2019 Issue 2 // Volume 115

THE BRIDGE

The Magazine of IEEE-Eta Kappa Nu

Connecting the World *with* Amateur Radio

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THE BRIDGE

The Magazine of IEEE-Eta Kappa Nu

ISSUE 2, 2019 | CONNECTING THE WORLD WITH AMATEUR RADIO

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The Bridge, May 2019 Introduction from the Guest Editor

Dear Eta Kappa Nu Members and Friends,

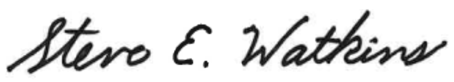
The theme for this issue of THE BRIDGE magazine is "Connecting the World with Amateur Radio." Amateur radio provides a rich environment for students and professionals to connect with others around the world and to apply their technical knowledge and skills. The features in this issue discuss how involvement in amateur radio can enhance a career in electrical and computer engineering and how projects in amateur radio can support one's professional education. The cover image highlights a few of the university amateur radio chapters with their QSL cards. (QSL is a radio three-letter code that means "I confirm receipt of your transmission.") These cards document a successful radio communication and provide a record on one's operator activity. Cards for the University of Chicago (N9UC), the University of Pennsylvania (W3ABT), Ohio State University (W8LT), the University of Arizona (K7UAZ), Texas A&M University (W5AC), Case Western Reserve University (W8EDU), Temple University (K3TU), Missouri S&T (WØEEE), and the Georgia Institute of Technology (W4AQL) are shown.

Amateur radio is an activity for individuals of all ages and technical backgrounds. It can be used for recreation, education, science, competitions, and emergencies. A recent scientific use was during the 2017 North American eclipse. Thousands of radio operators, often referred to as "hams," collaborated on measuring the effects of the solar eclipse on the upper atmosphere, see http://hamsci.org/seqp. Competition events are regularly held across the world in which hams are tasked with a transmitter hunt, sometimes called a fox hunt, to practice their technical skills. The amateur radio community also is a well-respected resource during emergencies, during which they can provide critical communication capability. Trained amateur radio volunteers are organized through the Amateur Radio Emergency Service (ARES) to provide public service and emergency communications in the U.S. and Canada, see http://www.arrl.org/ares and https://wp.rac.ca/ares/.

Many contributed to the making of this themed issue. Thanks go to the magazine editorial board, the authors of the feature articles, the magazine staff, the IEEE History Center, and the ARRL – the National Association for Amateur Radio. A special thank you goes to Brad Ziegler (KCØCDG) who collected the many QSL cards used in the issue (see his profile on page 34).

The early experiments in wireless telegraphy of G. Marconi have led to broad contributions to modern life. Amateur radio is a great activity, especially for someone pursuing an Electrical or Computer Engineering (ECE) career. It is an example of how our profession is "Advancing Technology for Humanity" (IEEE tagline). If you are not involved, check out the opportunities with your local chapter of hams.

Regards,



Amateur Radio for Electrical and Computer Engineers

Amateur radio refers to the use of radio frequency technology for non-commercial purposes. Amateur radio operators are allocated specific portions of the radio spectrum separate from those allocated for other purposes, such as commercial broadcasting and communications for marine and aviation industries. Operators must demonstrate knowledge of foundational principles, communications technology, and operational rules to become licensed and to be issued a unique callsign. Ham radio permits a wide variety of communication techniques and modes to be used for both short-range and long-range communication. For those with an ECE background, the practical applications of ECE topics and opportunities for experimentation are notable. In the U.S. and Canada, activities are supported by the ARRL, The National Association for Amateur Radio (www.arrl.org) and Radio Operators of Canada (wp.rac.ca). More information can be found at the Engineering and Technology History Wiki, see https://ethw.org/Amateur_Radio.

Perspectives on Amateur Radio

Howard Michel
(WB2ITX)
CEO, ARRL
IEEE President, 2015
IEEE Vice President, Member & Geographic Activities, 2011-12
HKN Gamma Kappa Chapter

"My story starts as a young teenager. I wanted to understand how radios worked. I got my novice ham ticket at 16 and upgraded to General and Advanced within a year. Ham radio started me down a path in engineering – in the Air Force, as a Professor, founding CTO of a tech startup in China, 2015 IEEE President, and currently as CEO of ARRL. In the fifty or so years since, I have not lost the kick I get from using technology that I have mastered. To me, this is the essence of my ham radio hobby and my professional career."

Thomas M. Coughlin
(KC6HOQ)
Coughlin Assoc. (Consultant)
IEEE-USA President, 2019
IEEE R6 Director, 2016-17
HKN Eta Chapter

"My first exposure to amateur radio was in high school in Sioux Falls, South Dakota. This exposure to building antennas and electronics, accessing satellite images, etc., had a big influence on me and broadened my interest in electronics. As I pursued my career, amateur radio has taught me the value of thinking through how a device works, in particular, learning how to debug an electronic circuit to get it to do what you want it to do. It also taught me some good lessons on working on technical projects with other people."

Witold M. Kinsner
(VE4WK)
Professor of ECE, University of Manitoba, Canada
IEEE Vice President, Educational Activities, 2018-19
IEEE Canada President / R7 Director, 2016-17
HKN Eta Chapter

"Amateur radio is a unique and unparalleled experience in building your own radios, antennas and other equipment to connect wirelessly with friends or strangers. I have been teaching ham radio to many university, college, and high-school students so that they would enhance their technical knowledge and skills. Ham radio does not distinguish between the very young and very seasoned individuals, but becomes a friend of those who are eager to discover new insights in many areas of engineering and technology. Also, ham operators constitute a community of explorers dedicated to serving those in need. Hams communicate when all else fails."

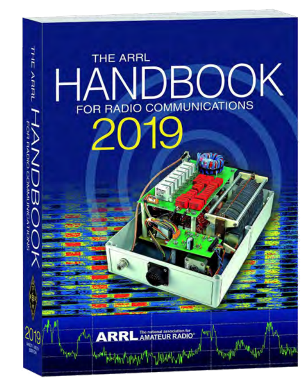
Francis B. Grosz, Jr.
(K5FBG)
IEEE Vice President, Member & Geographic Activities, 2019
IEEE R5 Director, 2016-17
HKN Alpha Chapter

"Amateur radio is a great way to make friends and learn about cultures all over the world. Some hams have made friends with whom they talk daily or weekly for decades. It is also a great technical adjunct to an electrical engineering career. And, I can tell you from experience that when disaster strikes, amateur radio is the one thing that still works."

Amateur Radio and Careers in Electrical and Computer Engineering

Ward Silver (NØAX)

I stumbled on to amateur radio by finding a QST magazine (http://www.arrl.org/qst) in the library sometime in 1966. A few years of collecting old electronic parts later, I was tutored on the Morse code by a high-school friend and became WNØGQP in early 1972, later NØAX which is the call sign I hold today. Thus, I launched on an electrical engineering career through the University of Missouri – Rolla (now the Missouri University of Science and Technology) where I discovered both the campus Radio Club (WØEEE) and the campus FM station (KMNR).



The ARRL Handbook. Cover image used with permission of ARRL..

After college, I worked as a field and product development engineer in several fields through 2001, then switched to teaching and writing. Today I am a Contributing Editor for the ARRL in charge of the *ARRL Handbook* [1] and several other widely read publications. At each stage of my professional career, the experiences I gained in amateur radio have been invaluable. This article explains why.

As newly graduated engineers quickly find out, the real world is a whole lot more complex than the homework and laboratory projects in school. Those first few years are crucial in getting up to speed and learning not just the technology, but the profession. Any extra background or experience gives you an edge — so where do you get it? That's where "ham radio" (amateur radio) comes in.

Fear of Knobs

In working with new engineers and teaching electrical and computer engineering laboratories, it's quickly apparent who has some practical experience by the way they handle equipment and materials. An electronics hobbyist, ham or not, has little hesitancy at the workbench. They lost their fear of knobs long ago! Instrumentation, radios, power supplies, cables, connectors — all are tools in their toolboxes to be applied to the problem at hand. In operating a ham radio station, there are a myriad of adjustments and configurations with which to experiment, getting nearly real-time feedback over the air. Experimenters can build, test and use their creations every day. The soldering iron, compiler or drill press stays active and in use!

Understanding Radio Frequencies

It's one thing to have a good understanding of the many equations that describe communication processes and signals. It's quite another to have a visceral grasp of the physical phenomenon those equations represent. Sidebands are a sine function on paper and a blip on a spectrum analyzer screen but on the air you can *experience* them by tuning a receiver. MATLAB is great, but there's no substitute for energetically adjusting a receiver to get rid of an interfering sideband or intermodulation product that is covering up a faint signal coming in from the other side of the planet or reflecting off the moon!

Hams also get a great feel for how radio frequency (RF) energy flows around and through equipment. That "ground" conductor that works so well at 60 Hz is more like an antenna at Very High Frequency (VHF) and might even disappear entirely at certain frequencies! In setting up a station, you quickly learn that every wire, cable, and cabinet is part of your antenna system, including the operator. You start thinking in terms of a wave instead of just voltage and current.

Everything Matters

Given the limited resources available to most hams, you quickly learn that even the most expensive radio can be quickly rendered non-operational by any of its supporting components. Power supplies have to meet specifications over a wide range of loads and environments. Cables and their connectors have to be installed properly and weatherproofed securely. Software interfaces and protocols have to be configured correctly. Antennas have to be pointed in the right direction and held there. Propagation changes every day, every hour, and every minute, challenging the ham to maintain communication in the face of often wild swings in signal strength and quality. And the sun, the geomagnetic field, the atmosphere and the ionosphere have to cooperate. In wireless communications, everything really does matter.

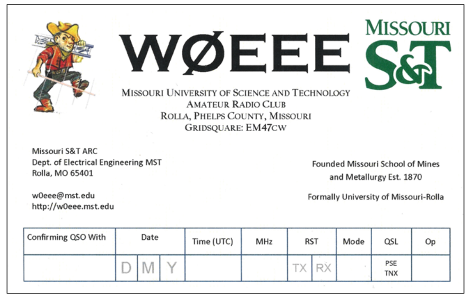
You get very good at estimating what it takes to make the system work and troubleshooting it when it doesn't. Troubleshooting is probably the hardest skill to teach in any field and is one of the most important things amateur radio has to offer an engineer. You learn about breaking down a problem, isolating and testing system components and recognizing signatures of various behaviors. You also learn to respect design and operating margins in a way that "book learning" simply cannot teach.

The System Big Picture

Here we arrive at what really makes amateur radio experience valuable — recognizing that you are really working with a system, not a collection of bits and pieces. In addition, you might not have control over some of the most crucial elements. If your team supports the local emergency communication systems, you'll have to work with public safety agencies and comply with the National Incident Management System. In your university club, you'll have to work with budgets and the administrators of the building housing the station. All of these things are part of your system, just like an amplifier, modem or tower.

A Community of Hams

Not only does amateur radio depend on equipment, it depends on the hams to make it work — several million around the world, with three-quarters of a million here in the US. Your ham license or "ticket" serves as an introduction and connection to them all. Whether the relationship is professional or personal, the resources available to you as an amateur are incredibly broad. Several IEEE colleagues and I have described our amateur radio experiences in *IEEE Microwave Magazine*. [2,3]



The American Radio Relay League (ARRL)

The national organization for amateur radio in the US, ARRL (www.arrl.org) is one of the world's oldest. Formed in 1914, the ARRL serves amateurs with technical references, sponsorship of activities and organizations, and represents amateur radio to municipal and national government agencies. You can obtain your license with the aid of study guides from the ARRL and even take your FCC license exam through the ARRL's Volunteer Examiners, part of the service's largest such program. You'll find a wealth of information on amateur radio via the ARRL's website, such as the Technology section at www.arrl.org/technology. Many professional engineers are ARRL members and include ARRL publications in their professional libraries. Howard E. Michel (WB2ITX), the 2015 President of IEEE and member of the Gamma Kappa HKN chapter, is the current Chief Executive Officer of ARRL. We'd love to welcome you as an ARRL member!

ARRL The national association for AMATEUR RADIO®

ARRL is the national (U.S.) association for amateur radio. Used with permission of ARRL.

I recently interviewed Toni Linden, amateur call sign OH2UA. He's the CEO of KNL Networks (Copenhagen, Denmark — knlnetworks.com). [4] I asked Toni about how his ham radio experience in worldwide competitions helped him build a worldwide communications service. He was unequivocal in his advice to young ham engineers:

> *"Be open-minded about what you want to be and grow into other careers. Ham radio really provides a wide background in electronics and radio. This allows you to grow and move within or between industries very easily."*

> *"Don't underestimate the network value of amateur radio which is worldwide and very deep. The word 'Amateur' sounds undervalued but ham radio provides a lot of background and impact. Use the network of people you'll connect with – they have many skills and capabilities you can work with. There is a very big community of ham radio operators and they have many resources!"*

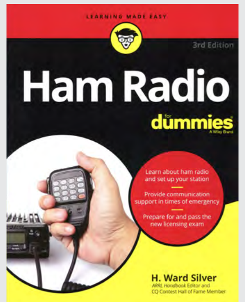
What began as a bedroom-and-basement hobby for a couple of curious high-school kids and our friends has blossomed into a successful engineering career for Toni and me. We have friends and associates in dozens of countries and experiences with signals "from dc to daylight." Ham radio has made a big difference in our lives. The relationships and resources to last you a lifetime might be as close as your school's radio club.

Ward Silver received a BSEE from the University of Missouri – Rolla in 1978 and has been a radio amateur since 1972. The combination led him to a 20-year career designing industrial and medical devices. In 2000, he began a second career as a teacher and writer, receiving the Bill Orr Technical Writing Award for 2003 and again in 2016 for QST magazine contributions. He is the President of the Yasme Foundation (www.yasme.org) (a non-profit corporation for conducting scientific and educational projects related to amateur radio), a member of the CQ Contest Hall of Fame, and in 2008 was the Dayton Hamvention's "Ham of the Year."

Ward is Lead Editor of the two primary amateur radio technical references: the *ARRL Handbook* and the *ARRL Antenna Book*. He is the author of all three ARRL licensing study guides. Along with *Ham Radio for Dummies*, he has written *Two-Way Radios and Scanners and Circuitbuilding Do-It-Yourself*. His most recent book for amateurs is *Grounding and Bonding for Radio Amateurs*.

Getting to Know Ham Radio

If this article piques your curiosity about ham radio, an inexpensive and easy-to-read overview is found in the author's *Ham Radio for Dummies* published by John Wiley & Sons [5]. Now in its 3rd edition, the book is written in the series' friendly informal style to introduce you to 21st century amateur radio. It explains what the amateur service is, what is involved in getting your license, basic technology elements and what there is to do in ham radio.



Ham Radio for Dummies by W. Silver. Cover image published courtesy of Wiley and Sons.

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Feature

Electrical and Computer Engineering and Amateur Radio

Dennis Silage, PhD (K3DS)
HKN Gamma Beta Chapter 1967

Undergraduate Electrical and Computer Engineering (ECE) students take courses with hands-on laboratories and exercises. Most also take a capstone project course in which they apply their knowledge as a team to solve a design problem. In times past many of these ECE students (it was called Electrical Engineering then) were amateur radio operators and their capstone projects were in RF electronics, microwaves, antennas and the misty beginnings of wireless digital data as well as amateur radio satellite communication. Today, many undergraduate students and even a few educators may not have heard of amateur radio and the many benefits of bringing it and ECE education together. Here we examine the role amateur radio once had and now can have again in ECE education. Modern applications of amateur radio reviewed here include satellite and high-altitude balloon communication, digital data networks, wide-area rover vehicles, digital voice, microwave technology and weak signal data communication. How to initiate the operation and maintain the activities of an amateur radio station in an ECE department is described and encouraged because the professional rewards are certainly wideband!

What's It All About?

Design projects in ECE are an important component of an undergraduate educational process that synthesizes course material into a relevant experience. Many undergraduate ECE capstone design projects use embedded software and hardware coupled with very limited range, unlicensed wireless data communication for semi-autonomous projects, e.g. UAVs and UGVs.

What is not used routinely though is an area that at one time was quite significant in the technical development of ECE students: amateur radio or, as it is sometimes called, ham radio. The reasons for this void are perplexing, since the use of amateur radio in ECE education is without any major obstacles to either undergraduate students or the faculty advisor. A perceived impediment may be the requirement for an amateur radio license, but a license is required only for transmission. Other concerns may be the resources for ECE education and whether opportunities for design innovation are available to the capstone design team.

Amateur radio is a service administered by the Federal Communications Commission (FCC) (www.fcc.gov) and requires a license by written examination. Although the technical and regulatory questions of the examination remain, they are quite reasonable for both the ECE undergraduate student and faculty advisor. In fact, this exercise can provide the student with a capstone design experience in regulatory issues.

Amateur radio can provide the resources for many other unique and interesting ECE capstone design projects that resonate with industry. The Temple University Amateur Radio Club (TUARC, www.temple.edu/k3tu), using the callsign K3TU, has been involved in many such undergraduate ECE projects. The history and recent activities of a few of these are reviewed in the remainder of this work.

Amateur Radio Satellites

Low-earth orbiting (LEO) amateur radio satellites can provide significant design experience in polarized antennas, automated tracking, RF modem design and telemetry analysis. The Radio Amateur Satellite Corporation (AMSAT, www.amsat.org) includes world-wide organizations of volunteers that design, build, arrange launches for and then operate satellites carrying amateur radio payloads. The earliest attempts were the OSCAR series of satellites beginning in 1961.

TUARC received confirmation of the reception of a telemetry signal from OSCAR 6 in 1973 and received the QSL card in Figure 1. Temple University's ECE capstone design projects, which developed a microcomputer-based azimuth-elevation (az-el) antenna tracking system and an automatic Doppler frequency shift correction for PSK digital data communication for LEO satellites, were awarded two successive Bendix Awards for IEEE Region 2. Our other projects include the development of satellite PSK DSP data modems and a complete refurbishing and qualification of the az-el tracking, cross-polarized VHF/UHF Yagi antenna system at the K3TU station. (A Yagi antenna is a type of directional antenna.)

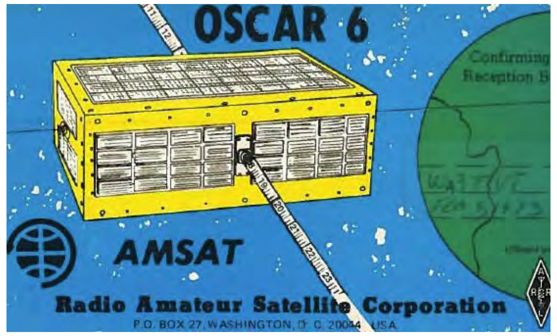

Fig. 1: QSL card of the reception of telemetry from the OSCAR 6 LEO satellite.

However, a LEO amateur radio satellite station can use an omni-directional, circular polarized antenna that does not have to be pointed to track and a high-performance software-defined radio (SDR) such as the FUNcube dongle (www.funcubedongle.com). The FUNcubes are small LEO amateur radio satellites for telemetry and linear transponder uplink and downlink for SSB AM voice, CW with Morse code and digital data (http://funcube.org.uk), see Figure 2.

Fig. 2: Internal view of the FUNcube SDR for LEO satellite reception.

ACRONYMS

AMBE	Advanced Multi-Band Excitation
APRS	Automatic Packet Reporting System
AFSK	Audio Frequency Shift Keying
ARHAB	Amateur Radio High-Altitude Ballooning
CW	Continuous Wave
DSB AM	Double Sideband Amplitude Modulation
DSP	Digital Signal Processing
DVB-T	Digital Video Broadcasting-Terrestrial
EM	Electromagnetic
EME	Earth-Moon-Earth
FCC	Federal Communications Commission
FEC	Forward Error Correction
FFT	Fast Fourier Transform
FM	Frequency Modulation
FSK	Frequency Shift Keying
HF	High Frequency: 1.8 to 30 MHz
LEO	Low Earth Orbiting
LIDAR	Light Detection And Ranging
MFSK	Multiple Frequency Shift Keying
MMIC	Monolithic Microwave Integrated Circuit
MT63	MultiTone digital modulation
OSCAR	Orbiting Satellite Carrying Amateur Radio
PSK	Phase Shift Keying
PSK31	Phase Shift Keying at 31 b/sec
QPSK31	Quadrature Phase Shift Keying at 31 b/sec
QSL	Q-signal: I confirm receipt of a transmission
RF	Radio Frequency
SDR	Software-Defined Radio
SHF	Super High Frequency: 3 to 30 GHz
SSB AM	Single-Sideband Amplitude Modulation
SSTV	Slow Scan Television
TNC	Terminal Node Controller
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
UHF	Ultra High Frequency: 0.3 to 3 GHz
VHF	Very High Frequency: 30 to 300 MHz

Amateur Radio High-Altitude Ballooning

Amateur Radio High-Altitude Ballooning (ARHAB, https://arhab.org) allows ECE students to design functioning models of satellites and launch them into a space-like environment at altitudes approaching 35 km (115 000 feet). The first launch of a weather balloon carrying an amateur radio payload was in 1987. An ARHAB flight consists of a balloon, a recovery parachute, and a payload. One payload is an amateur radio transmitter that permits tracking of the flight to its landing for recovery. Other payload components include a GPS receiver, sensors, data loggers, digital cameras utilizing an amateur radio Slow Scan Television (SSTV) transmitter and other scientific experiments.

A typical ARHAB flight uses a standard latex weather balloon and is usually in the air for up to 3 hours. However, the California Near Space Project flight in 2011 traveled 10,036 km (6,236 mi) from San Jose CA to a splashdown in the Mediterranean Sea 57 hours later. Figure 3 shows the ARHAB seal and motto.

Fig. 3: The seal and motto for Amateur Radio High-Altitude Ballooning: Knowledge from under the sky.

Digital Data Networks

Amateur radio developed a practical wireless digital data network beginning in 1978, using a microprocessor-based Terminal Node Controller (TNC). The TNC provided external support for the 8- or 16-bit, low clock frequency PC of the day. The original technical contribution was the development of the AX.25 packet radio data protocol over three decades ago, which was adapted from the industrial X.25 standard for amateur radio use. Amateur radio operators thus had developed complex wireless data communication systems with store and forward and self-organization more than a decade before the IEEE 802.11 standard.

An Audio Frequency Shift Keying (AFSK) transmission using APRS (www.aprs.org) on exclusive amateur radio frequencies allows sending and receiving digital messages as an alternative to vulnerable wired or wireless public networks, especially during natural disasters. TUARC operates an amateur radio APRS digital data repeating (digipeating) station which provides reliable communication throughout the Philadelphia metropolitan area.

APRS though is limited by the available bandwidth and FM transceivers on VHF and UHF to 9600 b/sec with AFSK. Although adequate for text messaging, amateur radio has now developed a high speed, self-configuring digital data network (www.broadband-hamnet.org). An ECE capstone design project used repurposed Linksys wireless routers on 2.4 GHz, which overlaps the upper portion of the 13 cm wavelength amateur radio band. Using an amateur radio frequency of 2.402 GHz (channel -1) allowed the use of RF power amplifiers and gain antennas which are not permitted for WiFi. The capstone design project developed an improved Remote Machine Discovery Protocol as an original contribution. The network used Raspberry Pi microcomputers and the project report is posted on the TUARC website. An example network is illustrated in Figure 4.

Rover Vehicles

Semi-autonomous rover vehicles are a common ECE capstone design project; examples are shown in Figure 5. However, WiFi data and video communication are limited in range because of the low power and the UHF frequency required by FCC regulation. Amateur radio projects do not have that limitation and can implement a far roving vehicle. The first-generation semi-autonomous rover vehicle using amateur radio was developed as an ECE capstone design project at Temple University with an array of sensors in 2004.

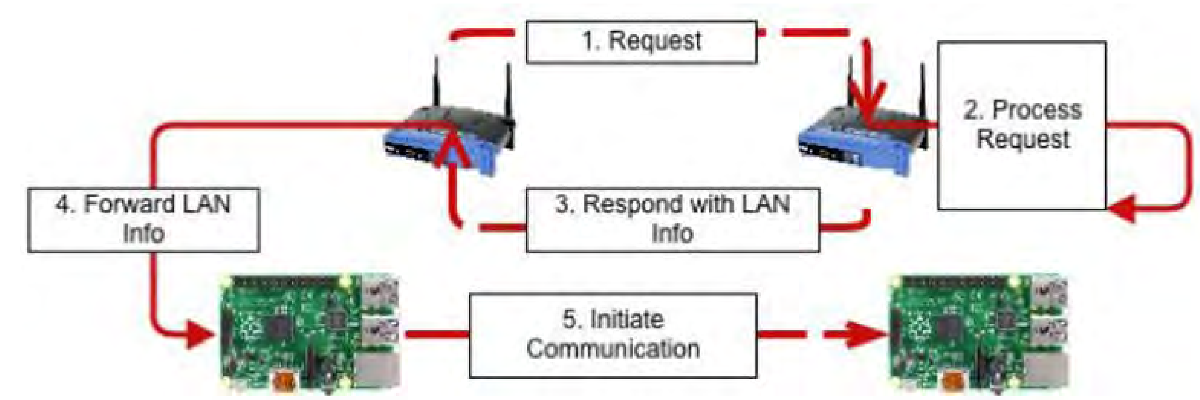

Fig. 4: High speed digital network using repurposed 2.4 GHz routers and Raspberry Pi microcomputers on amateur radio frequencies.

The rover has a biaxial tilt sensor which provides pitch and roll signals. Short-range ultrasonic sensors are used to avoid collisions. A tilt compensated electronic compass with a triaxial magnetometer measures true magnetic north for navigation. A triaxial accelerometer and a GPS receiver sends motion and location data. Thermal sensors are used for assessing a disaster scene.

Fig. 5: The first and second generation semi-autonomous rover vehicles using amateur radio frequencies.

Command and data communication for the rover uses 1200 b/sec AFSK with Hamming error correction on the amateur radio VHF, 2 meter wavelength band with 5 W of RF power. Analog video at 15 frames/second is transmitted on the amateur radio UHF, 70 cm wavelength band with 2 W of RF power. The processor is an Intel i386EX single board computer.

Simple reduced length vertical antennas (rubber duckies) are employed. Subsystem and total power consumption and the charge of the battery could be monitored and controlled remotely. Although the transmitted power is modest, it is more than that available for unlicensed WiFi (0.1 W).

However, the TUARC K3TU base station uses a high power, 50 W 2 meter control transmitter and high gain Yagi antennas on the roof of the Engineering Building to command and receive telemetry and video from the rover. Unlike WiFi, an amateur radio transmission can use high power and gain antennas which allowed the rover to be operated while at the Philadelphia City Hall nearly 3 miles away from our campus. The unique rover operation garnered local television news coverage. The rover project report is posted on the TUARC website.

An improved, second-generation rover is now an ECE capstone design project with a much larger 5 by 2-foot base, an articulating six-wheel design and four Raspberry Pi microcomputers with its own local area network. Command and data communication remain with amateur radio but now also include an APRS digipeater for extended range. The digital video transmission uses the European DVB-T standard executing on a Raspberry Pi. LIDAR augments the ultrasonic sensors for collision avoidance and a suite of noxious chemical sensors provides sophisticated information about the disaster.

Digital Voice

Amateur radio communication began simply with Continuous Wave (CW) Morse code transmissions but was using Double Sideband Amplitude Modulation (DSBAM) even before that of broadcast radio. Because of a limited available spectrum for its exclusive use amateur radio then employed early practical forms of SSB AM modulation, removing the redundant sideband of DSB AM, and demonstrated its performance in HF communication.

Amateur radio now also employs very low bit rate, compressed digital voice using AMBE on a DSP device. An ECE capstone design project used the AMBE-2020 (www.dvsinc.com) to produce a digital vocoder (voice encoder). Although a proprietary vocoder was used, there were frame data and processor control protocols developed for the project. A DSP audio frequency modem was also developed and the digital voice project report is posted on the TUARC website. The system is shown in Figure 6.

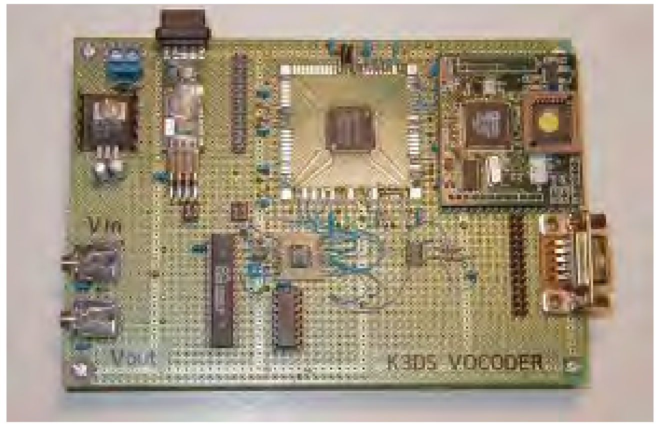

Fig. 6: Digital vocoder and DSP audio frequency modem.

This ECE capstone design project was published and presented at an ARRL Digital Communication Conference, which demonstrates that even undergraduate projects can add significantly to the base of knowledge in amateur radio [2]. Work is currently being done on a freeware software solution for compressed digital voice in amateur radio (https://freedv.org/).

Microwave Technology

Amateur radio experimentation in SHF has had a long tradition and is the last frontier before optical data transmission. Early generations of microwave engineers acquired much of their technical training by such activities. Amateur radio transmitter and receiver design and propagation studies have occurred even up to 250 GHz. There are microwave amateur radio contest events when *hill topping* (operating from a high elevation and in the clear) is needed. Transmitting and receiving in the SHF amateur radio band requires distributed or stripline design and the use of MMIC devices, like the example in Figure 7.

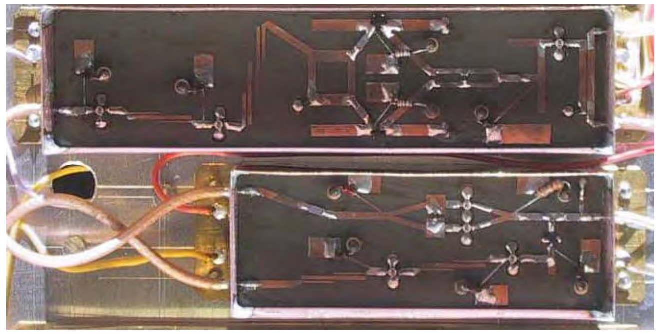

Fig. 7: Amateur radio microwave stripline design using MMICs.

An early ECE capstone design project in microwave technology was a 2 Mbps, high-speed (for 1994) digital data communication system using the 10 GHz amateur radio frequency and FSK. Gunn diode transceivers (known as Gunnplexers) were used with automatic frequency control (AFC) using a stripline design with MMICs. The ECE capstone design project system was demonstrated by a data transmission across the Temple University campus, between the Engineering and Computer Science buildings. At the time 10BASE-T wired, twisted pair Ethernet data communication was only 10 Mbps.

Weak-Signal Data Communication

Amateur radio has leveraged the advanced processor and sound card interface of the modern PC to produce several modes of weak-signal data communication. An amateur radio development in 1998 was PSK31 at 31 b/sec (www.bpsk31.com). This slow data rate is essentially that of a keyboard

Fig. 8: TUARC K3TU HF, LEO satellite, VHF and UHF stations.

message but results in a narrow bandwidth quite immune to noise and interference. However, that was not the only technical innovation. Text characters are produced as a variable length code (varicode) where the boundaries between character codes are marked by two or more consecutive zeros.

Like all such Fibonacci codes, the varicode has no character codes that contain more than one consecutive zero. The spaces between characters can be readily found regardless of the length of the character. The more frequently occurring characters have the shortest encodings. Varicode is also self-synchronizing if reception is impaired by sporadic HF channel fading.

Freeware PC processing software, such as DigiPan (Digital Panoramic Tuning), encodes and decodes the varicode text characters and uses the FFT DSP technique to select the narrow bandwidth signal to decode. A typical received SSB AM bandwidth is 3 kHz which contains many PSK31 signals shown as waterfall display and with the cursor selected signal as an in-phase and quadrature (I-Q) phase plot and decoded text. In addition to PSK31 there are many other amateur radio weak signal digital modes such as QPSK31, MT63, Throb, Olivia and Hellschreiber (http://wb8nut.com/digital/).

A recent weak signal data communication mode is JT65 which was developed by Dr. Joseph Taylor (K1JT) who is a Nobel Laureate in Physics and an amateur radio operator. The freeware JT65 mode is intended for extremely weak but slowly varying signals, such as those found on tropospheric scatter (troposcatter) or EME (moon bounce) paths. JT65 can decode signals that are many decibels below the noise in a 2.5 kHz band. This performance often allows the successful exchange of contact information without the signals even being audible.

JT65 uses Multiple Frequency Shift Keying (MFSK) and messages are transmitted as data packets after being compressed and then encoded with Reed-Solomon Forward Error Correction (FEC). FEC adds redundancy to the data and messages can be recovered by the receiver even if some of the data is corrupted.

From Faculty Advisor to Station Trustee

The involvement of an ECE faculty member is crucial to the eventual establishment of an amateur radio resource for ECE courses and capstone design projects. The ECE faculty responsible for the curriculum in digital data and wireless communication, DSP and EM wave propagation are the obvious sponsors of that effort. A faculty advisor can promote an amateur radio station as a laboratory facility of the ECE department, obtain an FCC license and become the station trustee. This is better than relying upon interested ECE students for the promotion since a licensed faculty advisor would be around a lot longer.

As an example of that development process, TUARC K3TU has been recognized as laboratory of the undergraduate ECE curriculum. The HF, VHF, UHF and SHF amateur radio station equipment and antennas were provided by the ECE Department of Temple University as a modest part of the undergraduate communication laboratory. The station and an antenna are shown in Figures 8 and 9.

However, even the best amateur radio station equipment would be poor indeed without adequate antennas. Fortunately, the Engineering Building is 10 stories tall and TUARC has two 30-foot towers supporting the HF and VHF and UHF Yagi antennas on the roof. A third 30-foot tower there supports the VHF and UHF LEO omni-directional amateur radio satellite antennas that do not have to be az-el positioned.

Fig. 9: TURAC K3TU VHF and UHF LEO satellite and UHF FM repeater antennas.

Nonetheless, TUARC is also a university organization open to all amateur radio licensed students, faculty, staff and even alumni. TUARC operates VHF and UHF linked repeaters and an APRS digipeater that proclaims that amateur radio is a vibrant part of Temple University and its ECE education.

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Dennis Silage (silage@temple.edu) is a Professor at Temple University where he teaches FPGA and system-on-chip embedded design, digital data communication, and digital signal processing. Dr. Silage holds an Amateur Extra class license (K3DS) and is the trustee of the Temple University Amateur Radio Club (K3TU, www.temple.edu/k3tu) which has been integrated into the undergraduate ECE capstone design. He was presented with the ARRL Atlantic Division Technical Achievement Award in 2001. He is the Faculty Advisor for the Iota Sigma Chapter of HKN and received the ASEE National Outstanding Teaching Award in 2007. He is a Senior Member of the IEEE and was acknowledged with the IEEE Philadelphia Section Benjamin Franklin Key Award in 2014. His PhD is in Electrical Engineering from the University of Pennsylvania.

Feature

GREAT IMPEDANCE MATCH FOR KNOWLEDGE TRANSFER: Amateur Radio as Part of Electrical and Computer Engineering Education

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Abstract

The amateur radio community is well-known for its creativity and ingenuity in projects constructed with a modest budget and basic laboratory equipment. The Electrical and Computer Engineering (ECE) community is known for its innovation and world-changing impact. When these two communities meet in the world of electrical and computer engineering education, great outcomes await for faculty and students. This article talks about how a university makes these connections to help student success. A starting point is to encourage students to take the Federal Communications Commission (FCC) amateur radio examination early on in their college education in order to get exposure to advanced topics in ECE well in advance of when they take courses on the topic. A second initiative is to encourage student creativity to design and implement their own projects, using amateur radio, in formal and informal laboratory settings of the university curriculum. Finally, amateur radio provides a rich set of topics for senior and graduate level project/thesis activity. This article will provide examples of how these amateur radio/ECE interactions occur along with specific project examples that demonstrate that amateur radio is still on the forefront of project innovation.

Introduction

A college education is designed to provide the academic foundation necessary to learn and develop proficiency in one's field of study. Hands-on learning through practical experiences shows improved learning comprehension and retention. Most universities have recognized this correlation and have put a strong emphasis on practical learning and teaching in both curricular and extracurricular activities. At California Polytechnic State University in San Luis Obispo (Cal Poly), this approach is embedded in the curricula through the school motto of "Learn by Doing."

Amateur radio is a great example of such a "Learn by Doing" activity for electrical and computer engineers. Over 262 college- and university-based amateur radio clubs exist in the United States alone, with an additional 70 worldwide [1,2]. These clubs provide a place for mentoring, group projects, and exposure to the technical and non-technical aspects of amateur radio both inside and outside the classroom.

It is very easy for students to get their amateur radio license in conjunction with their ECE curriculum. It can be as simple as a homework assignment, Internet-based self-study, or a focused time for intense study to pass the exam. Often times, college classes will encourage the effort to secure an amateur radio license by offering extra credit for the class or by making it a course requirement.

Amateur radio offers a wide range of technical and non-technical opportunities. The most obvious activities fall into the broad topic of electronic communication systems. The public service aspect of amateur radio will often have clubs supporting community activities while providing great social and learning experiences. The preparation and execution of those community activities requires system design, planning, volunteerism, and logistics as well. Participants are then users of the technology as well as creators.

This article focuses on these three areas: licensing, classroom projects, and extracurricular applications of amateur radio. There are many amateur radio resources covering the broad interests of ECE students. Many are offered by public safety, state, federal, and other local agencies that want to have radio operators support them. Technical training and projects range from antenna design, radio construction, software design radio implementations, data transmission protocols, and computer applications that use data transmitted over amateur radio allocated frequencies. There are also many networking opportunities for students when they attend meetings of their local club, amateur radio conventions, and even chatting with new friends they meet on the air, nearby and around the world. All these doors are opened if schools take advantage of these many resources and encourage students to pursue them.

Legal Use of the Radio Spectrum: Getting Students their FCC License

By licensing college students in their first year of study, they gain access to use the Federal Communications Commission (FCC) amateur radio allocated spectrum. The allocated spectrum covers a wide range of frequencies that demonstrate the breadth of wireless communication phenomena. There are three levels of licensing: the Technician, General and Extra Class levels. The first year licensing activity focuses on getting freshmen to take and pass the technician-level examination [3]. The FCC authorizes 14 different Volunteer Examiner Coordinator (VEC) Organizations to administer these examinations across the U.S (https://www.fcc.gov/volunteer-examiner-coordinators-vecs). Cal Poly has chosen the Laurel VEC organization because it does not charge any fees for taking the FCC examination. This no-fee solution simplifies using the FCC technician radio examination as a learning tool in the Electrical Engineering Curriculum and increases accessibility of the license for first-year students. Figures 1 and 2 illustrate an example of the local radio club providing an entire examination process for 160 students in a single class meeting period of 50 minutes.

Fig. 1: Volunteer examiners Cathi Okamura (KJ6OHR) and Ashley Threlfall (KF7JDL) checking in students prior to the in-class FCC examination. Photo Credit: Marcel Stieber (AI6MS).

Fig. 2: Freshman taking the amateur radio technician exam as part of an Introduction to Electrical Engineering course. Most students complete the multiple choice examination in about 30 minutes. Photo Credit: Marcel Stieber (AI6MS).

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In considering the use of the technician examination as a University teaching tool, it is useful to review the contents of this examination [4]. (Example questions can be found at: http://www.ncvec.org/).
The subject areas of the FCC technician examination are as follows:

- **Subelement T1** – FCC Rules, descriptions and definitions for the amateur radio service, operator and station license responsibilities.
- **Subelement T2** – Operating procedure.
- **Subelement T3** – Radio wave characteristics.
- **Subelement T4** – Amateur radio practices and station set up.
- **Subelement T5** – Electrical and Electronic principles.
- **Subelement T6** – Electrical components, semiconductors and Circuit diagrams.
- **Subelement T7** – Station equipment, troubleshooting, basic repair, and testing.
- **Subelement T8** – Modulation modes, Amateur satellite operation, digital communication.
- **Subelement T9** – Antennas and feed lines.
- **Subelement T0** – Electrical safety: AC and DC power circuits; Antenna installation; RF hazards.

Using the online study aid -- HamStudy.org -- it generally takes a student about five hours to be proficient enough to pass the 35-question technician exam. HamStudy.org takes students through the entire set of 423 questions, provides the correct answer and a short explanation justifying the answer. The five hours of study only provides enough time to identify correct answers; more time is needed to understand deeper principles. Motivated students are encouraged to pursue broader study. The General Class and Extra Class FCC license examinations require deeper knowledge and provide wider access to the amateur radio spectrum allocations, notably the High Frequency (HF) bands.

Using Amateur Radio Projects in the ECE Laboratory Curriculum

Amateur radio organizations such as the American Radio Relay League (ARRL) and the Radio Society of Great Britain (RSGB) provide a wealth of publications that are intended for both introductory and advanced audiences with an emphasis on practical implementation of projects. Many of the publications include step-by-step instructions on how to build and test electronic systems designs with modest

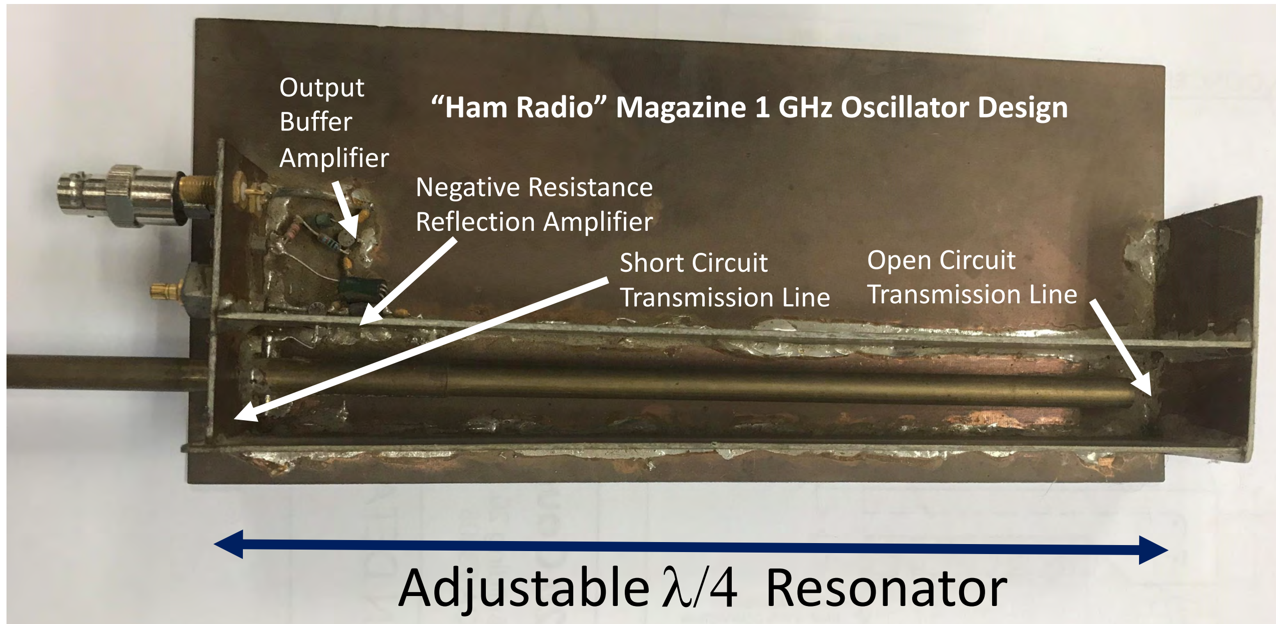

Fig. 3: This is an adjustable 1 GHz oscillator that was adapted from the article "Designing a Station for the Microwave Amateur Radio Bands; Part II" by Glen Elmore, (N6GN), from Ham Radio Magazine, June 1988.

cost and simple test and measurement equipment (examples include the QST and QEX Magazines from ARRL (http://www.arrl.org/qst and http://www.arrl.org/qex). University faculty in the electrical and computer engineering discipline are interested in finding practical construction projects that can be incorporated into their laboratory curriculum. These amateur radio community-created projects provide a large pool of ideas freely available for inclusion in the ECE laboratory curriculum. Students are often inspired when they are able to design and construct a useful project in the limited time available for their laboratory meetings. Figures 3-6 illustrate examples of the authors' use of amateur radio projects in the ECE laboratory curriculum.

Figure 3 shows an example microwave oscillator design used in a high-frequency electronics laboratory. The design uses a microwave frequency Bipolar Junction Transistor in a negative-resistance amplifier configuration to provide gain. The adjustable quarter wave transmission line resonator is used to provide frequency selective reflective feedback. The High-Q resonator provides for a stable oscillator with low phase noise. The design article from Ham Radio Magazine also demonstrates how to lock this microwave frequency resonator to a low frequency 10 MHz crystal reference oscillator using a simple phase-locked loop addition. Construction materials include double-sided PC board material, adjustable length brass hobby tubing and "dead bug" construction techniques.

Figure 4 illustrates two high-frequency filter designs used in a filter design course. (a) This is a 5.8 GHz amateur radio band bandpass filter using a copper pipe end cap and two 0.085-inch semi-rigid coaxial cable probes. (b) This is a 902 MHz band interdigitated bandpass filter made from brass hobby store tubing and double-sided PC board material. A senior project student also used the microwave CAD electromagnetic simulation program EM-Pro to compare the experimental performance to the simulated performance of the filters.

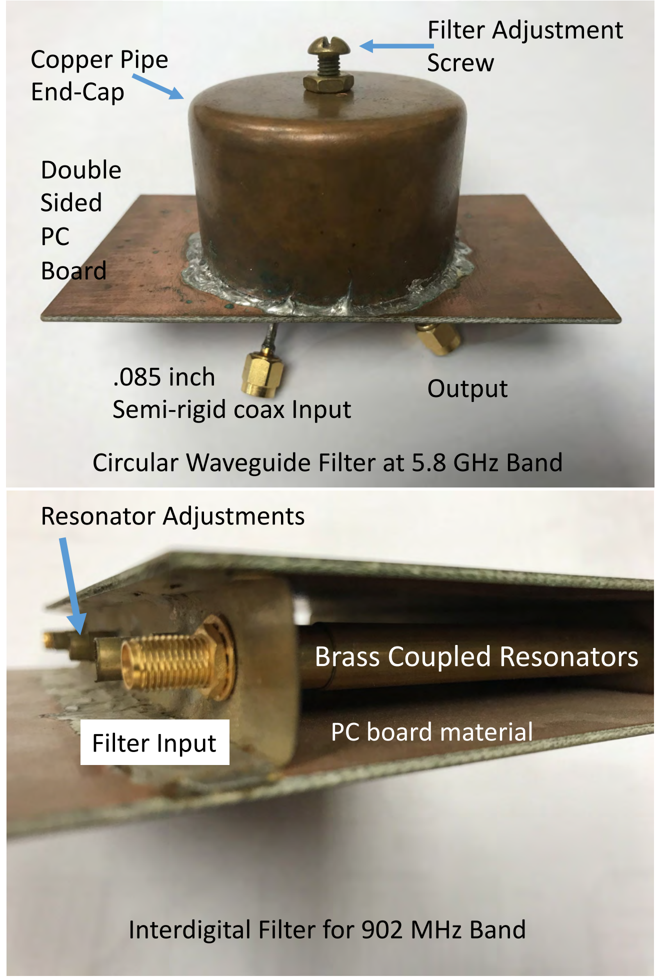

Fig. 4: Here are two examples of passive filter designs made from hardware-store equipment and semi-rigid 0.085-inch-diameter coax assemblies. Top, circular waveguide bandpass filter for 5.8 GHz, and bottom, an interdigitated coupled-resonator filter for the 902 MHz amateur band. Both designs are adapted from the *ARRL UHF/Microwave Projects Manual -- Volume 1* by Kent Britain (WA5VJB).

Figure 5 shows two implementations of digital communication modulators used as part of a digital communication laboratory experiment set. These I-Q modulators create flexible combinations of amplitude modulation and phase modulation depending on the input waveforms at the in-phase "I-Input" and quadrature phase "Q-Input" connectors. Both traditional PC board construction (a) and "Dead-Bug" construction (b) are used to fabricate these modulators. Sets of IQ modulator/demodulators along with student built antennas, power amplifiers, and pre-amplifiers are combined to demonstrate wireless digital communication links.

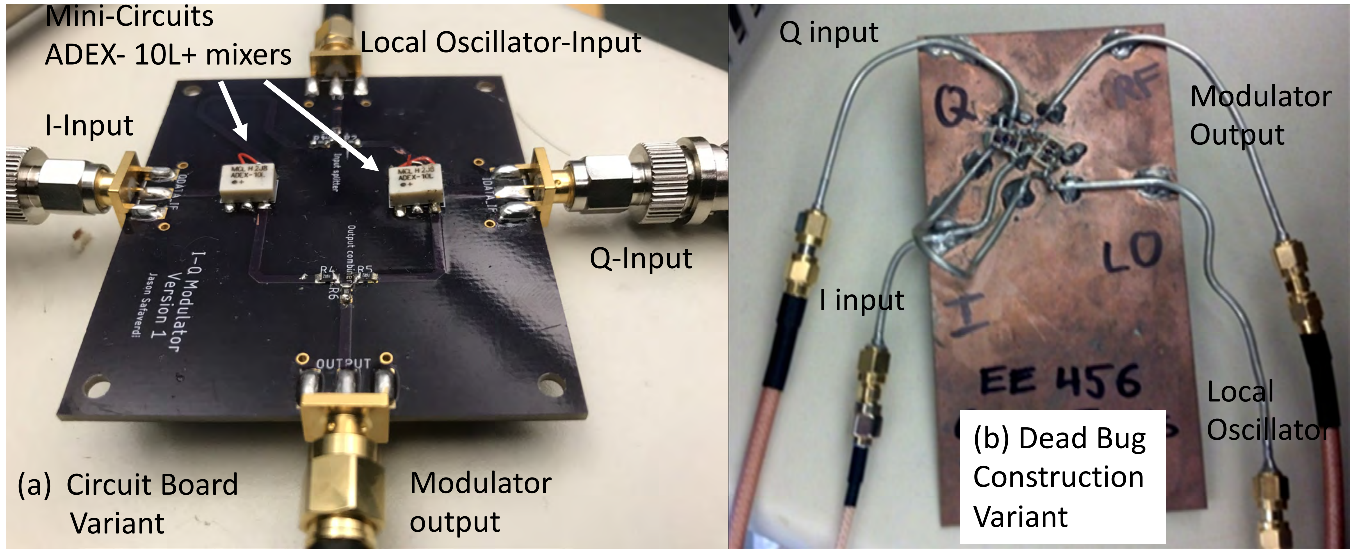

Fig. 5: These are I-Q digital communications modulator/demodulators designed for the 910 MHz amateur radio band. (a) This design uses two mini-circuits double balanced mixers and a student-designed PC board. (b) Students can also build a "dead bug" version of the modulator.

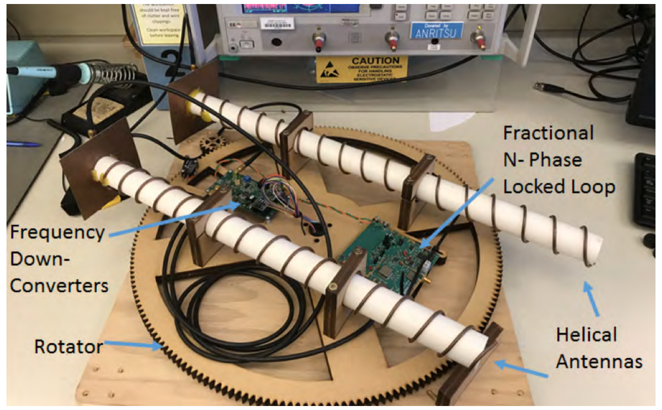

Fig. 6: Here is an example of a senior/graduate level system project involving a 2.4 GHz amateur radio band transceiver or radar system. This design is adapted from Small and Short Range Radar Systems, by Gregory Charvat (K1CXT) ISBN-13: 978-1439865996.

Figure 6 shows a simple radar system that is designed, constructed and tested as part of a senior/graduate level course in system design.

This prototype was constructed over a 10-week quarter with a team of 4 people. It can use FMCW or Doppler radar modes. This class has students work with analog and digital electronics, microprocessors, software and a significant amount of troubleshooting and design verification.

In summary, if one simply searches the term "amateur radio construction projects" or "amateur radio homebrew" one can benefit from a century of innovation in electronics projects from the amateur radio community. These projects are designed with the new experimenter in mind with limited budget and limited time. Amateur radio groups continue to incorporate the latest advances in electronic hardware and software into their designs that are made widely available. The Electrical and Computer Engineering Community can easily leverage this work toward compelling laboratory projects that can be used in the university laboratory education system.

Extracurricular Activities in Amateur Radio

Outside of the formal ECE curriculum, the amateur radio community offers students many opportunities to design, build and operate radio systems for public service, emergency communications, and experimentation or simply for fun. Amateur radio clubs are a great resource for universities to engage with electrical and computer education. Local and regional meetings, electronics trade shows, and radio conferences are widely available to students and faculty and provide excellent opportunities for networking and collaboration (http://www.arrl.org/hamfests-and-conventions-calendar). Each of these activities provides practical, hands-on experience that often ties directly back to the ECE curriculum.

RADIO CONTESTING

Some students participate in the art of radio contesting, where amateur radio operators strive to make as many contacts with other radio operators as they can in a dedicated time period. This competitive activity is a great engaging way to get students (including younger or less technical ones) on the air and learning more about how radios work. Through contesting, students will become familiar with radio operating techniques, RF power output, antenna gain, radio propagation and ionospheric effects, and many other aspects related to radio setup and usage. During these contests, operators rack up "points" which count towards their overall score. Awarding different points for different types of operation allows students to try different operating modes to increase their score (i.e. 1 point for voice contacts, 2 points for a digital-mode contact, and 3 points for a CW (Morse code) contact). Collegiate contests find students, faculty and staff operating their radios for up to a week between classes making contacts and earning points in friendly competition with one another.

These contests extend to more than just collegiate competitions: Jamboree on the Air (JOTA) and ARRL Field Day offer opportunities for collegiate operators to engage with the local and national amateur radio communities (http://www.arrl.org/contests). JOTA is an event organized through the scouting community and encourages young people to learn about the art of amateur radio. Field Day is an annual contest which encourages all amateur operators to exercise their operating privileges and make as many contacts as possible in a 24-hour period to demonstrate their emergency operating capability.

RADIO DIRECTION FINDING

Another engaging activity where students can apply their ECE skills is in the world of Transmitter Hunting (colloquially called Fox Hunts), in which Radio Direction Finding (RDF) techniques are applied to find hidden transmitters, as seen in Figure 7. Often using home-built directional antennas and low-cost transceivers, this offers opportunities to learn about antenna patterns, weak signal propagation, multipath, and many other complex RF concepts not ordinarily exposed to students. Some students even take the competition a step further, developing complex systems for direction finding utilizing custom circuitry. Others create custom antennas to be used for RDF, learning about special considerations for antenna design. Students can quickly find the parallels from this fun activity to real-world applications including search and rescue (including aircraft emergency transponders, elderly locating devices, and avalanche beacons) and stolen vehicle tracking (LoJack).

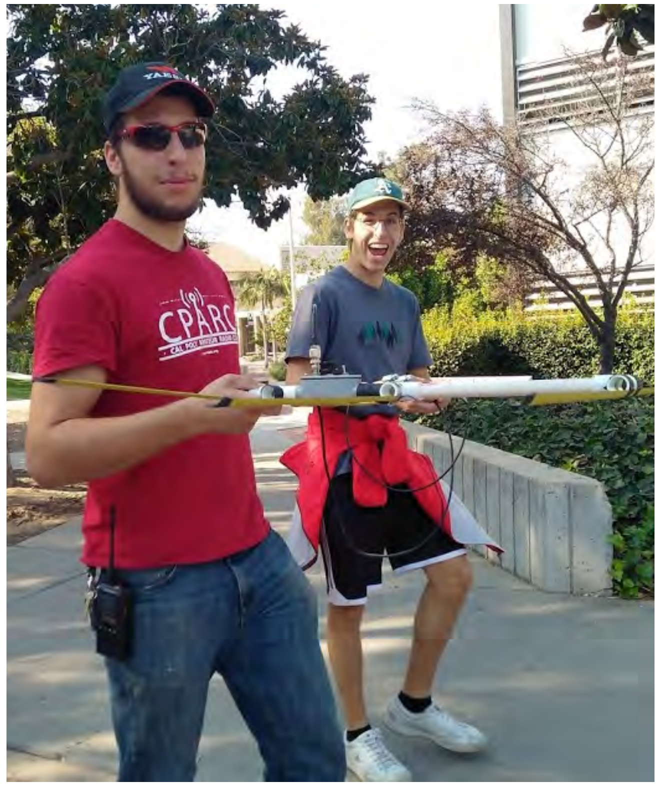

Fig. 7: Students Davide Lanfranconi (KM6FLL) and Andrea Lanfranconi using home-built directional antennas during a transmitter hunt. The hidden transmitter puts out telemetry for 10 seconds each minute. Transmitter hunters then run for 50 seconds before they get their next directional fix, plotting their direction bearings and triangulating the signal. Watch out for multi-path reflections though, as this can send the team off in a wrong direction. Photo Credit: Jack Gallegos (KK6YWG).

PUBLIC SERVICE EVENT SUPPORT

In the spirit of public service, student amateur radio operators can participate in a variety of activities allowing them to make a positive contribution to

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their communities. Amateur radio operators are often called in to perform communications service for events such as bike races and marathons. Their ability to set up communications systems relatively quickly without much infrastructure makes them well-suited for the task. Operating radio repeaters, which extend voice coverage beyond line of sight, communications ranges upwards of 50 miles are not uncommon for these type of events. Lately, low-cost networking equipment and digital technologies have allowed operators to introduce vehicle tracking using the Automatic Packet Reporting System (APRS) and exchanging data using IEEE 802.11 wifi mesh networks. Their FCC license privileges allow volunteers to use power limits and frequencies not available to consumers, further extending their communications abilities. As a result, student amateur radio operators fill crucial gaps where cellular coverage and conventional communication methods fall short. Students will often support the event logistics teams, seeing the ins and outs of the organization and emergency response behind these events. Often the volunteers will setup a dispatch operating position which is setup completely off-the-grid and powered by solar systems and battery banks designed and setup by the students.

Fig. 8: Cal Poly Students, Celestial Rodriguez (KM6MKR) (left) and AJ Fite (N7AJF) (right) as radio operators providing event logistics support for the 2018 Wildflower Triathlons. Photo Credit: Marcel Stieber (AI6MS).

For some, the public service side of amateur radio offers an opportunity to construct complex communications networks. For the Cal Poly Amateur Radio Club in San Luis Obispo, CA, this has allowed student operators to set up communications equipment for the yearly Wildflower Triathlon (Figures 8, 9, and 10). As the event site is in a remote location with virtually no connection to the outside world, club members assist in setting up an entire off-grid radio site; complete with an antenna tower and portable radio repeater installations. Students gain experience setting up solar panels, power distribution systems, troubleshooting antennas, weatherproofing RF cable assemblies, RF safety, and much more. In past years, students have also set up APRS vehicle tracking, Wi-Fi networking equipment, and computer-aided dispatch servers, allowing for data from medical/public safety agencies to be handled seamlessly across event staff and increasing situational awareness during the event. During the event, student operators work with alumni and community members to provide communications service, ensuring the safety and security of thousands of event goers.

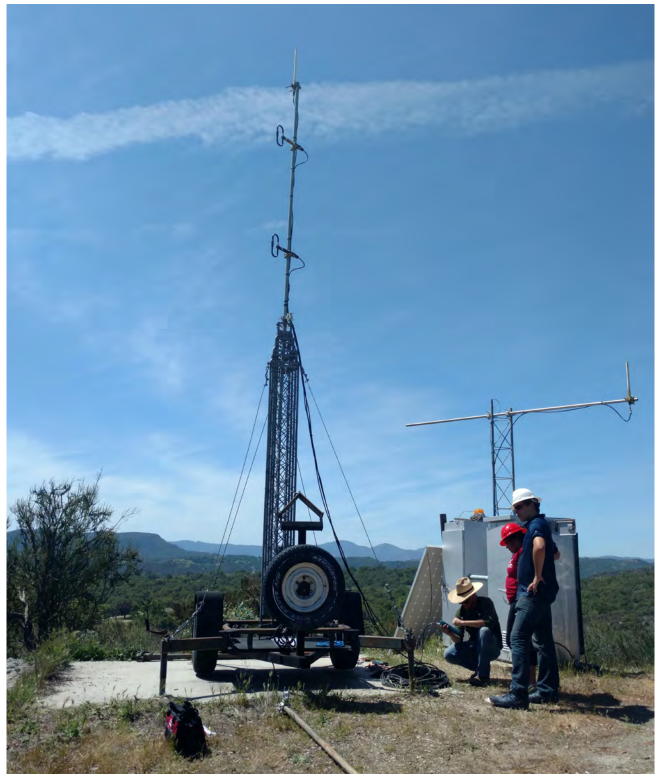

Fig. 9: Cal Poly Students setting up a temporary radio site for the 2018 Wildflower Triathlons. Left to right: Chris Blackmer (KJ6MNK), Jissell Jose (KM6GKN), and Davide Lanfranconi (KM6FLL). Photo Credit: Marcel Stieber (AI6MS).

On campus, student amateur radio operators offer a unique resource to their institutions. Many operators are CPR and First Aid trained, and routinely keep up-to-date in their technical and emergency preparedness training. Many college amateur radio clubs operate radio repeaters, which provide wide-area coverage for radio operators in the area, often providing backup power for use in disasters or simply power outages [5]. Many also are trained in handling radio messages using the Incident Command System (ICS), allowing them to be integrated into their campus emergency plans. Students are often encouraged to volunteer while in college, and amateur radio offers a unique opportunity for volunteering that combines technical knowledge with public service.

Fig. 10: Cal Poly University students, staff and alumni radio operator volunteers for the 2018 Wildflower Triathlons. Left to right, back row: Dan Malone (K6HPB), Jamari Ducre (KM6NPT), Andrew Musselman (KI6UOC), Davide Lanfranconi (KM6FLL), Clinton Dague (NR6T), Ethan Chao (KM6ESV), and AJ Fite (N7AJ). Front row: Allen Takahashi (N6KDM), Jack Gallegos (KK6YWG), Jissell Jose (KM6GKN), Celestial Rodriguez (KM6MKR), Marcel Stieber (AI6MS) and Arianne Olarig (KK6QFQ). Photo Credit: Allen Takahashi (N6KDM).

CONCLUSION

The value of the FCC amateur radio license to the Electrical and Computer Engineering curriculum is clear through the many examples shown in this article. The technician license exam has a low barrier of entry and provides excellent educational benefits to ECE faculty and students. Countless amateur radio projects and activities can be used to enhance the educational experience and provide direct, hands-on learning to improve comprehension and retention. Amateur radio not only improves the student experience, but also can benefit greatly the community through public service and volunteerism outside of the classroom. The authors hope that this article inspires you to explore the many opportunities that amateur radio can bring to the engineering curriculum and show how the ECE and amateur radio communities can work together to benefit each other.

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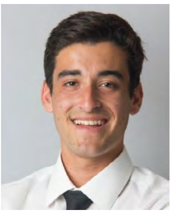
Dennis Derickson (callsign AC0P) received his BS, MS, and Ph.D. in electrical engineering from South Dakota State University (1981), the University of Wisconsin in Madison (1982) and the University of California in Santa Barbara (1992). His farming background and youth ham radio hobby heavily influenced his career in engineering. He worked on spectrum and network analyzer measurement equipment at Hewlett Packard (HP) in Santa Rosa, CA in the 1980's. He joined the Electrical Engineering faculty at Cal Poly in 2005 and has been department chair since 2010. He is a founding member of the start-up company Insight Photonics Solutions that is commercializing research initiated at Cal Poly (http://www.sweptlaser.com/). His outreach activities include summer science camps and robotics programs for local schools. As department chair, he has focused on Industry/Alumni/Partner outreach, entrepreneurship, enabling a project-rich hands-on environment for diverse students, and supporting a strong graduate program.

Charles "Chuck" Bland (callsign NA6BR) is an Engineering Technology Engineering alumnus of California Polytechnic State University in San Luis Obispo (1982), and completed his Master's in Computer Science at California State University, Sacramento (1995). Chuck received his amateur radio license while attending Cal Poly and has been actively involved in the Cal Poly Amateur Radio Club, technical, public service, and training activities. Upon graduating, Chuck joined Motorola Communications, designing and implementing voice and data communications systems for Public Safety. His duties included training of technical staff on system maintenance and operation, consultation with customers and their vendors on system hardware and software interfaces, evaluation of system performance, and providing support services. Chuck's background in amateur radio was an expression of his skills professionally and in the areas he explored as a hobby. After 35 years, Chuck returned to Cal Poly, joining the Electrical Engineering Department as an adjunct lecturer.



Jack Gallegos (callsign KK6YWG) is an Electrical Engineering student at Cal Poly. He is currently the president of the Cal Poly Amateur Radio Club, and is actively involved in public service and radio experimentation. Jack has been involved in amateur radio since 2015 and has been licensed since high school. Jack is also a volunteer examiner and has helped license over 300 people at test sessions hosted at Cal Poly. He has also been working with Tom Tengdin WB9VXY to incorporate electronic grading and improve exam efficiencies. Jack's primary hobby is currently amateur radio, though he has found many ways to tie his existing hobbies together; using radios on land, air, and sea to test novel communication systems. He also has applied his amateur radio skills to his professional life, completing internships in radar system and antenna design, and is looking to establish a career in the world of RF.

Marcel Stieber (callsign AI6MS) is an Electrical Engineering alumnus of California Polytechnic State University in San Luis Obispo (2012). He serves on the Cal Poly Electrical Engineering Industry Advisory Board and currently works as a Hardware Systems Integration Lead at Amazon Lab126 in Sunnyvale, CA. Marcel was former Club President and is currently Industry Advisor to the Cal Poly Amateur Radio Club (www.w6bhz.org). Marcel got his job through amateur radio and regularly gives back at local repeater workdays as an RF technician and volunteer tower climber. He serves as a Technical Advisor for several event management companies and local repeater groups. His Master's Thesis, based on his amateur radio experiences, was titled: Radio Direction Finding Network Receiver Design for Low-cost Public *Service Applications* (https://digitalcommons.calpoly.edu/theses/889/). Marcel helped to establish the Freshman Licensing Initiative and regular licensing sessions which have brought over 1,500 new licenses to amateur radio since 2009 (see: https://w6bhz.org/content/licensing).

Guglielmo Marconi

Guglielmo Marconi (1874-1937) was an inventor, engineer, and entrepreneur of Italian and Irish descent. Based on the early research of Heinrich Hertz and others, he began developing technology for wireless communication. After initial successes in his home country of Italy, he moved to the United Kingdom, where he demonstrated increasingly more capable long-distance communication systems. He made fundamental contributions toward understanding radio communication and developing commercial radio technology.

Fig 1. Guglielmo Marconi (undated). Courtesy of the IEEE History Center

By 1899, Marconi had demonstrated radio transmission across the English Channel, at a time when many believed that only local or short-range radio transmission was possible. Marconi addressed the technical challenge of radio communication across the Atlantic by establishing a high-power transmission station at Poldhu, a location on the southwestern coast of England. The figure shows the scale of this transmitter facility. In 1901, Marconi reported the first Transatlantic communication of the letter "s" in Morse code. He rapidly commercialized the developing technology by providing a variety of services especially in support of maritime communication. In later years, his companies were involved with broadcast communication systems.

Fig 2. Marconi in 1903 with the future King George and Queen Mary at the Poldhu wireless station, Cornwall, England. From the Smithsonian Traveling Exhibit.

In addition to his business success through communication patents and companies, he shared the 1909 Nobel Prize in Physics with Karl Braun "in recognition of their contributions to the development of wireless telegraphy." In addition he received the Franklin Medal from the Franklin Institute and the third Medal of Honor awarded by the Institute of Radio Engineers (IRE). A summary of his career is given in J. E. Brittain, "Electrical Engineering Hall of Fame: Guglielmo Marconi," Proceedings of the IEEE, 92(9), 1501-1504, 2004.

The Marconi Society was founded by Marconi's daughter to encourage advances in communication technology (see marconisociety.org). Marconi's legacy has been commemorated further through IEEE Milestones such as the following:

- Marconi's Early Experiments in Wireless Telegraphy, Italy, 1895
- Transmission of Transatlantic Signals, Poldhu, England, 1901

The IEEE Milestone program is administered by the IEEE History Center, IEEE History Committee and honors significant achievements in the history of electrical and electronics engineering.

Dr. Russ Meier

Eta Chapter '18

Dr. Meier is a Professor of Electrical Engineering and Computer Science at the Milwaukee School of Engineering (MSOE). He received B.S., M.S. and Ph.D. degrees in Computer Engineering from Iowa State University. At MSOE, he mentors future engineers in the areas of digital logic, computer architecture and electronics. His research interests include engineering education, embedded systems, evolvable hardware, and computer architecture. He has a 28-year history of teaching at the undergraduate and graduate levels. His teaching skills have been recognized with an Iowa State University Teaching Excellence Award, the Iowa State University Warren B. Boast Award for Undergraduate Teaching Excellence and the MSOE Oscar Werwath Distinguished Teacher Award.

Dr. Meier is a member of IEEE and IEEE-HKN, and the Computer and Education societies, as well as the American Society for Engineering Education (ASEE) and its Electrical and Computer Engineering and Educational Research and Methods divisions.

In addition to his teaching career, Dr. Meier works to improve engineering education as part of his professional service. Over a 20-year period, he has helped to create multiple workshops, conferences, online seminars, and certification programs for engineering and computer science professors. He currently is serving a two-year term as the IEEE Education Society President. The IEEE Education Society is an international community of thousands of IEEE members that promote, advance and disseminate state-of-the-art scientific information and resources related to the theory and practice of engineering and computer science education.

Dr. Meier has received multiple service awards from IEEE societies. In addition, the International Society for Engineering Education awarded him the title "International Engineering Educator Honoris Causa" in 2012 for outstanding contributions in engineering education. And, in 2017, IEEE elevated Dr. Meier to the rank of Fellow for his contributions to global online engineering education.

How has Eta Kappa Nu (IEEE-HKN) impacted your life? Your career?

I was inducted as a Professional Member of HKN in 2017. Already, I have met new people and made new friends that inspire me. When I wear my HKN lapel pin, members stop me and introduce themselves. Through these conversations we discover shared interests and usually projects that we can work together to implement within IEEE. These projects help IEEE achieve its mission of advancing technology for humanity.

What inspired you to choose the engineering field?

I grew up on a livestock farm in Nebraska just as the personal computer era was beginning. I was surrounded by large mechanical machines – tractors, combines, planters, augers – that fascinated me. I learned how gears, hydraulics, levers, and other mechanical components transferred energy to do work for us. These years growing up in the agricultural heartland of America were complemented by the arrival of computers in my high school. The Apple II and the BASIC programming language showed me the future would be radically changed by the microcomputer revolution. I sold some livestock and bought a TI99-4A home computer and began learning to program. It was awesome! I could make the computer do anything I wanted it to do. It was my ah-hah moment. I knew I had to pursue building machines that had computers inside.

What do you love about engineering and what do you love about education?

Engineers apply math, science and ethics to build products that benefit humanity. That is a noble profession, in my opinion. That is what I love about engineering.

What I love about education is the opportunity to mentor people that have had similar ah-hah moments to the one I described earlier. When I watch the eyes of a student light up and see their brain make connections to the material, it reinforces my deepest professional love of helping people better themselves for a brighter future.

Whom do you admire and why?

As a person, I admire my parents for raising their children to have strong ethics, to value education, and to face challenges with determination. They did this under their own economic challenges of an agricultural career. To me, it seemed like everything they did was for their kids – to ensure their kids had a future life that wasn't as difficult as theirs might have been.

As an engineer, I admire the engineers and computer scientists that accepted the challenges of electronic computing. We are more than 80 years into the electronic computer age, and computer architects have moved the computer from the room-sized machines of the 1930s to the microminiaturized machines that power the modern world. The pioneers in this industry were followed by the entrepreneurs of the 1970s and 1980s. Together they changed everything.

In your opinion, what has been the greatest change in engineering since you were a student?

The personal computer. Paper design has been replaced by computer-aided design in most – if not all – fields of engineering. Also, the vast amount of knowledge available in an instant through the internet. When I was a student, I read textbooks, technical journals and technical magazines in the library. Today, you simply do a keyword search and find gazillions of bits of information. Some of it is good information – curated by professionals – and other non-curated information is not so good. I think it is challenging for both students and professionals to filter this information.

I wish I had known…

I wish I had known the importance of taking a personal finance class. Topics in money management, personal credit, mortgages, investing, interest rates and budgets were not topics taught in my high school. I was also not encouraged to take this type of an elective by my university advising center. I've learned all about these things as a professional, but it hasn't been easy. I highly recommend all students take a personal finance class at the university. It will make starting your career and family life so much easier.

Best advice for new graduates…

Every day, you will face personal and professional challenges. These challenges often seem like insurmountable mountains. They are not. You will succeed at many things, and you also will make mistakes. Recognize this, seek resources to help you, use the skills and knowledge you have, and do your best.

From your perspective, what's the next BIG advance in engineering?

We have already experienced societal changes caused by personal mobile devices, such as smart phones and smart watches. Having these powerful handheld computers gives people tremendous opportunities to learn, process information and monitor their own health. Now, the natural place for computers and information to continue progressing into our lives is through wearables woven into clothing fabric, biosensors, biological nanonetworks and biologically implantable or injectable computing devices. When coupled with heads-up displays on the lenses of glasses or direct retinal stimulation, this new era of personal computers will change human society in similarly remarkable ways. The ethical question of "should humans augment themselves with computers" is certainly intriguing. I encourage you to visit the IEEE Code of Ethics and then write down your own personal thoughts. Keep this personal essay somewhere safe and come back to it in 10 to 15 years. You will then be able to compare what the engineering community did against your own thoughts and biases in 2019.

Graduate School Spotlight

The *fast track* to a master's

College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

Complete your degree in one year with UW–Madison's accelerated professional master's programs

Want to move your career forward—fast? Add an advanced degree to your resume in just one year at UW–Madison's top-ranked engineering school. Our master's degrees are for industry-bound professionals wishing to advance their technical expertise and ability to thrive in the field. All programs are course-only, self-funded, and accelerated to provide graduate-level training in a predictable and compressed timeframe.

Specialize in your choice of disciplines

Tailor the program to your interests—and maximize your earning potential—by studying an in-demand engineering discipline. We offer 17 options:

- Automotive engineering
- Biomedical engineering
- Biomedical innovation, design and entrepreneurship
- Construction engineering management
- Electrical engineering
- Environmental science and engineering
- Fundamentals of applied mechanics
- Geological and geotechnical engineering
- Human factors and health systems engineering
- Mechanical engineering
- Modeling and simulation in mechanical engineering
- Nanomaterials and nanoengineering
- Signal processing and machine learning
- Structural engineering
- Systems engineering and analytics
- Transportation engineering
- Water resources engineering

Program at a glance

Timeframe: Three semesters (fall, spring, summer), for a total of 12 months.

Mode of instruction: Face-to-face on UW–Madison campus.

Requirements: Coursework only, no thesis. At least 30 credits required for master of science degree.

Resident tuition: $6,005 for fall and spring semesters and $2,997 for summer courses (six credits).

Nonresident tuition: $12,668 for fall and spring semesters and $6,329 for summer courses (six credits).

Application deadline: December 1 to January 1 for fall 2020 program (varies by program).

Tuition rates as of fall 2018

Program details and admission requirements

Apply or gather more information at *advanceyourcareer.wisc.edu/college-of-engineering*.

Questions?

Contact Program Director Lee DeBaillie, at 608-262-2329 or debaillie@wisc.edu.

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IEEE-HKN
2019
Student Leadership CONFERENCE

Engineering Your Future!

THE HKN ADVANTAGE >>> START MAKING YOUR PLANS

November 1-3 | Tufts University | Boston, MA

The annual IEEE-HKN Student Leadership Conference is a signature program of the society and is an opportunity for your chapter to meet with other officers, members, faculty advisers, members of the Board of Governors, and staff. The conference includes opportunities for professional development, leadership training, and networking.

REGISTER TODAY: hkn.ieee.org/get-involved/student-leadership-conference/

Special Graduate School edition coming out in October 2019

The issue will focus on the programs available, the opportunities graduate schools can provide and expert advice for students. Reach the top electrical, electronics, computer science and computer engineering students from around the globe. **More than 34 percent of IEEE-HKN undergraduates go on to graduate school.**

Contact Christine Cherevko at c.cherevko@ieee.org to reserve your spot in this special edition and show off your graduate school program. **Space is limited.**

HKN IEEE

Are You Eta Kappa Nu?

Show Your Eta Kappa Nu!

If it's not on your card, it's not in your IEEE membership record. **Let us know!**

800-406-2590 **info@hkn.org** **www.hkn.org**

Brad Ziegler

KCØCDG

Brad Ziegler is a Ph.D. Student in Computer Engineering at Missouri S&T, Rolla, MO. He holds an M.S. in Education from Missouri Baptist University and a B.S. in Electrical Engineering from Missouri S&T (then "UMR"), which he attended from 1999 to 2004. Prior to his return to Rolla, Brad spent nearly 10 years in secondary education as a technology and engineering instructor, most of that at Parkway North High School in Creve Coeur. He hopes to become a collegiate instructor of engineering.

Brad has reacquainted himself with the school's radio club (WØEEE), of which he is currently serving as President (he was President back in 2000). He has lead the fundraising efforts to rebuild the antenna stack on the primary tower. He also constructed a DMR repeater and placed it in service in Rolla. Prior to his return to school, he became involved in public safety communications and continues to work as a Communications Unit Leader (COML) Instructor with the Eureka Fire Protection District. He trains amateur radio operators as Auxiliary Communicators to work within the incident command system when called upon by emergency management officials. He also enjoys HF contesting as time permits.

When not pursuing his studies or helping others pursue theirs, Brad also enjoys riding roller coasters, genealogical research and restoring antique Fords. Brad is a volunteer firefighter/EMT with the Rolla Rural Fire Protection District.

What has it meant to you to be inducted in IEEE-HKN?

I'm in the process of joining the Gamma Theta Chapter, now.

Do you have a best HKN story to share?

I appreciated the opportunity to assist the guest editor with this amateur radio special issue. I particularly enjoyed collecting the QSL cards that are shown on the cover and distributed through the issue.

Why did you choose to study the engineering field?

Electronics and computers were a hobby of mine originally, which led me into electrical engineering. I have come to realize that computer engineering is what I enjoy studying now.

What do you love about engineering?

Engineering is always evolving. So many changes and advances in the science are taking place, and this is where the cool hands-on stuff occurs.

What is your dream job?

I want to teach undergraduates in engineering or computers.

Whom do you admire and why?

There are many people I admire for various reasons from professors, managers to friends. Most of them have been influential on one aspect of my business or personal life and have been able to guide me through something that I found difficult to get through. In the end, everyone should strive to be lifelong learners, but also lifelong teachers and mentors. Be willing to share that "tribal knowledge" and train the next guy that is going to do your job.

What do you thing is the next BIG advance in engineering?

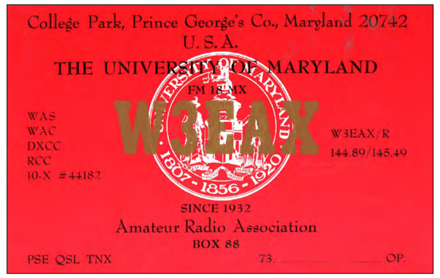
I'm continually impressed by the advances in 3D printing technology and the uses of it that are being developed every day. Imagine being able to go to an auto parts store sometime in the future and order your car part there to be printed up or seeing your doctor and he "prints" you a new organ to replace your failing one.

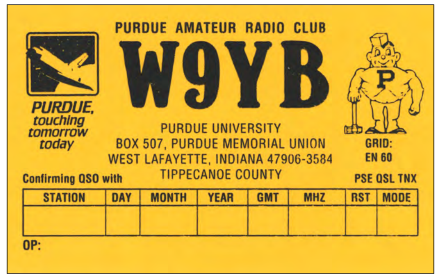
What is the most important thing you've learned in school?

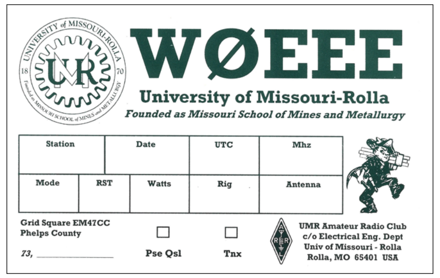
The greatest lessons that you will learn will not be in the classroom. Things like life, death, right, wrong, and true friendship cannot be taught. You will have to figure them out on your own.

What advice would you give to other students entering college and considering studying your major?

Relax. There will be times when everything hits you at once, and you will get burned out. Take time out to do nothing but one thing that you enjoy, to get away from everything else. (Just don't do it during an exam or major deadline.)







Dennis Leitterman

Gamma Theta Chapter
Life Senior Member
Actively Involved to Help Achieve IEEE Goals

Dennis Leitterman's involvement with IEEE began in 1971 during his freshman year of college and continued throughout the rest of his undergraduate years at Missouri University of Science and Technology, Rolla, MO, US, where he was elected IEEE Student Branch Chair, served as President of his IEEE Eta Kappa Nu (HKN) Student Chapter, and was a finalist for the HKN Outstanding Senior Award.

After completing his M.S. in Electrical Engineering, Dennis enjoyed a 30-year career with Hewlett-Packard in the Silicon Valley, where he focused on the computer sector and worked in engineering management, project management, software licensing, product marketing and business development. "HP was supportive of my IEEE activities," said Dennis, who took on many volunteer leadership roles throughout IEEE, including National Director of HKN. He now serves as Chair of the IEEE San Francisco Bay Area HKN Alumni Chapter as well as Chair of the IEEE-HKN Alumni Committee.

> I'm proud of IEEE and what it's accomplished. *I plan to continue my support to help achieve IEEE goals.*
>
> DENNIS LEITTERMAN

According to Dennis, "I've been blessed with a wonderful career and I believe in giving my time and financial resources to help improve the electrical and computer engineering profession; my current focus includes coordinating and participating in interactive career panel presentations with Electrical and Computer Engineering (ECE) students."

"IEEE's mission, vision, core values, near-term goals and key initiatives to support those goals all personally resonate with me," said Dennis, who's made annual donations to the IEEE Foundation for decades. He also supports the IEEE-HKN Fund and recently began donating to the IEEE Life Members Fund. "I'm proud of IEEE and what it's accomplished," he concluded, "and plan to continue my support to help achieve IEEE goals."

You can choose to directly support IEEE-HKN or any of the strategically identified IEEE initiatives that help meet the world's most pressing challenges and help us to realize the full potential of IEEE.

Microwave Theory and Techniques Society

OUR FOCUS

The Microwave Theory and Techniques Society (MTT-S) focuses on the theory and applications of radio-frequency (HF, VHF/UHF, microwave, millimeter-wave and terahertz), guided-wave and wireless technologies, as they relate to nanostructures, devices, integrated circuits, multi-circuit assemblies, components, packages, transmission lines, sub-systems, and systems involving the generation, amplification, processing, modulation, control, transmission, reception, detection and demodulation, and effects of electromagnetic energy transport. It also includes the interaction and interface of microwave signals with digital and optical circuitry and interconnecting transmission media. Examples include optical waves in suitably confined structures, as well as the applications of acoustic, magnetic, and plasmonic waves to microwave systems.

FREQUENCIES

Radio frequency (RF) is a term that refers to signals and associated currents having characteristics such that, if the current is input to an antenna, an electromagnetic (EM) field is generated suitable for wireless broadcasting and/or communications, radar, etc. These frequencies cover a significant portion of the electromagnetic radiation spectrum, extending from about 9 kHz, the lowest allocated wireless communications frequency (if it were audible it would be within the range of human hearing), to thousands of gigahertz (GHz). The discipline of microwave theory & techniques applies physical and mathematical principles to analyze devices, components and structures that interact with electromagnetic fields and often have dimensions representing a significant fraction of a wavelength, or when in-circuit wave propagation effects need to be considered.

TECHNOLOGY

The Society's focus includes scientific, technical, and industrial activities, subject to timely modifications approved by the IEEE Technical Advisory Board. Technical Committee focus areas of interest include microwave and millimeter-wave materials, solid state devices and integrated circuits, filters, passive components and packaging, microwave acoustics and photonics, high-power and low-noise techniques, frequency conversion, field theory, and computer-aided design and measurements. In addition, the Society is involved in terahertz technology, ultra-wide band and microwave systems, and multidisciplinary activities such as RF microelectromechanical (RFMEMS) devices, radio frequency identification devices (RFIDs), digital signal processing, biological effects and medical applications, and business issues.

OFFICIAL FIELD OF INTEREST

The field of interest of the society is theory, techniques and applications of guided wave and wireless technologies spanning the electromagnetic spectrum from RF/microwave through millimeter-waves and terahertz, including the aspects of materials, components, devices, circuits, modules, and systems which involve the generation, modulation, demodulation, control, transmission, sensing and effects of electromagnetic signals.

STUDENT OPPORTUNITIES

MTT-S offers various initiatives to students in microwave engineering to encourage our future leaders and key technical contributors. Several initiatives can be participated in from the home location, without the need to travel. Other initiatives are linked to the International Microwave Symposium (IMS), the flagship conference of MTT-S.

MTT-S has a program to offer financial support to undergraduate and graduate students pursuing full-time programs in RF and microwave engineering. Check out the scholarships and fellowships website for more details.

MTT-S

For an overview of the various student-related contests at the International Microwave Symposium (IMS), consult the Students at IMS website.

Chapter News

BEST PRACTICE SPOTLIGHT:
Mu Pi and Corresponding Student Branch at GH Raisoni College of Engineering work with Toastmasters International to Develop Public Speaking and Leadership Skills.

The IEEE-HKN Mu Pi chapter and the Student Branch at the GH Raisoni College of Engineering (GHRCE) in India joined forces for a successful program aimed at raising awareness of the importance of public speaking and the development of leadership qualities for a successful career.

The "Students to Mentors and Mentors to Leaders" program featured Karen Parikh, President of the Toastmasters Club, and Chandan Yadaw, of the IEEE-HKN Mu Pi Chapter.

Mu PI is the youngest professional chapter of GHRCE. It is the third HKN Chapter in India and 245th in the world.

The two groups worked with Brio, the Toastmasters International club of the college. The Brio Toastmasters Club follows all the rules, regulations and structure governed by Toastmasters International. Toastmasters chapters develop individuals who could be leaders. One of the toughest skills leaders must develop is public speaking. Toastmasters also instills ethics and values in their message to future leaders.

Participants in the GHRCE program learned about the latest technical trends and were then expected to speak about the trends, which led to an increase in their confidence.

The event was chaired by the club's president TM Karan Pareek and was coordinated by Chandan Yadav, representing IEEE-HKN and the IEEE Student Branch.

By adopting the theme "We Are Stronger Together," the Brio Toastmasters club collaborated with the

"We are stronger together."

Karen Parikh (right), president of the Toastmasters club GHRCE, is presented with the Best Speaker Award.

Best role-players and best speakers.

IEEE Student Branch and IEEE-HKN to witness the strength of leadership and technology. The meeting included audiences of various age groups, though about 150 MBA students from the college served as the primary audience for the event.

This event was basically a Toastmaster meeting followed by a table topics session. Speakers completed icebreaker exercises by giving technical speeches. Audience members also were asked to participate by speaking about a random topic, which was provided on the spot. The speakers were evaluated on rubrics designed by Toastmasters International.

The meeting educated all about how to improve their presentation techniques and public speaking skills. The event was concluded by distributing certificates to the best Icebreakers and thanking the audience.

Members perform the official handshake of Toastmasters.

One of the speeches explored "The Perseverance of Time."

About 150 MBA students from the college served as the primary audience for the event.

> The two professional chapters joined together and had ***wonderful synergy and energy.*** This event can be repeated at other centers.
>
> PREETI BAJAJ
> Governor At-Large for IEEE-HKN
> Board of Governors

IEEE-HKN 2018 OUTSTANDING Chapter Awards

The IEEE-HKN Board of Governors has conferred upon 27 student chapters the distinction of Outstanding Chapter for 2018. This represents the top 10 percent of all HKN chapters worldwide. The Award is based on the content and description of chapter activities that are contained in the Annual Chapter Report, which summarizes the chapter's activities from the previous academic year. IEEE-HKN President Karen Panetta (pictured below in front of the awards table) presented the awards. Ramandeep Vilkhu (below holding ceremonial check), who was inducted into the Gamma Chapter at Ohio State University, was named the 2018 IEEE-HKN Alton B. Zerby and Carl T. Koerner Outstanding Electrical or Computer Engineering Student Award recipient. He is currently pursuing his Ph.D. in Electrical Engineering at Stanford University. He holds a patent for "Power Harvesting from Fabric Electrochemistry."

IEEE-HKN PATHWAYS to Industry

IEEE-HKN students from Arizona and New Mexico met with academics and industry professionals during IEEE-HKN's "Pathways to Industry" workshop held during the ECEDHA Conference in Tucson, Ariz. Presenters and panels of experts discussed a wide range of topics, from choosing, applying and succeeding in Graduate School, to workshops on professional development and "The Next Big Thing" in technology. The event was sponsored by IEEE-USA, Keysight Technologies, Texas Instruments and ECEDHA.

Leaders Aren't Born. They Attend EVO.

Georgia C. Stelluto

IEEE-USA's two-day flagship event, **EVO – the Evolution of You™** -- will challenge you to think differently while embracing innovation and creativity. You'll develop valuable new relationships and share insights with industry peers, all while expanding your knowledge on the journey to becoming a more effective leader.

Register Now to Save $100

Plan to join us at EVO 2019 from 2-3 August 2019 at the Westin Convention Center in Pittsburgh, PA USA for this one-of-a-kind leadership conference.

EVO will focus on learning and networking, featuring insightful and inspiring keynotes, dynamic panel discussions and immersive sessions to help you advance your career while effecting change in your organization. And take in the sights and fun side of beautiful Pittsburgh, with an opening night Riverboat Cruise planned for Friday and an EVO 3k Fun Run scheduled for Saturday morning.

Take your career to the next level by investing in the **Evolution of You™.** Register now to save $100 off our normal rate. Plus, supercharge your conference experience with an exclusive **EVO All Access Pass*** for only $100 more -- which includes front-row reserved seating at all keynotes/sessions, VIP lounge and an IEEE-USA backpack.

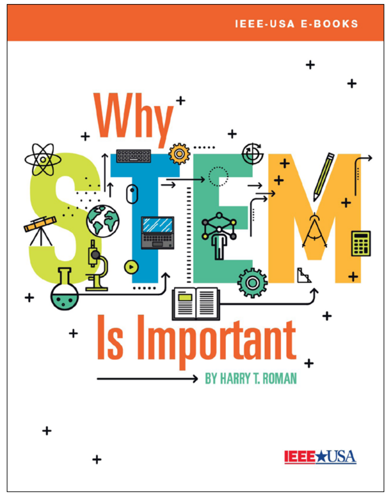
**Available for a limited time only.*

IEEE★USA

IEEE-USA's New Audio and E-Books Encourage STEM Education and Making the Transition from Student to Engineer

IEEE-USA's new audio and E-books address the full circle of engineering education and preparation. The books help parents, teachers and tutors get children excited about the concept of STEM and also help engineering students prepare for the workforce. Take a look!

In IEEE-USA's new audio book: Why STEM Is Important, veteran author and educator Harry T. Roman helps parents, teachers and educators encourage kids to see the world through engineers' eyes.



Close your eyes and listen, as Roman demystifies the STEM concept for you -- and for anyone else who is interested. In clear, direct language, the author explains what STEM is; what it is not, and why this educational model promises to launch a new era of U.S. economic productivity.

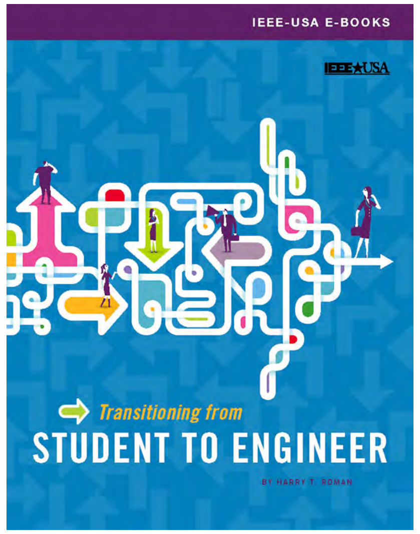
STEM (Science, Technology, Engineering and Math) is all about combining content and process to solve problems, and to create new products and services – a fundamental necessity for economic growth. It is not about making kids into engineers, but rather how to help them think about, analyze and solve problems and challenges more effectively.

Many of you listening to this audio book will hear and envision how closely it mirrors what engineers do on the job. Maybe you will work with local schools, and help teachers, parents and students solve relevant problems. Maybe you already are. If not, consider getting involved.

IEEE members can get their free, new audio book download by going to: https://ieeeusa.org/shop/policy/new-ebook-why-stem-is-important/

Click on the headphones, and follow the instructions, to get your free audio book download in MP3 format today!

IEEE-USA's New E-Book: *Transitioning from Student to Engineer* offers insights to help ease the transition from student to engineer.



Calling all engineering students and recent graduates: Did you know that 15 percent of your career will require technical skills -- while 85 percent of it will demand professional or "people" skills?

To help engineering students and those who are in the earliest years of their careers, author Harry T. Roman has written IEEE-USA's new E-book, *Transitioning from Student to Engineer.* This slim, but idea-packed volume is overflowing with solid advice that everyone in its target audience should read and note.

Roman introduces the importance of people skills in a way most students and young engineers can relate. "For the past four or five years," he writes, "you have been totally immersed in technical subject matter, probably barely tolerating a humanities course interlude here and there -- and perhaps wondering why you even have to bother with it... Well, on the job, the humanities -- in the form of professional, people and soft skills -- reign supreme."

Roman points out that engineering is more than being mathematically facile and technologically creative. "Ultimately," he says, "it's about people doing great things in service to other people and society -- something no mathematical expression can quite capture."

Transitioning from Student to Engineer is available at: https://ieeeusa.org/shop/careers/transitioning-from-student-to-engineer/

It is only $2.99 for members and $4.99 for non-members.

Free Download For Young Professionals: 2018 IEEE-USA Salary & Benefits Special Report

Download a free copy of the 2018 IEEE-USA Salary & Benefits Special Report: Young Professionals. This report can be used to benchmark your annual salary, or just to gain knowledge about compensation within the YP cohort across the United States. To receive your free download, use password YP2019.

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Your participation will help create a more accurate snapshot of technology professionals' compensation, and for your time, you will receive 10 free uses of the IEEE-USA Salary Calculator and a free copy of the 2019 Salary & Benefits Report -- both available later this year! Use the salary data to benchmark your current benefits, evaluate salary and benefits offers, and provide a valuable resource for young engineers entering the workplace.

**Sorry, Student members are not eligible to participate, but Young Professionals are!*

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