Electrical Engineering Department

CAPT Robert J. Voigt, USN
Chair

Research and scholarly activity are fundamental to the vitality and viability of any discipline. This is particularly applicable to electrical engineering, which is broadly based and rapidly expanding. Research helps faculty and midshipmen keep abreast of advancing technologies and it ultimately improves the effectiveness of the academic environment by encouraging a modern and relevant curriculum.

Funding for our research comes from the Office of Naval Research (ONR), the Naval Research Laboratory (NRL), the Naval Surface Warfare Center (NSWC), the Johns Hopkins University/Applied Physics Laboratory (JHU/APL), the Armed Forces Communications Electronics Association (AFCEA), and from within the Naval Academy. Research topics supported during the past year included an initiative in control and reconfiguration of shipboard electric power systems, distributed control of shipboard systems, stability of shipboard electric power systems, various aspects of digital signal processing (including image and video processing, adaptive DSP, and reconstruction of periodic SONAR signals), development of microelectromechanical (MEM) microwave switches and thermal control devices, packaging of microwave and optical components, design of wireless sensor system/power nodes, near earth radio frequency (RF) propagation, high power vacuum electronics, operation and control of buck converters, electronics for detection of nuclear materials by an Underwater Autonomous Vehicle (UAV) and microdosimetry of space radiation, optical calibration of thermoluminescent dosimeter (TLD) readers, development of ad hoc networking protocols, and software defined radio. This faculty and midshipman research contributes directly to the fleet's operational capabilities, and provides relevant topics which benefit the professional as well as the academic development of our midshipmen.

Sponsored Research

Electric Ship Integration

Researchers: Assistant Professor Edwin L. Zivi (Weapons and Systems Engineering Department)
and Associate Professor John G. Ciezki
Sponsor: Office of Naval Research (ONR)

This research supports the U.S. Navy's push towards the development of an Electric Warship. The investigators are part of a collaborative effort that includes faculty from MIT, Purdue University, and University of Missouri at Rolla. The effort specifically involves the integration of research, analyses, software and hardware tools, monographs, and curricula to support multidisciplinary ship design, power system analysis, and automation engineering. The USNA technical thrust is in the area of automation engineering. Initial have focused on the development of an automation laboratory and the structuring of an undergraduate course in automation. The investigators have specified, procured, and configured the equipment and software for an automation systems research laboratory located in Maury 103. This distributed control prototyping environment has been used to support one Trident project, two Bowman projects, and three senior design projects. Specifically, three students collaborated to design, assemble, and exercise a low-power three-zone power system and associated control system. This system successfully reconfigured the power system upon detection of selected faults and failures. As part of this effort, power converter modules have been designed and will be integrated into the system. The Systems Engineering automation course curricula including lecture, laboratory and student projects has been defined and preparation of course materials, including a textbook in the form of an automation monograph are underway. A complimentary Electrical Engineering power systems course for non-EE majors has been outlined and preparation of a teaching manuscript has been initiated. This material will also support current core courses as well as future multidisciplinary engineering offerings.

Distributed Control of Shipboard Systems Technical Support

Researcher: Associate Professor John G. Ciezki
Sponsor: Office of Naval Research (ONR)

This project supports efforts to develop intelligent distributed load management schemes for a naval warship operating with a power electronics-based power distribution system. The USNA researcher and a faculty member from the Naval Postgraduate School (NPS) were tasked with providing power system and shipboard domain expertise to the NuTech Solutions principal investigators. A key deliverable for this project was a comprehensive survey, performed at NPS, which provided the basis for assigning electrical load priorities for a variety of ship operating conditions. The USNA investigator aided in defining the parameters of the survey, formulating the questions, and interpreting the results. This data was then integrated into a market-based distributed agent algorithm and compared against centralized load-shedding algorithms. Additional USNA responsibilities included critiquing the results of the study, formulating suggestions for follow-on studies, and crafting recommendations for additional metrics to assess the efficacy of the various algorithms.

Digital Signal Processing (DSP) Research Laboratory

Researchers: Professor Delores M. Etter, Assistant Professor Robert W. Ives,
and CDR Thaddeus B. Welch, III, USN
Sponsor: Office of Naval Research (ONR)

The Digital Signal Processing Research Laboratory supports faculty in performing DSP research that has application to the Department of the Navy. It also supports Midshipmen experiences with DSP through DSP courses and in their design projects. Topics of special interest to our research group include image and video processing, adaptive DSP, real-time systems, digital communications, and biometrics.

Continued Development of Microelectromechanical Systems (MEMS) Microwave Switches

Researcher: Assistant Professor Samara L. Firebaugh
Sponsor: The Johns Hopkins University / Applied Physics Laboratory (JHU/APL)

Microelectromechanical relays offer many potential advantages over solid-state switches for routing microwave signals, and could facilitate active aperture phased array systems (like the Aegis system) on small vehicles such as missiles or airplanes. They have much lower insertion loss, behave linearly over a wide operation range, and require little power for operation. In AY01-02, this research resulted in a redesigned switch so that it would operate at a lower actuation voltage. In AY02-03, the device was fabricated, packaged and tested. The performance of the new switches met expectations, with an actuation voltage of less than 40 V, insertion loss less than 0.2 dB, and isolation of greater than 20 db at 20GHz. Continuing research involves an investigation of the power limits of the current switch.

Development of a Microelectromechanical Systems (MEMS) Thermal Control Device

Researcher: Assistant Professor Samara L. Firebaugh
Sponsor: The Johns Hopkins University / Applied Physics Laboratory (JHU/APL)

The new “micro” satellites being developed by the National Air and Space Administration (NASA) require lightweight, low-power thermal control. To meet this need, microfabrication technology is being used to construct a variable emissivity thermal radiator, based on the principle that heat cannot travel by conduction or convection in the vacuum of space. The device consists of an array of gold plates, each on the size scale of 100 um – 1 mm in width, suspended above a silicon substrate which is in thermal contact with the satellite. In the “off” state, the gap between the plates and substrate insulates the satellite. When a voltage is applied between the plates and substrate, an electrostatic force develops which pulls the plates into thermal contact with the substrate. Heat from the satellite can then travel from the substrate into the plate where it can be emitted as light from the thermally emissive gold surface. JHU/APL has designed the first generation of these devices, and they are currently being fabricated.

Advanced Packaging Applications

Researcher: Associate Professor Deborah M. Mechtel
Sponsor: The Johns Hopkins University / Applied Physics Laboratory (JHU/APL)

Wide bandwidth applications have driven the demand for optical waveguides and other components for the processing and transmission of information. Polymers are attractive materials for optical waveguides at both the chip and substrate levels because of their desirable electrical and optical properties as well as their ease of processing. This research involves the development of a technique to simultaneously use polyimide as both a dielectric layer and as an optical waveguide in the same multichip substrate structure. The technique, using poled polymers, will permit electrical and optical interlayers to be formed simultaneously, thus allowing buried optical waveguide and electrical signal lines on the same MCM-D.

In addition, a technique that employs a noninvasive, laser-based instrument to probe MCM structures fabricated with poled polyimide interlayer dielectrics and thin film metallizations on silicon carriers has been employed. The electro-optic interaction between the poled dielectric and the laser beam allows the strength of the internal fields within the MCM to be determined as a function of position. Electric field measurements and mappings can be useful in diagnosing module performance, locating sites of circuit shorts and opens, and determining the efficacy of field containment structures. The detection of electric fields in polyimide with buried circuit elements in multiple layers characteristic of MCM-D structures is being studied. Test systems of two dielectric layers with one metal interlayer are being studied.

The details of the poling and processing operations along with the mechanical, thermal, electrical, optical and electro-optic properties for both lightguide and dielectric layer applications are being examined.

Design of a Wireless Sensor System/ Power Node Using MC68HC908 Microcontroller and the Bluetooth Communication Link

Researcher: Professor Antal A. Sarkady
Sponsor: Naval Surface Warfare Center, Carderock Division (NSWCCD),
Philadelphia, PA, Code 825, Henry Whitesel

A power node can be defined as an electronic system (or box) that concentrates/formats information arriving from many sensors and takes appropriate control action when certain well-defined events occur. This power node is intended for machinery monitoring and advanced damage control applications on U.S. Navy ships. Typically, one or more power nodes is placed in a compartment and the nodes are interconnected and/or networked throughout the ship by Bluetooth wireless spread-spectrum type transmitters/receivers. These power nodes are powered by rechargeable batteries, operate at low average-power levels and have small physical size. An important property of this type system is the ease of shipboard installation (cabling is not required), this also allows rapid system reconfiguration. A particularly challenging network problem is to assure proper connectivity between nodes when the compartment doors are fully closed and latched (*i.e.,* "dogged").

Several Ericsson and IBM Bluetooth training tool kits were tested and evaluated. A preliminary test performed aboard the ex-*USS America*, using two laptop computers equipped with 0 dBm IBM Bluetooth PC cards demonstrated that the Bluetooth system can communicate across a shut and dogged hatch.\

Radio Frequency (RF) Propagation Measurements

Researchers: Various Electrical Engineering majors
Adviser: CDR Thaddeus B. Welch, III, USN
Sponsor: Armed Forces Communications Electronics Association (AFCEA) gift fund

The effects of placing an antenna very near to the ground or near the human body are being measured. This geometry is of concern for tactical forces as well as for civilian cellular, cordless, wireless, and PCS system users and designers (3G and 4G alike). Their work includes both narrowband and ultra-wideband measurements.

High Power Vacuum Electronics

Researcher: Assistant Professor James D. Zuber
Sponsor: Naval Research Laboratory (NRL), Dr. Bruce Danly and Dr. Baruch Levush,
Code 6840 - Vacuum Electronics Branch

During the period June-November 2002, the work involved the physical set-up and testing of a 36 GHz gyrotron TWT (traveling wave tube) amplifier at the Naval Research Laboratory (NRL) in Washington D.C., working with a team of researchers headed by Dr. Dean Pershing. The unique aspect of this gyro-TWT testing effort focused on the use of dielectric loading disks to achieve a distributed loss mechanism to enhance device stability and control TWTA gain. In addition to the primary focus, the project also made use of a new electron gun design from Communications and Power Industries, Inc. (CPI), as well as a specially designed input coupler that accommodates both linear and circular input signal polarizations. The initial portion of the summer was consumed with individual device testing and characterization, followed by preparations and set-up for functional testing. The operational testing occurred in the latter part of the summer and was conducted with a very good vacuum on the tube (*i.e.,* 10^{-9} torr) and a helium cooled superconducting magnet. The results of the work were presented in September 2002 at the 27th International Conference on Infrared and Millimeter Waves held in San Diego, CA.

Since November 2002, computer simulations for the operation of a specially designed Ku band TWT were set up and run. This work was carried out using the NRL 6840 CHRISTINE 3D TWT modeling software. The device was fabricated with special features and tapers that may result in better linearity performance for communication applications. CPI delivered the device in March 2003, and the physical performance testing is upcoming. Actual experimental data will then be compared with simulation results. It is hoped that the new design will reduce amplifier intermodulation products, resulting in an increase in device performance and efficiency.

Independent Research

Mixed-Frequency Operation of Cascaded DC Buck Converters

Researcher: Assistant Professor Thomas E. Salem

As the U.S. Navy migrates towards the all-electric warship, the need exists for research and further understanding of the design, operation, and control of largely distributed DC power systems. Within such a system, many types and levels of power conversion will be required. Traditionally, these converters are designed to produce a well-regulated output within necessary specifications. This project considers approaching the overall power conversion process with a cascaded arrangement in which the first converter's output requirements are relaxed allowing for the possibility of lower power loss within the converter at the expense of output voltage ripple, which the second converter will clean-up.

To date, extensive simulation (PSpice) work has been conducted resulting in both open and closed loop operation of the Buck converter. A scaled system has been specified and components have been ordered (and received) for assembling the converter. Future work will entail building the converter, detailing and conducting experiments (both simulation and physical), and evaluation of the data.

Combined Feedforward and Feedback Control of a Buck Converter

Researcher: Assistant Professor Thomas E. Salem

In conjunction with the aforementioned research on cascaded Buck converters, this project examines the efficacy of combining both feedforward and feedback control techniques for a Buck converter. Feedforward control of a Buck converter facilitates a stable output via control action on the converter due to fluctuations on the input voltage. Feedback control enables control action to occur based upon measurement and evaluation of the output and usually presumes a stable input voltage source. Combined, these techniques should yield a robust controller for the Buck converter capable of meeting the goals of the cascaded approach.

To date, extensive simulation (PSpice) work has resulted in working simulations of both control techniques. Once additional ordered parts arrive (dspace) and the converter is assembled, experimental tests will be conducted and the results examined.

Midshipman Research Course Projects

Electronics for Detection of Nuclear Materials by an Unmanned Aerial Vehicle

Researcher: Midshipman 1/C Brian R. Deforge, USN
Advisers: Visiting Professor James F. Ziegler
and Professor Martin E. Nelson (Mechanical Engineering Department)

This project involved design of a detector for neutron radiation and electronic circuits for signal detection and analysis, suitable for a small payload in a underwater autonomous vehicle (UAV). The project was successful, with the device able to detect neutrons from the neutron reactor in Rickover Hall with high efficiency.

Electronics for Microdosimetry of Space Radiation Which is Harmful to Human Spaceflight

Researcher: Midshipman 1/C Roger B. Callahan, USN
Advisers: Visiting Professor James F. Ziegler
and Professor Vincent L. Pisacane (Aerospace Engineering Department)

This project involved the design of a microdosimetry detector which approached the size of a human cell (10um diameter). In addition, the required electronic circuits for signal detection and analysis, suitable to be a payload on a satellite, were investigated and designed. The requirement of inclusion on a satellite payload meant that the entire electronic package had to perform at less than 1 watt, which was a significant accomplishment. The package was successfully completed and was found to meet all payload and performance requirements. It will be a payload on the next Naval Academy satellite.

Reconstruction of Periodic Sonar Signals Hidden in Wideband Noise Using Ensemble Averaging and Multi-rate DSP

Researcher: Midshipman 1/C Samuel P. Peterson, USN
Advisers: CDR Charles B. Cameron, USN, and Professor Antal A. Sarkady

The reconstruction of periodic acoustical signals with time domain periodic averaging requires a reliable estimate of the fundamental frequency of the signal. The reconstruction task is particularly difficult when the signal is "hidden" in additive noise and the signal-to-noise ratio is poor. This is usually the case in most passive SONAR problems when early detection and characterization of targets is required. Statistically reliable estimates of the fundamental frequency of a noisy periodic signal can be computed in the frequency domain using Bartlett's smoothing procedure. In this procedure, a long, noisy signal is segmented into M mutually exclusive time segments and a power spectral estimate for each segment is computed. Spectral estimates are ensemble-averaged to enhance the signal power and to reduce the residual spectral variance of the additive noise. In Bartlett's smoothing procedure the spectral line detection efficiency improves if $M > 50$.

The Bartlett's smoothing procedure merely provides a range of values for the fundamental frequency within a range of four times the standard deviation of the embedded periodic signal. In the reconstruction phase, the recorded noisy signal is reused to obtain one or more cycles of the "clean" signal. In the reconstruction procedure, the noisy signal is segmented into J mutually exclusive time segments, each exactly T seconds in length. Ensemble averaging in the time domain of these segments recovers the required "clean" signal with an enhancement efficiency when $N > 50$ and when the proper value of T is used. Because in most problems the correct value of T is not known, the enhancement procedure is iterated over a range of four times the standard deviation and that iteration which provides the maximum signal-to-noise ratio is declared the winner. For proper enhancement, an integer number of sample points must occur for each choice of T. This requires a new sampling rate be used on the original time sequence for each choice of T. The resampling is efficiently achieved using an FFT interpolation technique. The algorithms are optimized for the SHARC ADSP-21060 DSP hardware and can be used in real time applications.

The research completed in this project involved the reconstruction of periodic sonar signals that had been hidden in wideband noise. Ensemble averaging, multi-rate DSP, Bartlett's smoothing procedures, and sampling algorithms were used in this project.

Voice Operated Radio Controlled Car

Researcher: Midshipman 1/C John P. Supple, USN
Advisers: Professor Delores M. Etter and Assistant Professor Robert W. Ives

This project attempted to take a commercial off-the-shelf radio controlled car and convert the controller such that it could be voice activated. This involved modifying the existing controller to accept microphone inputs, to develop a simple speech recognition algorithm to enable a fixed set of voice commands to control the car, and the means to enact this algorithm in real-time.

The project consisted of several phases. The first phase was to analyze how the remote-controller for the car worked, to understand how it could be altered to accept voice commands. The next phase was to create a speech recognition algorithm (1) to study and analyze different speech signals in order to pick words that are most easily recognized, and (2) to identify a means to recognize them. This phase of the project was done in MATLAB®, and after comparing approximately ten words, "forward," "wrong," "port," and "starboard," worked best for an algorithm which counted the number of zero-crossings in the speech waveform. The microprocessor which performed this algorithm in real-time was the Texas Instrument's DSK 6711 with the PCM 3006 board.

Software Defined Radio for Digital Data Transfer

Researcher: Midshipman 1/C Gregory J. Twohig, USN
Advisers: CDR Thaddeus B. Welch, III, USN, and Assistant Professor Robert W. Ives

With an increased use of computers and the Internet, means of transmitting digital data over a variety of mediums have multiplied. With competing standards and changing environments, different waveforms are better suited for different scenarios. Furthermore, when connecting two devices, a common waveform must be used. It would be infeasible to install every physical system that might be necessary at a given location. Mobile systems in particular might need to shift waveforms to connect to a local service.

The software-defined radio (SDR) represents an optimal solution to such a problem. This technology utilizes the computing power of a digital signal processor (DSP) along with generic analog hardware to create and recover modulated signals. A digital data source feeds the SDR a file and characteristics of the type of signal that should be produced. The DSP then creates the necessary signals digitally and sends the output to a digital to analog converter (DAC). High-end SDRs use the processing power of field programmable gate arrays to drive DACs at wireless frequencies. The flexibility of programmable processors allows one physical SDR system to take the place of several analog systems.

This project involved the creation of a software-defined radio that varied carrier frequency, bit shape, modulation technique and symbol rate. Although this is only a small sampling of all the applications of an SDR, the results obtained proved its viability as a real-time hardware solution.

Trident Scholar Projects

Optical Calibration of TLD Readers (Trident Report # 305)

Researcher: Midshipman 1/C Jeffrey H. Dormo, USN
Advisers: Associate Professor R. Brian Jenkins and
Professor Martin E. Nelson (Mechanical Engineering Department)
Sponsor: Office of Naval Research (ONR)

The Navy uses thermoluminescent dosimeters (TLDs) on all of its nuclear warships. TLDs measure the amount of radiation a person receives through the use of a small internal crystal. Electrons in the crystal are excited to a higher energy state when they absorb radiation. If the crystal is later taken out of the TLD and heated to a high temperature, the electrons drop back to the lower energy state, emitting light. A TLD reader determines the radiation exposure by measuring the emitted optical energy.

Presently, TLD readers need to be calibrated frequently to ensure the measurements are accurate. A reference light source is used to calibrate the output of the reader. However, the power emitted by this light source is not stable over time, resulting in poor calibration. For this project, four light sources were compared as possible alternatives. The sources are a commercial light emitting diode, a commercial laser diode, a scintillating C-14 doped radioactive source, and a tritium source.

The first part of this project determined the cause of the instability in the output of the TLD reader. This included understanding the effects of environmental temperature variations on both the reader components and light sources. Consequently a temperature data acquisition system (DAQ) was developed to record the time variation of these temperatures. A second DAQ was then implemented to measure the optical power stability of each light source. After the power stability of each source was measured, the stability of the photomultiplier tube output in the reader was verified. Finally, since the Navy prefers to eliminate the use of unnecessary radioactive sources, various methods of guiding the light from the diode sources to the TLD reader using optical fiber were considered.

The research determined that the Ocean Optics LED and the C-14 source are relatively temperature independent. The C-14 operates within the ± 1% power stability criterion defined by the Naval Dosimetry Center.

Development of Mobile Ad Hoc Networking Protocols for Troop Transport Operations in a Littoral Environment (Trident Report # 307)

Researcher: Midshipman 1/C Nathan A. Fleischaker, USN
Adviser: Captain Joseph C. McGowan, USNR
Sponsors: Office of Naval Research (ONR) and the Naval Research Laboratory (NRL)

During amphibious operations, the movement of Marines from their host Navy ships the area of operations is extremely critical to mission accomplishment. The rapid and reliable dissemination of information is paramount. Both conventional radios and existing digital communications are insufficient to this task. Mobile ad hoc network(ing) (MANET) is a potential solution to this problem. The Office of Naval Research (ONR) has sponsored projects to provide connectivity to Marines on the ground within a wide area relayed network. However, a host of technical challenges continue to impede the implementation of reliable and seamless networking.

MANET routing protocols determine the best path that will allow data to travel throughout the network. The focus of past research has been developing these protocols for a ground environment. In a littoral environment, communication takes place while time-varying interference is present. The presence of this interference affects the quality and status of the links between nodes. Current routing protocols clearly define links as either functioning or non-functioning, but time-varying noise can cause links to be temporarily non-functioning. In such a case, the discovery of new routing path may not be necessary, and may actually congest the network unnecessarily. The fundamental factors in this aspect of routing protocol design include how a routing protocol deals with the discovery of neighboring nodes and classifies links in the network. The investigation of the effects of these factors in a routing protocol's performance will be the basis for creating an improved routing protocol optimized for littoral operations.

Three existing MANET protocols: Ad Hoc on Demand Distance Vector (AODV), Dynamic Source Routing (DSR), Optimized Link State Routing (OLSR) are being investigated. AODV is being used as the baseline routing protocol to be modified because it already contains the option of configuring the type of neighbor discovery techniques. The effectiveness of the changes to these protocols are being evaluated using ns-2, an open-source network simulation tools. Simulation results are providing the basis for further development of existing protocols for both simulation and possible implementation using YP's or Navy 44' as a test platform.

The final product in this project was a protocol optimized for implementation in a littoral environment which will improve communications during troop transport: making adaptation to information and obstacles faster, increasing the coordination and effectiveness of amphibious landings and ultimately improving the success of the overall amphibious operation.

Designing a Bluetooth-Based Wireless Network for Distributed Shipboard Monitoring and Control Systems (Trident Report # 310)

Researcher: Midshipman 1/C Kenneth J. Hoover, USN
Advisers: CDR Charles B. Cameron, USN, and Professor Antal A. Sarkady
Sponsor: Office of Naval Research (ONR)

A Bluetooth based network has been developed for monitoring and controlling power systems on board U.S. Navy Vessels. This network is intended for distributed measurement and control and is ideally suited for controlling individual slave nodes. The slave nodes are individual electronic systems which collect information from many sensors and make appropriate control decisions based on the occurrence of well-defined events. Bluetooth is a low-cost, low-power wireless standard, which boasts a theoretical maximum baud rate of approximately 750 kbps. The Bluetooth standard allows networking of several slave nodes. An important advantage of this system is that it can be configured for many shipboard applications. This wireless standard uses a spread-spectrum modulation scheme that allows reliable communication between devices within several subnetworks (piconets) in the same physical vicinity. A robust wireless network has been designed to maintain reliable connectivity among nodes even when the communication channels are adversely affected by the opening and closing of watertight doors. For testing the throughput of the Bluetooth network a low-level C++ program has been designed. The program establishes a Bluetooth piconet and records transmission times for several different size files. Experimental performance data have been collected using several different Bluetooth packet types and network topologies. Initial tests were completed in a long hallway to provide baseline control data. In addition, shipboard testing was done on board the *ex-USS America*. These tests have proved the practicability of using a Bluetooth network for shipboard control and monitoring systems.

Midshipmen Design Projects

ATM Network Simulation

Researcher: Midshipman 1/C Agur S. Adams, USN
Advisers: Commander Charles C. Cameron, USN, and Lieutenant William C. Pritchett, USN

Microdosimetry Electronics for a Satellite: USNA-IT

Researcher: Midshipman 1/C Roger B. Callahan, USN
Advisers: Visiting Professor James F. Ziegler
and Professor Martin E. Nelson (Mechanical Engineering Department)

FIRST Robot

Researchers: Midshipmen 1/C Charles E. Chambers and James R. Diefenderfer, USN
Advisers: Lieutenant Aaron M. Still, USN, and Dr. E. Curran Wooten

Optically Triggered Coil Gun

Researcher: Midshipman 1/C Matthew S. Cornue, USN
Advisers: Lieutenant Commander Daniel L. Johnston, USN, and Lieutenant Commander Brian P. Dulla, USN

Electronic Mosquito Repeller

Researcher: Midshipman 1/C Kevin D. Dalton, USN
Advisers: Associate Professor David S. Harding and Dr. E. Curran Wooten

Laser Listener

Researcher: Midshipman 1/C Bradley P. Davenport, USN
Advisers: Associate Professor R. Brian Jenkins and Associate Professor Deborah M. Mechtel

Comm Link for a Nuke-Sniffing UAV

Researcher: Midshipman 1/C Brian R. Deforge, USN
Advisers: Commander Thaddeus B. Welch, III, USN, and Visiting Professor James F. Ziegler

Autonomous Obstacle Avoidance Vehicle (Drive Motors)
Researcher: Midshipman 1/C Damien A. Dodge, USN
Advisers: Commander Edward J. Nava, USN, and Commander Frederic P. Forney, USN

Digital Wireless Weather (RF Data Link)
Researcher: Midshipman 1/C Timothy J. Fenton, USN
Advisers: Commander Thaddeus B. Welch, III, USN, and Assistant Professor James D. Zuber

Voice Recognition System
Researcher: Midshipman 1/C James C. Hagerty, USN
Advisers: Professor Delores M. Etter and Associate Professor Louiza Sellami

Wireless Digital Weather Station (Sensors and PIC)
Researcher: Midshipman 1/C Nicholas Q. Hennefent, USN
Advisers: Commander Charles B. Cameron, USN, and Professor Richard L. Martin

Free Space Optical Data Link
Researcher: Midshipman 1/C Andrew R. Kano, USN
Advisers: Commander Thaddeus B. Welch, III, USN, and Commander Jeffrey P. Link, USN

Capacitor Discharge Mortar
Researcher: Midshipman 1/C Paul K. Kramer, USN
Advisers: Major Kevin M. Shea, USMC, and Associate Professor John G. Ciezki

The Button Pusher 0 Digital Alarm Clock
Researcher: Midshipman 1/C Aaron J. Lanzel, USN
Advisers: Commander Charles B. Cameron, USN, and Captain David C. Summers, USMC

Free Space Optical Data Link
Researcher: Midshipman 1/C Chester Lee, USN
Advisers: Commander Thaddeus B. Welch, III, USN, and Commander Jeffrey P. Link, USN

Autonomous Obstacle Avoidance Vehicle (Sensor Suite)
Researcher: Midshipman 1/C Daniel P. Manteufel, USN
Advisers: Commander Edward J. Nava, USN, and Commander Frederic P. Forney, USN

Voice Recognition System
Researcher: Midshipman 1/C Aaron S. McAlpin, USN
Advisers: Professor Delores M. Etter and Associate Professor Louiza Sellami

Unmanned Formation Vehicles (UFVs)
Researcher: Midshipman 1/C Michael J. McGeehan, USN
Advisers: Commander Charles B. Cameron, USN, and Lieutenant Ann C. Chamberlain, USN

Swimming Pool Timer and Lap Counter
Researcher: Midshipman 1/C John W. Meise, USN
Advisers: Captain Robert J. Voigt, USN, and Captain Joseph C. McGowan, USN

Digital Alarm Clock
Researcher: Midshipman 1/C Marklon K. Millington, USN
Advisers: Captain David C. Summers, USMC, and Major Robert J. Nash, USMC

WEBTOES
Researcher: Midshipman 1/C Daniel G. O'Connor, USN
Advisers: Professor Delores M. Etter and Commander Thaddeus B. Welch, III, USN

Ultrasonic Bird/Geese Repeller
Researcher: Midshipman 1/C Adam S. Peck, USN
Advisers: Associate Professor David S. Harding and Dr. E. Curran Wooten

Autonomous Obstacle Avoidance Vehicle (Microprocessor Control Program)
Researcher: Midshipman 1/C Andrew J. Peterson, USN
Advisers: Commander Edward J. Nava, USN, and Commander Frederic P. Forney, USN

Solar Splash
Researchers: Midshipmen 1/C Jatooporn Pholtavee and Thienchai Punyafong, USN
Adviser: Assistant Professor Samara L. Firebaugh

VHF Transmitter
Researcher: Midshipman 1/C Scott J. Rose, USN
Advisers: Professor Antal A. Sarkady and Professor Richard L. Martin

Weather Station with Computer Interface
Researcher: Midshipman 1/C James W. Shey, USN
Advisers: Commander Charles B. Cameron, USN, and Commander Daniel L. Johnston, USN

Optical Receiver
Researcher: Midshipman 1/C Nicklaus G. Smith, USN
Advisers: Associate Professor R. Brian Jenkins and Associate Professor Deborah M. Mechtel

PIC Processor Stepper Motor Control Application
Researcher: Midshipman 1/C Charles C. Spivey, USN
Advisers: Professor Lawrence L. Tankersley (Physics Department) and Professor Richard L. Martin

Induction Catapult
Researcher: Midshipman 1/C Pamela M. Stafanski, USN
Advisers: Associate Professor John G. Ciezki and Lieutenant Aaron M. Still, USN

DSP-Based Transmitter/Receiver
Researcher: Midshipman 1/C Asong E. Suh, USN
Advisers: Commander Thaddeus B. Welch, III, USN, and Professor Richard L. Martin

Voice Operated Radio Controlled Car
Researcher: Midshipman 1/C John P. Supple, USN
Advisers: Professor Delores M. Etter and Assistant Professor Robert W. Ives

Electronic Ignition System
Researcher: Midshipman 1/C Timothy J. Thurston, USN
Advisers: Lieutenant Jesko M. Hagee, USN, and Assistant Professor Thomas E. Salem

Software-Defined Radio for Digital Data Transfer
Researcher: Midshipman 1/C Gregory J. Twohig, USN
Advisers: Commander Thaddeus B. Welch, III, USN, and Assistant Professor Robert W. Ives

City Traffic Grid
Researcher: Midshipman 1/C Jordan M. Womble, USN
Advisers: Captain Robert J. Voigt, USN, and Captain Alfredo DuBois, USMC

Journal (Refereed) Manuscripts

FIREBAUGH, S.L., Assistant Professor, Jensen, K.F., and Schmidt, M.A., "Miniaturization and Integration of Photoacoustic Detection," *Journal of Applied Physics*, vol. 92, no. 3, August 2002, pp. 1555-1563.

Photoacoustic spectroscopy (PAS) is an absorption spectroscopy technique that is currently used for low-level gas detection and catalyst characterization. It is a promising technique for chemical analysis in mesoscale analysis systems because the detection limit scales favorably with miniaturization. This work focuses on the scaling properties of photoacoustic spectroscopy, and on the miniaturization of gas-phase photoacoustic detection of propane in a nitrogen ambient. The detection system is modeled with a transmission line analogy, which is verified experimentally. The model includes the effects of acoustic leaks and absorption saturation. These two phenomena degrade the performance of the photoacoustic detector and must be controlled to realize the scaling advantages of photoacoustic systems. The miniature brass cells used to verify the model employ hearing aid microphones and optical excitation from a mechanically-chopped, 3.39-μm He-Ne laser, transmitted into the cells with an optical fiber. These cells are able to detect 10 ppm of propane in nitrogen (a signal level of ~ 1 Pa/W). We also describe the development of a miniaturized photoacoustic system formed by microfabrication. In this case, the pressure-driven deflection of the detection membrane is measured optically. These systems show that photoacoustic detection may be inappropriate for systems with large variations in gas concentration because of absorption saturation and changing gas acoustic properties. Nevertheless, photoacoustic spectroscopy is a promising technique for the analysis of dilute mixtures in miniature chemical systems.

Hofman, G.J., Peterson, R.J., Gelderloos, C.J., ZIEGLER, James F., Visiting Professor, and Ristinen, R.A., "Light-hadron Induced SER and Scaling Relations for 16- and 64-Mb DRAMS," IEEE Transactions on Nuclear Science, vol.47, no.2, pt.2, April 2000, p. 403-407.

This research reports on soft error rates (SER) of 16 and 64 Mb dynamic memory chips induced by three types of elementary particles, neutrons, protons, and pions, with emphasis on results obtained with pion beams. Significant SER differences, up to a factor 1000, are seen between various manufacturers and cell technologies. Reaction mechanisms are discussed. By comparing SER rates to nuclear reaction cross- sections, we can present guidelines for predicting failure rates.

IVES, Robert W., Assistant Professor, Magotra, Neeraj, and Stearns, Samuel D., "Effects of Multiple-Pass Filtering in Lossless Predictive Compression of Waveform Data," *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 40, No. 11, November 2002, pp. 2448-2453.

This article presents the effects of the predictive filtering of waveform data in multiple passes as the first stage of a two-stage lossless compression algorithm. Predictive compression has a proven track record when applied to high dynamic range waveform data, wherein the waveform data is input to a linear predictor or perhaps an adaptive predictor for decorrelation and the resultant residue is then subjected to an entropy coder to (ideally) represent the signal with a minimum number of bits. This compression is commonly applied with no loss of information. In this work, an adaptive filter is used for prediction but instead of a single run through the predictor, the residue is continually passed back through the predictor in an attempt to further decorrelate the residue. Multiple passes of a gradient adaptive lattice filter has given the best decorrelation, yielding improved compression ratios. We run the compression technique on a seismic database, then provide some comparative lossless compression results using several coding schemes and show that using multiple pass predictive filtering can improve the compression rates attainable.

Losey, M.W., Jackman, R.J., FIREBAUGH, S.L., Assistant Professor, Schmidt, M.A., and Jensen, K.F., "Design and Fabrication of Microfluidic Devices for Multiphase Mixing and Reaction," *Journal of Microelectromechanical Systems*, vol. 11, no. 6, December 2002, pp. 709-717.

Using silicon microfabrication technology, microchemical devices have been constructed for the purpose of conducting heterogeneously catalyzed multiphase reactions. The motivation behind the design, the fabrication approach, and the experimental characterization are presented for two classes of devices. The first design involves multiple parallel channels with integrated filter structures to incorporate standard catalytic materials. These catalysts are in the form of finely divided porous particles in a packed-bed arrangement. The second device involves the incorporation of porous silicon as a catalyst support, in the form of a thin layer covering microstructured channels. These microstructured channels simulate the structure of a packed bed and enhance mass transfer relative to an open channel. The ability to incorporate features at the tens-of-microns scale can reduce the mass-transfer limitations by promoting mixing and dispersion for the multiple phases. Directly integrating the catalyst support structures into the channels of the microreactor allows the precise definition of the bed properties, including the support's size, shape and arrangement, and the void fraction. Such a design would find broad applicability in enhancing the transport and active surface area for sensing, chemical, and biochemical conversion devices. Reaction rates for the gas-liquid-solid hydrogenation of cyclohexene using the integrated catalyst with porous silicon as a support compare favorably to those rates obtained with the packed-bed approach. In both cases, the mass transfer coefficient is at least 100 times better than conventional laboratory reactors.

NELSON, M., Professor (Mechanical Engineering Department), Messner, G., JENKINS, R. Brian, Associate Professor, and Cassata, J., "Development of a Temperature Stabilized Light Source for TLD Readers," *Health Physics*, Vol. 82, No. 6, June 2002, pp. S141-S142.

Currently the US Navy uses scintillations from a radioactive C14 source for periodic calibration of its TLD readers. It would be preferable to use a non-radioactive reference light source. However, these sources currently produce unacceptable variations in the light output due to ambient temperature changes and the TLD heating process. To solve this problem, a temperature isolation box was designed and built to keep the output of the reference light source constant. The light source is stabilized using a thermoelectric (TE) cooler to maintain the box at a constant temperature. The TE cooler heats or cools the box based on a feedback signal pro vided by a thermistor. The system has been designed to maintain the temperature of the box to within one degree of 25 C for a period of one month. The isolation box has been placed externally to a Bicron model 3500 TLD reader and employs a fiber optic cable to transmit the reference light source to the reader's photomultiplier tube. The system has been evaluated by varying the ambient temperature between 10 C and 40 C and using a data acquisition system, that simultaneously records both the isolation box temperature and ambient temperature with time. While the system meets most operational requirements, further improvements in instrumentation could be made for the light source power output, thereby reducing system complexity.

von Gutfeld, R.J., Dicello, J.F., McAllister, S.J., and ZIEGLER, James F., Visiting Professor, "Amorphous Magnetic Wires for Medical Locator Application," *Applied Physics Letters*, Vol.81, no. 10, Sept. 2002, pp. 1913-1915.

This letter evaluates the feasibility for implanting short segments of Barkhausen wires in treatment volumes of patients requiring radiation therapy. Such locating of deep-seated sites prior to each treatment is not done routinely or is usually achieved through imaging with ionizing radiations. Present therapeutic procedures can result in substantial heterogeneities in the dose distributions or significant doses to surrounding normal tissues, resulting in poorer control of the tumors and/or increased complications. The implants make it possible to accurately locate the wire by way of re-entrant flux measurements, and hence, pinpoint the treatment volume prior to and during treatment.

WELCH, Thaddeus B., III, Commander, (USN), Musselman, R.L., EMESSIENE, Bomono A., Midshipman 1/C, (USN), GIFT, Philip D., Midshipman 1/C (USN), "The Effects of the Human Body on UWB Signal Propagation in an Indoor Environment," *IEEE Journal on Selected Areas in Communications,* Vol. 20, no. 9, Dec. 2002, pp. 1778-1782.

Ultra-wideband (UWB) communication systems are investigated for their ability to operate in dense multipath environments. While a great deal of time and effort has been spent characterizing both the indoor and outdoor

UWB channels, the effects of human body interaction with a close proximity UWB antenna remains unexplored. Measurements of a commercially available UWB antenna performance in an anechoic chamber and in various indoor multipath environments were conducted. Comparisons of these measurement results indicate that while the human body creates a deep null (23.6 dB) in a light multipath environment, this null is drastically reduced (6.8 dB) in a dense multipath environment.

York, G.W.P., Wright, C.H.G., Morrow, M.G., WELCH, Thaddeus B., III, Commander, (USN), "Teaching Real-time Sonar with the C6711 DSK and MATLAB," *Computers in Education Journal*, Vol.12, no.3, July-Sept. 2002. pp. 79-87.

A sonar system serves as an excellent platform for teaching DSP topics such as beamforming, sampling theory, demodulation, filtering, image processing, and Doppler velocity estimation. While MATLAB simulations are useful for teaching the basic theory, many of these concepts are more easily taught to undergraduates if appropriate real-time demonstrations and laboratory experiences are available. The challenge of transitioning from MATLAB to real-time hardware is often the expense and a steep learning curve for the students. This paper describes a real-time DSP sonar educational platform based around the programming ease of MATLAB and the low- cost Texas Instruments C6711 digital signal processing starter kit. Classroom uses of this platform are discussed.

ZUBER, James D., Assistant Professor, Kevin L. Jensen, and Thomas E. Sullivan, "An Analytical Solution for Microtip Field Emission Current and Effective Emission Area," *Journal of Applied Physics*, Volume 91, Number 11, 2002, pp. 9379-9384.

Classical field emission theory relates the material work function and applied electric field at the emitter surface to tunneling current density, based upon the one-dimensional (1-D), planar Fowler-Nordheim (F-N) equation. The extension of this theory to non-planar, tip-anode geometries is complicated by the spatial variation of the electric field and resultant current density along the microtip surface. To relate this spatially dependent electric field to the applied voltage in this tip-to-plane geometry, experimenters have adopted empirically determined field enhancement factors (*i.e.,* $F=\beta V$) and emission area terms to explain quantitative measurements of microtip current. In this work, the nature of the field enhancement and area terms are defined analytically by employing an exact three-dimensional (3-D) electric field solution in prolate spheroidal coordinates and examining the relationship between total tip current and current density. The analytical and numerical results based on this model provide a physical context for understanding the validity of the generally used field enhancement factor β.

Conference Proceedings

Aimale, V., CIEZKI, J.G., Associate Professor, and Hendrey, M., "Distributed Control for Shipboard Systems," *Proceedings of the 13th Ship Control Systems Symposium (SCSS)*, Orlando, FL, April 2003. (CD-ROM)

Modern warships are critically reliant on an intricate grid of utilities, especially electrical power, to effectively operate under conditions ranging from training to combat to emergency damage control. Crews are challenged with radically different operational situations within the tight physical limitations of the shipboard environment. The necessary watertight compartment layout creates an operational environment requiring excess redundancy of both control systems and manpower. At present, the task of facing and resolving extreme situations rests largely on the shoulders of the crew.

The dynamic nature of underway operations in both training and combat make it impossible to anticipate all possible circumstances that a warship might be confronted with. Success in both the near and long term planning windows requires a new breed of shipboard systems control that effectively distributes and blends decision-making among several layers of control agents. Maintenance of operational effectiveness and availability in this dynamic environment requires reactive, adaptive, and cognitive agents that will greatly augment but not replace the human decision maker.

Our research focuses on a potential Distributed Control System (DCS) via Intelligent/Autonomous Agents in Warships is an improved self-healing capability for restoring combat effectiveness or sea-worthiness after an attack, accident, or system failure. We have explored the utilization of different Multiagent System for the Distributed

Control of Shipboard Power Systems utilizing a simple homogeneous Market-Based control. This paper describes the methodology and the results of simulated Shipboard Electrical Power System Controlled by different Multiagent System.

ESTES, Daniel R. J., Ensign, (USN), SARKADY, Antal A., Professor, WELCH, Thaddeus B., III, Commander, (USN), and Whitsel, Henry, "Assessment of Radio Frequency Propagation in Naval Shipboard Environment with Bluetooth Applications," *Proceedings of the 13th International Ship Control Systems Symposium (SCSS)*, Orlando, FL, 7-9 April 2003. (CD-ROM)

This paper discusses several in-hull RF propagation studies on board one decommissioned and several active Naval ships in the 0.8 – 2.5 GHz range. During these tests, it was repeatedly demonstrated that radio signals will propagate from one compartment to another even when the watertight doors (hatches) are shut and sealed. In fact, signals have been received across several bulkheads. Results indicate approximately 20 dB of attenuation is associated with transmission through a bulkhead/watertight door. It has also been found that the wireless channel aboard Naval vessels does not show good correspondence with a Ricean channel.

Finite element modeling of a shipboard compartment has been performed and supports the hypothesis that rubber door gaskets and other non-conductive structures are the source of bulkhead penetration/leakage.

For comparison, ultra-wideband channel measurements within the hull of a ship have also been taken. These measurements will be used to characterize the propagation within a single compartment as well as through a sealed bulkhead/watertight door. During a test aboard ex-USS AMERICA, with Bluetooth cards placed in two adjacent compartments, connectivity was demonstrated between the cards even when watertight doors were shut and sealed. The Bluetooth cards were operating at 0dBm power levels, in the 2.4 GHz ISM band.

ETTER, Delores M., Professor, "Nanoscience Research for Advanced Military Electronics," *Proceedings of the International Society for Optical Engineering (SPIE),* Vol. 4608, July 2002.

Many future systems will be smaller and smarter. The technology to support these future systems will require an emphasis in nanoscience research in materials and in nano-techniques for advanced electronics. An important catalyst for this research will be collaboration among universities, government, and industry. This paper will discuss an important new DoD initiative that was designed to support this collaboration in four areas of advanced electronics.

FIREBAUGH, S.L., Assistant Professor, Charles, Jr., H.K., Edwards, R.L., Keeney, A. C., and Wilderson, S.F. "Low-Cost Deflection Measurement for Rapid Characterization of Microelectromechanical Systems (MEMS)," *Proceedings of the 2003 IEEE Instrumentation and Measurement Technology Conference,* Vail, CO, 20-22 May 2003, pp. 499-502.

Nonintrusive measurement of small out-of-plane motions of microscale structures is critical to the development of microelectromechanical systems (MEMS). This paper presents a low-cost deflection measurement system for MEMS structures based on a fiber optic displacement sensor. The system is demonstrated by the characterization of a microwave switch. The calibration and linearity of the system are explored, and the performance is compared to a more elaborate system that is nearly a hundred times more expensive.

HOOVER, Kenneth J., Midshipman 1/C, (USN), SARKADY, Antal A., Professor, CAMERON, Charles B., Commander, (USN), and Whitesel, Henry, "A Bluetooth-based Wireless Network for Distributed Shipboard Monitoring and Control Systems," *Proceedings of the 57th Meeting of the Society for Machinery Failure Prevention Technology,* Virginia Beach, VA, April 2003, pp. 91-99.

A Bluetooth based ``power node'' has been developed for monitoring and controlling power systems on board US Navy Vessels. For this application a ``power node'' is defined as an electronic system, which collects information from many sensors and makes appropriate control decisions based on the occurrence of well-defined events. Bluetooth is a low cost, low power wireless standard, which is incorporated on each ``power node.'' This wireless standard allows networking of several ``power nodes.'' An important advantage of this system is that it can be configured for many shipboard applications. The Bluetooth standard uses a spread-spectrum modulation scheme

that allows reliable communication between ``power nodes'' within several sub-networks (piconets) in the same physical location. A robust wireless network that maintains reliable connectivity among nodes even when the communication channels are altered by the opening and closing of watertight doors has been designed. Versatility is achieved by the use of the Motorola \mc microcontroller in the ``power node.'' This microcontroller is in-circuit-programmable, allowing rapid software changes. The goal of this project is to have tested a working prototype network consisting of several ``power nodes'' on the ex-USS America.

IVES, Robert W., Assistant Professor, ETTER, Delores M., Professor, and WELCH, Thaddeus B., III, Commander, (USN), "Bit-Plane Compression of High Dynamic Range SAR Imagery,*" Proceedings of the 36th Asilomar Conference on Signals, Systems and Computers*, Pacific Grove, CA, 3-6 Nov 2002, pp.1397-1401.

This paper describes a technique to compress 16-bit/pixel magnitude or 32-bit/pixel complex synthetic aperture radar (SAR) imagery without loss. Here, the image is divided into its 16 or 32 individual bit-planes and each bit-plane is separately subjected to a raster scan to record the run-lengths of zeros and ones. The run-lengths are then coded using the CCITT Group 3 facsimile standard (a modified Huffman code). Performance is measured by comparing this technique to other lossless image compression techniques, such as JPEG-LS and JPEG-2000.

Morrow, M.G., WELCH, Thaddeus B., III, Commander, (USN), and Wright, C.H.G., *"*A Tool for Real-time DSP Demonstration and Experimentation," *Proceedings of the 2nd Signal Processing Education Workshop,* Pine Mountain, GA, Oct 2002, Paper # 4.8, pp. 162-167.

An innovative, stand-alone software package that demonstrates numerous DSP concepts is described, and examples of the program's capabilities are given. By providing a simple and intuitive interface to capable DSP hardware, teachers and students alike can perform real-time interactive, graphical applications. Experimental learning provides simple access to real-time DSP filters and other concepts. This package can help ease the introduction of DSP theory and application to students at all age levels, and stimulate and encourage student interest in DSP. To facilitate student projects with graphical interfaces to DSP hardware, a complete software example has also been made available for use.

PETERSON, Samuel P., Midshipman 1/C, (USN), SARKADY, Antal A., Professor, and CAMERON, Charles B., Commander, (USN), "Reconstruction of Periodic Signals Hidden in Wideband Noise Using Ensemble Averaging and Multi-Rate DSP," *Proceedings of the 57th Meeting of the Society for Machinery Failure Prevention Technology,* Virginia Beach, VA, April 2003, pp. 173-185.

The reconstruction of periodic acoustical signals with time domain periodic averaging requires a reliable estimate of the fundamental frequency (f l) of the signal. The reconstruction task is particularly difficult when the signal is "hidden" in additive noise and the signal-to-noise ratio is poor. This is usually the case in most passive SONAR problems when early detection and characterization of targets is required. Statistically reliable estimates of the fundamental frequency of a noisy periodic signal can be computed in the frequency domain using Bartlett's smoothing procedure. In this procedure, a long, noisy signal is segmented into M mutually exclusive time segments and a power spectral estimate for each segment is computed. Spectral estimates are ensemble-averaged to enhance the signal power and reduce the residual spectral variance of the additive noise. In Bartlett's smoothing procedure the spectral line detection efficiency improves with M 1/2 when M > 50.

The Bartlett's smoothing procedure merely provides a range of values for the fundamental frequency within a range of four times the standard deviation of the embedded periodic signal. In the reconstruction procedure, the noisy signal is reused to obtain one or more cycles of the "clean" signal. In the reconstruction procedure, the noisy signal is segmented into J mutually exclusive time segments, each exactly T seconds in length. Ensemble averaging in the time domain of these segments recovers the required "clean" signal with an enhancement efficiency of J 1/2 when N >50 and when the proper value of T is used. Because in most problems the correct value of T is not known, the enhancement procedure is iterated over the a range of four times the standard deviation and that iteration which provides the maximum signal-to-noise ratio is declared the winner. For proper enhancement, an integer number of sample points must occur in T, for each choice of T. This requires a new sampling rate be used on the original time sequence for each choice of T. The resampling is efficiently achieved using an

FFT interpolation technique. The algorithms are optimized for the SHARC ADSP-21060 DSP hardware and can be used in real time applications.

REDDELL, Noah F., Ensign, (USN), WELCH, Thaddeus B., III, Commander, (USN), and Bollt, Erik M., "A Covert Communication System Using An Optimized Wideband Chaotic Carrier," *Proceedings of the Military Communications Conference (MILCOM),* Anaheim, CA, Oct 2002. (CD-ROM)

We explore the advantages of designing a communication system based on chaos by using digital signal processing techniques. Existing work developing chaotic communication schemes has been done on a theoretical basis or in component based electrical circuits that are not as flexible, particularly for research. Our work takes a unique technological approach towards exploring the benefits of chaos. We use discrete methods to implement chaotic dynamical systems. Most of our current results are from MATLAB simulations, but we are working towards implementing chaos on digital signal processors (DSPs). These high-speed processors produce a chaotic carrier through flexible software algorithms. The use of discrete methods allows for schemes that out perform earlier systems. We demonstrate a new dual synchronizing response system that exploits the ability to store samples over an entire bit period and then perform an intelligent comparison. Our results show better bit error probability in comparison to previously published chaotic techniques. We introduce a method and algorithms for improving the bit error probability of our scheme by systematically searching for better parameter sets.

SALEM, Thomas E., Assistant Professor, and CIEZKI, John G., Associate Professor, "An Assessment of Power Engineering Education," *Proceedings of the 2003 American Society for Engineering Education (ASEE) Annual Conference and Exposition*, Session 2132, Nashville, TN, June 2003. (CD-ROM)

Academic power engineering programs have been in a state of decline for numerous years. During this same timeframe, technology and the application of power electronics has been growing at a rapid pace. Additionally, the utility industry has experienced a dramatic change in regulation, the end of the Cold War has reshaped U.S. defense considerations and impressed new requirements on military systems, and the U.S. economy has both soared and slumped. Integral to the success of the U.S. economy is cost-effective and reliable power generation and transmission. Electrical brown-out or black-out events result in a loss of production capability or necessitate expensive backup generation equipment; soaring utility costs mean less capital for both product development and workforce expansion.

This paper begins with an overview of the U.S. economic trends that have influenced the employment demand for power and power electronic engineers. The demand for new talent will then be evaluated in the context of the demand for more-capable and cost-effective military platforms. In particular, the technological requirements of an "Electric Warship" will underscore the need for engineering graduates, both civilian and military. Next, an assessment is offered on the current state of electric power programs within the academic community for meeting these needs. In recognition of projected technology-driven military platforms, an enhanced power engineering concentration within the electrical engineering curricula at the Naval Academy has been proposed. The paper will conclude with an overview of the selection process for curriculum topics, course sequencing, and laboratory content.

SALEM, Thomas E., Assistant Professor, and CIEZKI, John G., Associate Professor, "The Development of a Power Engineering Concentration," *33rd ASEE/IEEE Frontiers in Education (FIE) Conference,* Boulder, CO, Nov 2003. (CD-ROM)

In response to current and future demands upon the Navy for technical expertise in the power and power electronics fields, the Electrical Engineering Department at the United States Naval Academy has launched an initiative to develop a power engineering concentration within the EE major. To formulate and develop this concentration, priorities for student learning have been established within a twofold mission statement: to develop and equip future Naval Officers and to produce competent and qualified future civilian engineers. From this perspective, course content, sequencing, laboratory experiments, classroom demonstrations, and student research and design projects have been proposed. Along the way, attention was given to structuring the class material within the framework of learning objectives and outcome assessments necessary for meeting ABET accreditation. This paper will present

a detailed discussion on this process highlighting the selections made, emphasizing the goals and objectives for student learning, and presenting a status update on the implementation of this effort.

Wage, K.E., Buck, J.R., WELCH, Thaddeus B., III, Commander, (USN), and Wright C.H.G., "Testing and Validation of the Signals and Systems Concept Inventory," *Proceedings of the 2nd Signal Processing Education Workshop*, Pine Mountain, GA, Oct 2002, Paper # 4.6, pp. 151-156.

The Continuous-Time Signals and Systems Concept Inventory (CT SSCI) is a 25-question multiple-choice exam designed to measure students' understanding of core concepts taught in undergraduate linear systems courses. The CT SSCI questions emphasize conceptual understanding over computational skills. As a new assessment instrument, the CT SSCI is being carefully tested to establish its validity. This paper reports results from the first year of an ongoing study testing the CT SSCI at four campuses. The data collected from 174 students in undergraduate linear systems courses contain no evidence of racial or gender biases in the CT SSCI. GPA is found to be the strongest predictor of student performance. The normalized gain between pre-test and post-test in these courses is consistent with that found from the Force Concept Inventory for lecture format courses.

WELCH, Thaddeus B., III, Commander, (USN), IVES, Robert W., Assistant Professor, Morrow, M.G., and Wright, C.H.G., "Using DSP Hardware to Teach MODEM Design and Analysis Techniques," *Proceedings of the International Conference on Acoustics, Speech, and Signal Processing (ICASSP),* Hong Kong, China, April 2003. (CD-ROM)

While many communication topics are difficult for undergraduate students to internalize, demonstrations and laboratory experiences have been shown to greatly stimulate the learning process. This paper describes a highly successful combination of theory, demonstrations, lab exercises, and real-time DSP experiences using MATLAB and the Texas Instruments C6711 digital signal processing starter kit. This approach, when also combined with state-of-the-art measurement equipment, has proven highly successful in reinforcing modem design and analysis techniques.

WELCH, Thaddeus B., III, Commander, (USN), ETTER, Delores M., Professor, Wright, C.H.G, Morrow, M.G., and TWOHIG, G.J., Midshipman 1/C (USN), "Experiencing DSP Hardware Prior to a DSP Course," *Proceedings of the 2nd Signal Processing Education Workshop*, Pine Mountain, GA, Oct 2002, Paper # 8.5, pp. 297-301.

Students with limited exposure to discrete-time systems and possessing only basic C/C++ programming skills can successfully complete laboratory exercises involving real-time digital signal processing (DSP) hardware, despite having never completed a DSP course. The laboratory exercises discussed in this paper were part of a coordinated effort to expose all junior year Electrical Engineering (EE) students at the U.S. Naval Academy to real-time DSP hardware.

WELCH, Thaddeus B., III, Commander, (USN), Musselman, R.L., Norgard J.D., DeForge, B.R. Chambers II, C.E. Rose, S.J., Cornue, M.S and. Suh, A.E., "Measurement of UWB Signal Interactions with the Human Body," *Annual Symposium on Wireless Personal Communications*, Blacksburg, VA, June 2003, pp. 49-57.

Ultra-wideband (UWB) communication systems are investigated for their ability to operate in dense multipath environments. While a great deal of time and effort has been spent characterizing both the indoor and outdoor UWB channels, the effect of human body interaction with a close proximity UWB antenna remains unexplored. Measurements of a commercially available UWB antenna (3-5 GHz) performance in an anechoic chamber, and in various indoor multipath environments were conducted. Comparisons of these measurement results indicate that while the human body creates a deep null (16.8 dB) in a light multipath environment, this null is drastically reduced (6.9 dB) in a dense multipath environment. Interestingly, the dense multipath environment, which is a huge problem in traditional communication systems, clearly demonstrates one of the advantages of the UWB signal and its associated system.

ZUBER, James D., Assistant Professor, and Kevin L. Jensen, "Modeling Device Performance and Feature Variation in Microtip Field Emitters," *Electrochemical Society Proceedings of the 2nd International Symposium on Cold Cathodes*, Volume 2002-18, (November 2002), pp. 211-227.

A theoretical model for vacuum field emission that applies to real three-dimensional (3-D) microtip emitters has been developed. This model provides electric field variation along the microtip surface, an analytical solution for current density, a basis for defining effective emission area and tip current, and a framework for addressing the current deviations due to fabrication process variability. Array current and frequency response can be analyzed by treating the local tip radius as a random variable and using a probabilistic model to calculate expected values. The results of these statistical analyses highlight the importance of tip radius uniformity in FEA operation, demonstrate its quantitative effect, and reveal an analytical basis for which the Rayleigh probability density function may be a good model for tip radius variation. The quantification of tip radius variation and the geometrical characterization of individual tips are critical to device modeling where emission characteristics are paramount.

Technical Reports

ETTER, Delores M., Professor (co-author), "Review of NASA's Computing Information and Communications Technology (CICT) Program," National Research Council Report (Summer 2003)

This report discusses top-level issues that are relevant to the entire CICT program in general observations. It also discusses the research portfolio of the CICT program as a whole, and reviews the quality of the CICT research plans and overall methodology. It discusses how well the CICT program has connected with the community outside of NASA, and the quality of the technical staff and facilities at the NASA CICT facilities.

ETTER, Delores M., Professor (co-author), "Effectiveness of Air Force Science and Technology Program Changes," National Research Council Report (Summer 2003)

This report reviewed the effectiveness of the Air Force S&T program and, in particular, the actions that the Air Force has taken to improve th4e management of the program in recent years in response to concerns voiced in numerous study reports and by Congress. The committee focused on S&T Investment, Workforce, Planning, and Communications: Advocacy and Visibility.

ETTER, Delores M., Professor (co-author), "Missile Defense - Summer Study," Defense Science Board (Fall 2002 - classified)

The Missile Defense Task Force considered recommendations to help guide the ballistic missile defense system toward a fully integrated layered defense capable of defeating ballistic missiles of all ranges in any phase of their flight. The summer study specifically examined evolution of ballistic missile threats (counter-countermeasures organization and process); boost phase technology; battle management command, control, & communications, and international cooperation.

ETTER, Delores M., Professor (co-author), "Technology for Base Security," Naval Research Advisory Committee, (Fall 2002).

This report evaluated technology for base security. After the 9/11 terrorist attacks, increased base security was provided by reserve units. As the reserve units begin to be released, there is a strong interest in using technology to provide some of the increased security. A number of recommendations were made in this report for technology that could be used by the Navy in their protection of bases world-wide.

ETTER, Delores M., Professor, "Joint Simulation System (JSIMS) Software Architecture Review," Director of Defense Research and Engineering Report, Department of Defense, Dec 2002.

> JSIMS is a DoD program that will provide a critical simulation tool to the Joint Staff for conducting theater-level training and mission rehearsal for DoD using near-real time interactions. Its focus on incorporating the commander-in-the-loop in a realistic environment is very relevant to military operations. This report was the response to a request for a technical assessment of the JSIMS software architecture. A review team (chaired by Dr. Etter) brought together expertise from the government (OSD, DARPA, ONR, NSF, and the Naval Academy) and from SEI (an FFRDC). The report briefly reviews the mission and current status of JSIMS and makes observations and recommendations based on the review discussions.

Presentations at Professional Meetings and Conferences

ETTER, Delores M., Professor, "Science and Technology for Directed Energy Weapons," Lexington Institute Capitol Hill Forum on Directed Energy, 11 July 2002.

ETTER, Delores M., Professor, "Speech Signal Processing," Presentation to the Naval Academy's President's Circle, U.S. Naval Academy, Annapolis, MD, 13 Sept 2002.

ETTER, Delores M., Professor, "A Guide to Department of Defense (DoD) Research Funding," SME New Engineering Faculty, Arlington, VA, 4 Nov 2002.

ETTER, Delores M., Professor, "Adaptive Signal Processing," IEEE Student Chapter, U.S. Naval Academy, Annapolis, MD, 13 February 2003.

ETTER, Delores M., Professor, "Department of Defense (DoD) S&T Investment Planning Process," Presentation to staffers for the House Committee on Science, 30 April 2003.

FIREBAUGH, S.L., Assistant Professor, Charles, Jr., H.K., Edwards, R.L., Keeney, A. C., and Wilderson, S.F., "Fabrication and Characterization of a Capacitive Micromachined Shunt Switch," American Vacuum Society 50th International Symposium, Baltimore MD, 2-7 Nov 2003.

IVES, Robert W., Assistant Professor, ETTER, Delores M., Professor, and WELCH, Thaddeus B., III, Commander, (USN), "Bit-Plane Compression of High Dynamic Range SAR Imagery," 36th Annual Asilomar Conference on Signals, Systems and Computers, Pacific Grove, CA, 3-6 Nov 2002.

IVES, Robert W., Assistant Professor, "Compression of SAR Imagery," Naval Research Laboratory, Washington DC, 4 Dec 2002.

MCGOWAN, Joseph C., Captain, (USN), and Spencer, Richard G.S., "Adaptive Line Enhancement for In-Vivo Nuclear Magnetic Resonance (NMR) Spectroscopy," National Institute on Aging, International Society of Magnetic Resonance in Medicine, Toronto, Canada, May 2003.

Morrow, M.G., WELCH, Thaddeus B., III, Commander, (USN), and Wright, C.H.G., "A Tool for Real-time DSP Demonstration and Experimentation," 2nd Signal Processing Education Workshop, Callaway Gardens, Pine Mountain, GA, October 2002.

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