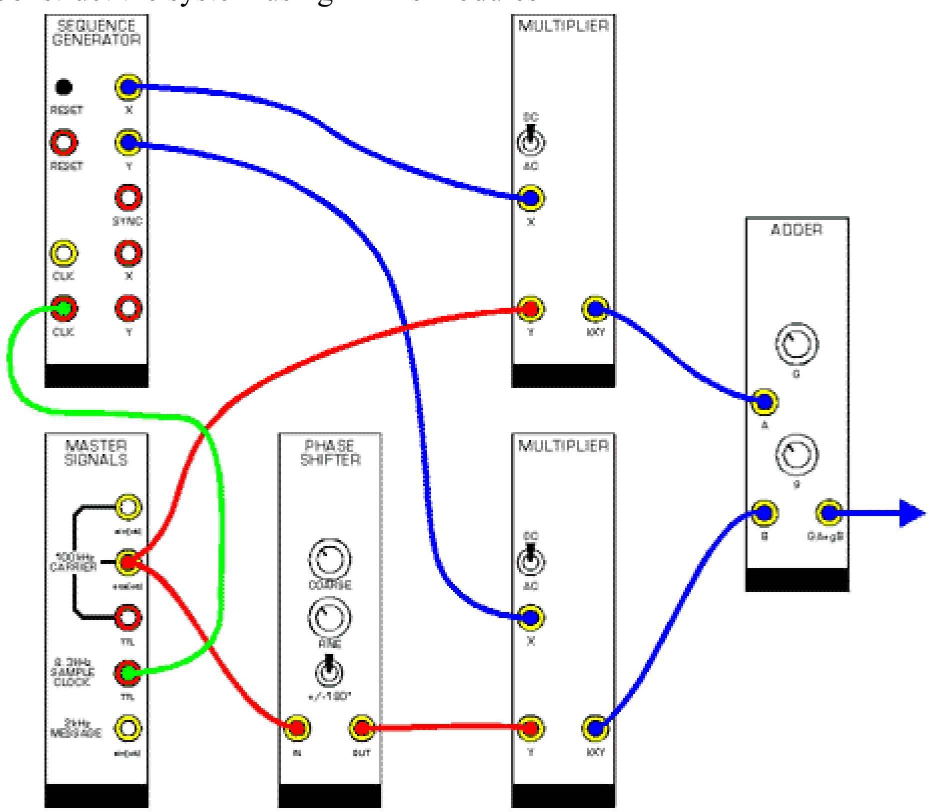


Figure 5 (a). ALS Wireless Communication module deals with physical aspects of wireless communications. It touches upon such problems as fundamentals of radio wave propagation, reflection, interference and antenna systems.

Figure 5 (b). ALS Telephony module assist learners in understanding science and technical issues related to the operation and maintenance of conventional and cellular phone systems.

V. Conclusion

As illustrated, GWEC modules can be used to design new wireless courses or revise and/ or enhance existing curricula. Incorporation of GWEC modules offer the following advantages:

- A modular approach to develop and implement wireless communication courses
- A cost effective way to maintain the currency of the curriculum
- A standardized way to deliver courses in multi-campus environment
- Limited development time is required

The laboratory component of the wireless courses can adequately be supported by TIMS modules and ALS simulation software.

The Courses built around and utilizing GWEC wireless curriculum modules and resource material not only provide the theoretical foundation of the state-of-the-art wireless technologies for EET graduates but also enable them to develop required hands-on analytical and problem solving skills, thus enabling EET graduates to become better prepared for the challenges of a rapidly changing wireless industry.

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