

**SESSION 8: Electrical Engineering Individual Projects  
Electromagnetics: Applications**

**Guest House Meeting Room B**

Session Chairman (1<sup>st</sup> Group): Brian Wynn

**Group 1**

12:25 **David Chick**

“Multiple Band Microstrip Patch Antenna for Cell Phones:  
Analysis and Design”

12:45 **Bryce Gardiner**

“Multiple Band Microstrip Patch Antenna for Cell Phones:  
Fabrication and Experimental Results”

1:05 **Jacob Mattson**

“77 GHz Automobile Radar”

1:25 **Michael J. Beck**

“Magnetic Coil Design for Wireless Neural/Cardiac  
Stimulation”

**Faculty Advisors: Om P. Gandhi  
Richard Normann (Dept. of Bioengineering)**

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**SESSION 8**

**12:25 p.m. Guest House Room B**

**MULTIPLE BAND MICROSTRIP PATCH ANTENNA FOR CELL PHONES: ANALYSIS AND DESIGN**

David Chick, Bryce Gardiner (Om P. Gandhi, Sai Ananthanrayanan), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

The overall goal of this project has been to design a compact antenna suitable for multiple band operation at frequencies used by mobile handheld devices, particularly cellular telephones since the trend has been to incorporate ever increasing functionality and features into these devices. The frequencies of interest are 850MHz (GSM850) and 1900MHz (GSM1900), 1575MHz (GPS L1), 2450MHz (WLAN/Bluetooth), 3670MHz (WiMAX), and 5500MHz (WLAN). One promising antenna capable of operating at multiple bands is the H-shaped microstrip patch antenna. Therefore, this presentation will explain the analysis and design of an H-shaped microstrip antenna based on the work of [1]. Analysis of the H-shaped microstrip is explained by placing electric and/or magnetic walls along the coordinate axis of the H. The walls essentially single out a small section of the patch, which can then be easily analyzed to reveal approximate design equations for the first four fundamental modes. Using these equations, a design procedure is discussed and an example is demonstrated for a set of four frequencies. Simulations of the design were carried out using Agilent ADS/EMDS. Since differences between the equations and the simulations were often observed, some general design guidelines are also provided.

[1] A. F. Sheta, A. Mohra, S. F. Mahmoud, "Multi-Band Operation of a Compact H-Shaped Microstrip Antenna," *Microwave and Optical Technology Letters*, vol. 35, no. 5, pp. 363 - 367, December 5, 2002.

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**SESSION 8****12:45 p.m. Guest House Room B****MULTIPLE BAND MICROSTRIP PATCH ANTENNA FOR CELL PHONES: FABRICATION AND EXPERIMENTAL RESULTS**

Bryce Gardiner, David Chick (Om P. Gandhi, Sai Ananthanayanan), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

This presentation will focus on the fabrication and experimental results of the H-shaped patch antennas built during this study. Each antenna was constructed on a dielectric foam with  $\epsilon_r \approx 1.07$  and thickness  $h = 3.25\text{mm}$ . The copper ground plane and patch surface (thickness  $0.14\text{mm}$ ) were attached to the dielectric using a strong but thin layer of contact cement. A standard SMA type coax connection was used for the feed. The return loss ( $S_{11}$ ) was measured using an Agilent HP 8720 network analyzer, and the radiation pattern of several antennas was measured in an anechoic chamber. The results of these measurements are illustrated, compared to predictions, and interpreted based on the desired behavior. The H-shaped patch successfully resonated at four frequency bands but often suffers from extremely low 3dB bandwidth ( $\sim 1.0\%$ ), unwanted resonant bands, and poor VSWR on some bands. Lastly, conclusions are drawn regarding the suitability of these antennas based on the design procedures, fabrication, and measured results.

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**SESSION 8**

**1:05 p.m.**

**Guest House Room B**

**77 GHZ AUTOMOBILE RADAR**

Jacob Mattson (Om P. Gandhi), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

This presentation presents and explains the power density measurements for a 77GHz forward-looking automotive radar device. As a public safety precaution, the Federal Communication Commission (FCC) requires the power density from forward-looking radar devices to be less than  $60 \text{ W/cm}^2$  at 300 cm from the face of the device. To ensure compliance with FCC regulations, the time-averaged power density levels of a specific automotive radar device were measured in an anechoic chamber using a waveguide coupled Dorado model GH-10 horn antenna with effective area of  $2.375 \text{ cm}^2$  and an Agilent model AT-W8486A millimeter wave detector with an Agilent model AT-E4416A power density meter. Measurements were taken at distances between 10 cm and 300 cm from the face of the radar device. The maximum time-averaged power density at 300 cm was measured to be  $0.5 \text{ W/cm}^2$ , which is far less than the maximum allowed by the FCC and is in close agreement with the theoretically calculated power density of  $0.3 \text{ W/cm}^2$ . Additionally, the half-power beam width of the device in the horizontal plane was measured to be 14.2 degrees, which agrees very well with the theoretically predicted value of 13.4 degrees.

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**MAGNETIC COIL DESIGN FOR WIRELESS NEURAL/  
CARDIAC STIMULATION**

Michael J. Beck (Om P. Gandhi, Department of Electrical and Computer Engineering; Richard Normann, Department of Bioengineering), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

The project was to determine which coil configuration will induce the most voltage in an implanted coil. A software program was written to calculate the magnetic field strength—at any point in space—generated from either a solenoid or spiral coil. A separate program was written to calculate the total magnetic flux through the secondary implanted solenoid or spiral coil. The software program that was written to model the magnetic field strength was used in conjunction with the software that calculates magnetic flux to calculate induced coil voltages. In order to ensure the validity of the calculated voltages, coils were built and the induced voltages were measured using varying coil configurations, displacements, radii, currents, and signal frequencies. The measured voltages verified that the software program indeed produce accurate calculated voltages. With confidence in the software, the software was used to determine the external coil parameters to maximize induced voltage used to power electrode arrays that stimulate or record from the neurons of the central nervous system.

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Electromagnetics: Applications**  
(Session 8 cont.)

**Guest House Meeting Room B**

Session Chairman (2<sup>nd</sup> Group): David Chick

**Group 2**

- 2:05 **Jason R. Saberin**  
“Reduced Coupling Configurations of Antennas for Improved Channel Capacity”
- 2:25 **Fernando Nelson**  
“HFSS Simulation of an X-Band, Radial Waveguide Band-Stop Filter”
- 2:45 **Brian Wynn**  
“Non-Destructive Measurements of Dielectric Materials Using an HFSS-Simulated TE013 Mode Cylindrical Cavity”
- 3:05 **Quinn Tate**  
“Design and Testing of a 16-Channel Coil Array for Improved Carotid Artery Imaging”

**Faculty Advisors: J. Mark Baird  
Cynthia Furse  
Om P. Gandhi  
J. Rock Hadley (Utah Center for Advanced Imaging Research)**

**SESSION 8: Electrical Engineering Individual Projects  
Electromagnetics: Applications**  
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**Guest House Meeting Room B**

Session Chairman (2<sup>nd</sup> Group): David Chick

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**SESSION 8                      2:05 p.m.              Guest House Room B**

**REDUCED COUPLING CONFIGURATIONS OF ANTENNAS FOR IMPROVED CHANNEL CAPACITY**

Jason R. Saberin (Om P. Gandhi, Cynthia Furse), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

As traditional wireless communication systems such as single-input single-output (SISO) are reaching their technological limits, advances in this field such as multiple-input multiple-output (MIMO) systems promise to exploit rich multipath environments to increase data throughput. Factors such as the influence of mutual coupling on antenna arrays can lower throughput of information in a MIMO channel. MIMO antenna arrays can be optimized to mitigate effects of mutual coupling. In this project, four inset-fed patch antennas were designed, simulated, and built for a center frequency of 915 MHz. With the use of a four-channel MIMO test bed, the MIMO antenna arrays were tested and channel capacities were compared with different antenna spacings. These spacings were later placed and contrasted in a two-dimensional and three-dimensional arrangement. It was observed that improvements of up to 10% in channel capacity could be achieved if a three-dimensional approach for placement of MIMO antennas was used as opposed to planar two-dimensional arrays.

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researched and their implementation was also modeled, as well as the scattering matrix model.

Research into radial waveguides is the starting point so that we can get a better insight into a more accurate cylindrical resonating cavity design and implementations such that dielectric constant measurements do not have to be restricted to the current 2-inch circular samples; but instead, we could use any size dielectric sample and measure (using the cavity) the electric properties of the material in question.

**SESSION 8**                      **2:25 p.m.**                      **Guest House Room B**

**HFSS SIMULATION OF AN X-BAND RADIAL WAVEGUIDE BAND-STOP FILTER**

Fernando Nelson (Om P. Gandhi, J. Mark Baird), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

Radial waveguides are used extensively as part of radial line slot antennas (RLSA) and radial waveguide fed slot arrays (RWSA), which are both instrumental in medical, radar, and communications applications. Radial waveguides are also used to measure high-dielectric constants of materials because of the low sources of errors incurred by using such waveguides.

This article reports the simulation techniques used with High Frequency Structured Simulation (HFSS) software in order to measure the S-parameters of an X-Band radial waveguide band-stop filter. This filter will be used as a feed to a cylindrical resonating cavity with very high quality factor ( $\approx 20,000$ ). The cavity in turn is used to measure the dielectric constant of materials.

The radiation patterns of the open-ended radial waveguide with TM excitations were also studied. Mode-matching techniques were

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**SESSION 8                      2:45 p.m.              Guest House Room B**

**NON-DESTRUCTIVE MEASUREMENTS OF DIELECTRIC MATERIALS USING AN HFSS-SIMULATED TE<sub>013</sub> MODE CYLINDRICAL CAVITY**

Brian M. Wynn (Om P. Gandhi, J. Mark Baird), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

At L-3 Communications, Inc., microwave cavities are very useful for measuring the dielectric strength of RF materials (e.g., antenna radomes, monolithic microwave integrated circuits) that are used in the manufacture of commercial and military communications systems. However, a novel device is needed to rapidly test the dielectric strength of said materials in a non-destructive manner. A High Frequency Structure Simulator (HFSS) RF modeling program is a useful tool and low-cost method of designing a novel 10 GHz, TE<sub>013</sub> Mode Cavity to determine the feasibility of manufacturing a

prototype cavity. The cylindrical-shaped cavity includes a band stop filter that protrudes outwardly in a radial direction from the body of the cavity. The filter is configured to constructively reflect leaking waves propagating outwardly in the radial direction back into the body of the cavity when a sheet of RF material is running through the cavity. Upon running the HFSS solution solver, the value of the resonant frequency and the quality factor, Q, of the dielectric material is determined. When the measured and modeled output data corresponds with each other, the relative permittivity,  $\epsilon_r$ , and loss tangent,  $\tan \delta$ , of the dielectric material is determined and validated. This new cavity alleviates the requirement to cut a circular disk portion from a sheet of RF material in order to test its dielectric strength with the existing cavities at L-3 Communications, Inc. The design of this cavity is currently a work in progress.

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**SESSION 8                      3:05 p.m.                      Guest House Room B**

**DESIGN AND TESTING OF A 16-CHANNEL COIL ARRAY FOR IMPROVED CAROTID ARTERY IMAGING**

Quinn Tate (Om P. Gandhi, Department of Electrical and Computer Engineering; J. Rock Hadley, Utah Center for Advanced Imaging Research), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

The carotid arteries on each side of the neck branch off at a bifurcation of the common carotid artery and supply the majority of oxygen-rich blood to the brain. This bifurcation is prone to accumulate plaques, which lead to atherosclerosis, a hardening and narrowing of the blood vessel which may lead to stroke. Thus, high-

resolution imaging of the carotid artery is important to medical professionals in order to detect, treat, and monitor carotid artery disease. Current carotid coils consist of two bilateral paddles, each containing two overlapped receiver loop antennas or channels. These paddles provide improved Signal to Noise Ratio (SNR) over clinically available coils. However, this design has a limited field of view (FOV). The location of the carotid bifurcation varies greatly from person to person; this makes it difficult to place the coils so that the bifurcation is located within the coil FOV. The new design implements 16 channels by combining 8 overlapped loop antennas on each side of the neck. This coil will increase the available FOV extending it from the lower neck to the ear. Another issue with the 4-channel carotid coils is their parallel imaging capability. This is determined by the number and placement of loops around the sample volume and is, therefore, limited. The new 16-channel carotid coil will have improved parallel imaging capability, enabling the magnetic resonance imaging (MRI) pulse sequences to acquire the necessary data faster. There is some penalty in SNR using parallel imaging schemes, but there is also an advantage of additional diagnostic information.

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**Group 3**

3:45 **Bindu Dudipala**  
“Fabrication of Dye-Sensitized Nanocrystalline Solar Cells”

4:05 **Beena Dudipala**  
“Optically-Transparent Antenna for Automobile Applications”

4:25 **Jason Weaver**  
“Multichannel Secret Key Generation”

**Faculty Advisors: Om P. Gandhi**  
**Ashutosh Tiwari (Dept. of Materials Science)**

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**FABRICATION OF DYE-SENSITIZED NANOCRYSTALLINE SOLAR CELLS**

Bindu Dudipala (Om. P. Gandhi, Department of Electrical and Computer Engineering; Ashutosh Tiwari, Mike Snure, Paul Slusser, Department of Materials Science and Engineering), Department of

Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

Solar energy is an attractive renewable energy source but has remained in the outskirts of power production due to high manufacturing costs. This project demonstrates a new variety of low cost solar cells called dye-sensitized nanocrystalline solar cells. Conventional solar technology is compared to this novel form of solar harvesting. Four of these cells were created and characterized using the dye Ruthenium 535. Degussa P25 TiO<sub>2</sub> powder and NaOH are the required materials to create the TiO<sub>2</sub> nano tubes which used to fabricate solar cells. The starting materials and processes required are very inexpensive and require no extraordinary processing equipment. This is very exciting in contrast to the extensive amount of energy and equipment required to fabricate conventional p-n junction solar cells. Conventional solar cells operate by exploiting the photovoltaic effect that exists in some semiconductor systems. This means that one material must satisfy at least three functions simultaneously: light absorption, built-in electric field, and separation of positive and negative charges. A dye-sensitized solar cell operates in a way that separates the functions of light absorption and charge separation. These devices show promise to replace Si-based solar as the cost of Si increases and the realization of high efficiency comes about. These cells have 10-percent efficiencies compared to conventional solar cells even with highly disordered structures. A reverse bias may destroy the dye solar cell. Never reverse bias above + 0.3 v. The working electrode (TiO<sub>2</sub>) should never be connected to a positive terminal unless reverse bias occurs.

**SESSION 8****3:45 p.m.****Guest House Room B****FABRICATION OF DYE-SENSITIZED NANOCRYSTALLINE SOLAR CELLS**

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**SESSION 8****4:05 p.m.****Guest House Room F****OPTICALLY-TRANSPARENT ANTENNA FOR AUTOMOBILE APPLICATIONS**

Beena Dudipala (Om. P. Gandhi, Bryan Stenquist, Department of Electrical and Computer Engineering; Ashutosh Tiwari, Mike Snure, Department of Materials Science and Engineering), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

Optically-transparent antennas have potential applications as receivers/transmitters for wireless automotive applications. The current project carried out the design and performance of the optically transparent antenna. In this project, a transparent antenna was fabricated with an optically transparent and conducting material Zn<sub>0.98</sub>Al<sub>0.02</sub>O using pulsed laser deposition (PLD). The performance of the antenna was measured by the parameters (S<sub>11</sub>-parameter magnitude [dB], radiation pattern) operating at 2.1 GHz by a network analyzer and compared with the parameters of a conventional copper based antenna at 2.1 GHz with the same dimensions. Although copper is not a transparent material, it was included for comparison and evolution purposes since it gives the best characteristics due to its high conductivity. The antenna chosen was a square patch antenna (36 mm) on a glass substrate. The transparent conducting ZnO film with resistivities of the order of 10e-4Ω cm were prepared by impurity doping with 2 percent Al, which is 95 percent transparent and ideally conductive compared to that of copper. The performance (S<sub>11</sub> = -23.465dB, Phase (S<sub>11</sub>) = 151.487°, good radiation pattern) of the antennas was excellent. These conducting thin films are useful in heat reflecting films for solar thermal collectors. These antennas can be incorporated in car windows or light panels, thus preserving ca

aesthetics. These antennas could also be incorporated in the displays of wireless communications electronic equipment.

**SESSION 8**                      **4:05 p.m.**                      **Guest House Room B**

**OPTICALLY-TRANSPARENT ANTENNA FOR AUTOMOBILE APPLICATIONS**

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reflecting films for solar thermal collectors. These antennas can be incorporated in car windows or light panels, thus preserving aesthetics. These antennas could also be incorporated in the display of wireless communications electronic equipment.

**SESSION 8**                      **4:25 p.m.**                      **Guest House Room F**

**MULTICHANNEL SECRET KEY GENERATION**

Jason Weaver (Om P. Gandhi), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

This paper explores shared high bit-rate secret key generation through the measurement of received signal strength in a multichannel reciprocal radio environment. Secret key cryptography is an emerging technology which allows for secure communication over a public wireless channel. Currently, public key cryptography is the most prevalent technology used to provide security. This technique requires factorization of large numbers and is computationally complex for simple wireless devices. Secret keys generated from the measurement of a wireless channel are computationally easier allowing for simpler devices to utilize the technology. Recent research into quantum computers suggests cryptography relying on factorization could be crackable and, thus, no longer secure.

Several past works have been done on secret key generation with varying success. This paper takes an in-depth look at the techniques used in by past authors to generate secret keys. The past works generated a 30-bit key through the use of a technique called High Rate Uncorrelated Bit Extraction (HRUBE). While HRUBE was originally studied over a single wireless channel at each device, this paper applies HRUBE through the use of multiple wireless channels per device. The multiple channels were achieved through the use of polarized flat panel antennas. The channel reciprocity was verified





**SESSION 9: Electrical Engineering Individual Projects**

**Guest House Meeting Room A**

Session Chairman (1<sup>st</sup> Group): Justin Ferguson

**Group 1**

3:05 **Chase Thompson**

“Automobile Wiring Fault Locator: Noise Characterization and Interface”

3:25 **Jordan Nicholls**

“Automobile Wiring Fault Locator: Simulation and Algorithm Development”

3:45 **Chad Mann**

“Automobile Wiring Fault Locator: PCB Design and Software Integration”

4:05 **Justin Ferguson**

“Automobile Wiring Fault Locator: Conclusion and Test Bench”

**Faculty Advisors: Cynthia Furse  
Priyank Kalla**

**SESSION 9**                      **3:05 p.m.**                      **Guest House Room A**

**AUTOMOBILE WIRING FAULT LOCATOR: NOISE CHARACTERIZATION AND INTERFACE**

Chase Thompson, Jordan Nicholls, Chad Mann, Justin Ferguson (Priyank Kalla, Cynthia Furse), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

The Automobile Wiring Fault Locator system is designed to detect intermittent faults in the electrical wiring in an automobile. The fault-finding system uses Spread Spectrum Time Domain Reflectometry (SSTDR) test signals sent on the existing automobile wiring to gather information about faults. This test signal must be within the noise margin of the electrical systems in the car. The waveform that is reflected back is analyzed to determine if a fault occurred, the type of fault it is, and how far away the fault is from the test signal source. To achieve this, the project is divided into four parts: 1) noise characterization and interface, 2) simulation and algorithm development, 3) printed circuit board (PCB) design and software integration, and 4) test bench.

The noise characterization and interface part of the project involves measuring and characterizing noise levels in an automobile, designing and building the automobile wiring interface, and capturing the baseline data from the test bench. Noise level characterizations are needed to ensure that the output SSTDR signal injected into the automobile wiring does not interfere with the normal operation of the car's systems. An interface is needed to allow communication between the SSTDR signal and the wiring of the automobile. Baseline data from the test bench is needed for the correct operation of the comparison and detection algorithms.

**SESSION 9**                      **3:05 p.m.**                      **Guest House Room A**

**AUTOMOBILE WIRING FAULT LOCATOR: NOISE CHARACTERIZATION AND INTERFACE**

Chase Thompson, Jordan Nicholls, Chad Mann, Justin Ferguson (Priyank Kalla, Cynthia Furse), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

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**SESSION 9**                      **3:25 p.m.**                      **Guest House Room A**

**AUTOMOBILE WIRING FAULT LOCATOR: SIMULATION AND ALGORITHM DEVELOPMENT**

Jordan Nicholls, Chad Mann, Justin Ferguson, Chase Thompson (Priyank Kalla, Cynthia Furse), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

An accurate simulation of the output of the Spread Spectrum Time Domain Reflectometry (SSTDR) system is needed in order to develop and test the algorithms used to find the faults in automobile wiring. The MATLAB® simulation is constructed using the impulse response of the given system. The impulse response is convolved with a sinc function that is characteristic of the SSTDR system being used. The comparison algorithm compares the output of the SSTDR to a stored baseline measurement using a normalized cross correlation to determine how similar the signals are. If the signals differ by more than a specified tolerance, a wiring fault has most likely occurred, so the signal is stored. This eliminates the majority of the raw information so only the important signals are processed by the detection algorithm. The detection algorithm determines whether or not a fault has occurred in the system. If a fault has occurred, it determines the nature of the fault and the distance to the fault so that it can be located and corrected.

**SESSION 9**                      **3:25 p.m.**                      **Guest House Room A**

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Jordan Nicholls, Chad Mann, Justin Ferguson, Chase Thompson (Priyank Kalla, Cynthia Furse), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

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**SESSION 9**                      **3:45 p.m.**                      **Guest House Room A**

**AUTOMOBILE WIRING FAULT LOCATOR: PCB DESIGN AND SOFTWARE INTEGRATION**

Chad Mann, Justin Ferguson, Chase Thompson, Jordan Nicholls (Priyank Kalla, Cynthia Furse), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

The printed circuit board (PCB) design and software integration part of the project includes the schematic design, board layout, embedded software, and programming/debugging of the Automobile Wiring Fault Locator (AWFL) system. The system needs an effective way to receive, compare, and store Spread Spectrum Time Domain Reflectometry (SSTDR) data to be used in determining the location of a fault. The PCB prototype and associated software are designed to meet these requirements. The prototype employs a microcontroller that communicates with both an SSTDR chip and a secure digital (SD) memory allocation chip over a serial peripheral interface (SPI) bus. The microcontroller software is written in the C programming language.

**SESSION 9**                      **3:45 p.m.**                      **Guest House Room A**

**AUTOMOBILE WIRING FAULT LOCATOR: PCB DESIGN AND SOFTWARE INTEGRATION**

Chad Mann, Justin Ferguson, Chase Thompson, Jordan Nicholl (Priyank Kalla, Cynthia Furse), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

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**SESSION 9**

**4:05 p.m.**

**Guest House Room A**

**AUTOMOBILE WIRING FAULT LOCATOR: CONCLUSION AND TEST BENCH**

Justin Ferguson, Chase Thompson, Jordan Nicholls, Chad Mann (Priyank Kalla, Cynthia Furse), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

The test bench is built to test and calibrate the Automobile Wiring Fault Locator (AWFL) prototype. Due to the nature of the wiring faults, which the AWFL device detects, its prototypical testing must first be completed in the safety of a laboratory instead of on a working automobile. The test bench is designed to test the three following circuits from an automobile: the head lights, a power window, and a car stereo. These circuits were determined to be of greatest importance for testing from interviews conducted with mechanics. The faults in each circuit are recreated on the test bench at precise locations based on these interviews. The exact location of the fault is created on the test bench to calibrate the AWFL. The test bench circuits were constructed by removing existing circuits and wiring from a scrapped automobile. To ensure an accurate length of fault timing, a Field Programmable Gate Array (FPGA) is used to create faults on the above circuits for a predetermined length of time.

**SESSION 9**

**4:05 p.m.**

**Guest House Room A**

**AUTOMOBILE WIRING FAULT LOCATOR: CONCLUSION AND TEST BENCH**

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**SESSION 9: Electrical Engineering Individual Projects  
(Session 9 cont.)**

**Guest House Meeting Room A**  
Session Chairman (2<sup>nd</sup> Group): Daryl Wasden

**Group 2**

- 4:45 **Arash Farhang**  
“Distributed Spectrum Sensing for Cognitive Radio”
- 5:05 **Daryl L. Wasden**  
“A Distributed Spectrum Sensing Model for Cognitive Radio”
- 5:25 **William Peter Blackham**  
“Translating Glove for American Sign Language”

**Faculty Advisors: Behrouz Farhang  
Priyank Kalla**

**(Session 9 cont.)**

**Guest House Meeting Room A**  
Session Chairman (2<sup>nd</sup> Group): Daryl Wasden

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**SESSION 9****4:45 p.m.****Guest House Room A****DISTRIBUTED SPECTRUM SENSING FOR COGNITIVE RADIO**

Arash Farhang, Daryl L. Wasden (Priyank Kalla, Behrouz Farhang), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

Cognitive Radio (CR) is a new and emerging technology for allocating vacant portions of the spectrum to secondary users (SUs). Currently, the electromagnetic spectrum is licensed to primary users (PUs). CRs developed by the Wireless Communications Lab at the University of Utah use filterbanks to give a good estimate of spectral use. This estimate is used to allocate the spectrum to SUs. False sensing of spectrum availability due to shadowing, however, can be problematic. In addition, frequency allocation can be much more efficient, if the band most available over time is chosen. Multiple software radios (SRs) were utilized to address these issues. A database of spectral information was compiled using data obtained from SR nodes in the Emulab network at the University of Utah. A total bandwidth of 2 MHz from 929-931 MHz was chosen for construction of the database. This was divided up into 16 125 kHz sub-bands each with 192 points of resolution. Measurements were taken at MEB rooms 3122, 3144, 3146, and 3240 between the hours of 10 a.m. to 3 p.m. on September 15<sup>th</sup> through October 3<sup>rd</sup>, 2008. A Polyphase Discrete Fourier Transform Filterbank implementation was used to analyze the data. This information was used to create a map of spectral availability to reliably assign bands to SUs, thereby reducing interference with PUs.

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**SESSION 9**                      **5:05 p.m.**                      **Guest House Room A**

**A DISTRIBUTED SPECTRUM SENSING MODEL FOR COGNITIVE RADIO**

Daryl L. Wasden, Arash Farhang (Priyank Kalla, Behrouz Farhang), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

Cognitive Radio (CR) is an emerging technology used to allocate unused portions of the licensed radio spectrum to unlicensed secondary users (SUs). Avoiding interference with licensed primary users (PUs) requires an accurate and timely estimate of local spectral activity. One possible estimation method is energy detection. An efficient implementation of an energy detector is possible with a Polyphase Discrete Fourier Transform Filterbank. The filterbank reduces spectral leakage among adjacent bands, improving the dynamic range and the accuracy of the energy detector. Energy measurements were analyzed to determine spectrum availability and to assign SUs to unused frequency bands in real-time. The complete system included several Universal Software Radio Peripherals (USRPs) connected to a network testbed available for research at the University of Utah called emulab and a central processing server run on one of the machines in the Cade Lab (a computer lab) at the University of Utah. Simulations were run using real-time data collected from the USRPs. Frequencies between 900 MHz and 950 MHz were examined and found to be relatively inactive in the Merrill Engineering Building at the University of Utah. Due to the low activity in this region of the spectrum, false radio signals were blended with actual measured signals during simulation to

**SESSION 9**                      **5:05 p.m.**                      **Guest House Room A**

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**SESSION 9**

**5:25 p.m.**

**Guest House Room A**

TRANSLATING GLOVE FOR AMERICAN SIGN LANGUAGE

William Peter Blackham (Priyank Kalla), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

The purpose of this project is to be able to interpret the hand signs of American Sign Language and translate it into written English. To do this the user will wear a glove fitted with tilt sensors and flexible resistors to capture the manipulation of the user's hand. The data from the flexible resistors will then be passed to the FPGA board using a series of analog to digital converters. As these flex resistors and the tilt sensors create a digital model of the hand, the program can then compare the captured hand signal to a database to find the correct letter or word to be displayed. This project is essential because approximately 28 million Americans are reported to have severe to profound hearing loss. This means that American Sign Language is the third most used language in the United States. Unfortunately, this population is unable to communicate effectively and currently struggles to be a part of our society. This translating glove system is the solution to this current problem.

**SESSION 9**

**5:25 p.m.**

**Guest House Room A**

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**SESSION 10: Electrical Engineering and Computer Engineering Individual Projects**

**Guest House Meeting Room A**

Session Chairman: Glenn Barton

- 12:05 **Glenn Barton**  
“Development and Implementation of Control Logic Simulation Methods”
- 12:25 **Stephen Sieb**  
“The \$20 Oscilloscope”
- 12:45 **Matthew M. Maddex**  
“Analog Maximum Power Point Tracking Circuit”
- 1:05 **Gregg Durrant**  
“Miniature Remote Controlled Conduit Vehicle”
- 1:25 **Isaac D. Jensen**  
“Simple Video Streaming Viewer”
- 1:45 **Shahene A. Pezeshki**  
“Engineering Education: Teleology Applied to Electrical Engineering High School Outreach”

**Faculty Advisors:** **Marc Bodson**  
**Cameron Charles**  
**Neil Cotter**  
**Richard Grow**  
**Holly Moore (Salt Lake Comm. College)**  
**Angela Rasmussen**  
**Joe Zachary (School of Computing)**

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**SESSION 10                      12:05 p.m.              Guest House Room A**

**DEVELOPMENT AND IMPLEMENTATION OF CONTROL LOGIC SIMULATION METHODS**

Glenn Barton (Angela Rasmussen, Marc Bodson, Richard Grow, Department of Electrical and Computer Engineering; Holly Moore, Salt Lake Community College), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

MATLAB™ and Simulink are used to implement new simulation models for industrial automation and control systems. Industrial hardware models are created in Simulink using first-principle physical modeling techniques. These Simulink models are designed to replicate the behavior of actual industrial hardware components such as tanks, valves, and transmitters. The Simulink model communicates via Ethernet with a programmable logic controller, which can respond to the signals in real-time. The simulation models developed here provide control engineers with a way to test, tune, and debug control logic more easily than by using physical industrial hardware. These simulation methods also provide engineers with a proving ground that can be used for testing new and advanced control topologies, as well as optimizing existing ones.

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**SESSION 10**

**12:25 p.m.**

**Guest House Room A**

**THE \$20 OSCILLOSCOPE**

Stephen Sieb (Angela Rasmussen, Neil Cotter), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

In an effort to make teaching engineering concepts more easy in schools, an inexpensive oscilloscope has been designed with a simplified interface and functionality. The oscilloscope will replace current methods of teaching simple circuit analysis in the classroom. The oscilloscope has been designed to fit in the palm of the hand, be self powered, be able to power a circuit, make simple measurements, and make simple calculations. The circuits' functionality features average DC voltage measurements, instantaneous voltage measurements at both 10 ms and 1 ms resolution with the ability to store 20 of these values and display them on the LCD screen, measure frequency up to 100 rad/s, measure the phase delay in degrees, and output a 100 Hz sin wave. The oscilloscope features a 3-button design, making it useful for students K-12. The goal of such an oscilloscope is to teach math and engineering skills in schools and get kids excited about such skills, drawing more people into these fields.

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**SESSION 10**

**12:45 p.m.**

**Guest House Room A**

**ANALOG MAXIMUM POWER POINT TRACKING CIRCUIT**

Matthew M. Maddex (Angela Rasmussen, Cameron Charles),  
Department of Electrical and Computer Engineering, University of  
Utah, Salt Lake City, UT 84112

Solar power has been shown to be the most abundant source of power for wireless sensor nodes. One challenge of using solar power is the fact that the solar cells' maximum operating point changes throughout the day. To maximize the energy harvested from a solar cell, a maximum power point tracking (MPPT) circuit is used. Previous works have implemented MPPT systems as DCDC converters in conjunction with a microprocessor running an algorithm to maximize the operating point of the solar cell. The DCDC converter acts as an energy buffer, controlled by the MPPT circuit, allowing the solar cell to operate at different conditions than the rest of the system. This work involves the design of an analog MPPT circuit to replace the microprocessor required in other systems. The analog design can be implemented with a few inexpensive, off-the-shelf components. One advantage of this design is in its flexibility. No prior knowledge of the solar cell or battery is required for the analog MPPT circuit to operate. This work also acts as a proof of concept. This design could be implemented as a system on a chip, integrating both the MPPT circuit and a DCDC converter on a single chip. In addition to the smaller footprint of a single integrated circuit, the integrated design could be optimized to minimize power consumption.

**SESSION 10**

**12:45 p.m.**

**Guest House Room A**

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Matthew M. Maddex (Angela Rasmussen, Cameron Charles),  
Department of Electrical and Computer Engineering, University of  
Utah, Salt Lake City, UT 84112

Solar power has been shown to be the most abundant source of power for wireless sensor nodes. One challenge of using solar power is the fact that the solar cells' maximum operating point change throughout the day. To maximize the energy harvested from a solar cell, a maximum power point tracking (MPPT) circuit is used. Previous works have implemented MPPT systems as DCDC converters in conjunction with a microprocessor running an algorithm to maximize the operating point of the solar cell. The DCDC converter acts as an energy buffer, controlled by the MPPT circuit, allowing the solar cell to operate at different conditions than the rest of the system. This work involves the design of an analog MPPT circuit to replace the microprocessor required in other systems. The analog design can be implemented with a few inexpensive, off-the-shelf components. One advantage of this design is in its flexibility. No prior knowledge of the solar cell or battery is required for the analog MPPT circuit to operate. This work also acts as a proof of concept. This design could be implemented as a system on a chip, integrating both the MPPT circuit and a DCDC converter on a single chip. In addition to the smaller footprint of a single integrated circuit, the integrated design could be optimized to minimize power consumption.

**SESSION 10**

**1:05 p.m.**

**Guest House Room A**

**MINIATURE REMOTE CONTROLLED CONDUIT VEHICLE**

Gregg Durrant (Angela Rasmussen), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

This presentation describes the development and construction of a small, compact remote-controlled vehicle that has the power and agility to install a pull-string through 2-inch conduit while giving the installer a visual picture of the inside of the conduit via a video link to a laptop or other analog display. The main uses for the vehicle will be to inspect the inside of the conduit to find internal damage or blockage and to install pull string-in conduit. The Miniature Remote Controlled Conduit Vehicle (MRCV) overcomes current robotic crawler limitations of inspecting conduit of smaller sizes (2 to 6 inches). The current solution of inspecting small conduit is to use products like the mini see snake that are pushed through the conduit and cost between 5,000 to 11,000 dollars. The primary users of the MRCV will be electrical and communication cable installers with a target cost for vehicle between 600 to 1200 dollars.

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**SESSION 10**

**1:25 p.m.**

**Guest House Room A**

**SIMPLE VIDEO STREAMING VIEWER**

Isaac D. Jensen (Angela Rasmussen), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

Streaming media has always been very difficult to enjoy in the comfort of your family room. In order to do so one must get the streaming media to a television set. Getting media to display on a television can be done, but with expensive equipment. The objective of this project is to use a microcontroller for a simple and cheap solution for streaming video to a television. The microcontroller chosen for this project was the Parallax Propeller. This microcontroller has eight 80 MHz processors (cogs) that can be used to run different applications. The benefit of using this microcontroller is that it has the ability to display to a television with its built in circuitry, making the physical size of the viewer smaller. A microcontroller was chosen over a digital signal processor because of its simplicity in programming and flexibility. Cost and open source was also a consideration, making the Parallax Propeller microcontroller the cheapest and best solution for this project. In this project the design of the viewer was developed as well as the programming of the microcontroller to receive, process, and display video and audio. Also a “How To” website was created for anyone that wishes to reproduce and/or modify the viewer. With the availability of eight processors, which can be accessed at any time, the viewer can have many more functionality such as a keyboard, mouse, web camera, multiple displays, etc.

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**SESSION 10****1:45 p.m.****Guest House Room A****ENGINEERING EDUCATION: TELEOLOGY APPLIED TO ELECTRICAL ENGINEERING HIGH SCHOOL OUTREACH**

Shahene A. Pezeshki (Joe Zachary, Neil Cotter), Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT 84112

The main goal for this thesis is to explore an effective way to teach engineering concepts. Frequently concepts are learned by rote repetition without an understanding of how fundamental principles relate to each other. The effective teaching concept of teleology is applied to this thesis. Teleology in this application is illustrating how all concepts of a subject fit together from the beginning of a learning course. Through consultation with Joe Zachary, software written in Java was developed that is a graphic representation of an electronic circuit board. The interactive learning software allows for users to click on electronic components leading to web pages that teach how the components work. Animated Java applets are incorporated from outside learning sources. This software is supplementary to Professor Neil Cotter's High School Outreach program. Graphics in the software represent the physical circuit board and components in the High School Outreach kit. With interactive learning software, the aim is to help clarify the meaning of a current lesson which fits within the context of more general electronics concepts.

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