MASTER OF SCIENCE
IN
ELECTRICAL ENGINEERING

ULTRA-WIDEBAND ANTENNA DESIGN FOR THE USQ-146 INSTALLATION ON THE H-60 HELICOPTER

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The current configuration of the USQ-146 radio system on the H-60 helicopter uses two vertically-polarized transmit antennas and one vertically-polarized receive antenna. The purpose of this design is to replace the two existing transmit antennas with one vertically-polarized ultra-wideband omni-directional antenna for use on an H-60 equipped with a USQ-146 radio system. The antenna should have a VSWR less than three, ideally less than two, over the frequency range of 30-500 MHz. The antenna has to mount through an existing cargo hole and retract or fold for ten-inch ground clearance beneath the helicopter when landed. The H-60 3-D solid model was created with the MicroScribe-3DX digitizer, Rhinocerous NURBS modeling software V1.1 and Ansoft's High Frequency Structure Simulator (HFSS) Solid Modeler. The antenna was designed and its performance predicted using HFSS. HFSS is based on the finite element method and generates accurate results for realistic antennas. Three sizes of nine configurations of flat blade antennas were analyzed with HFSS. The successful design was an 88 cm tall bell-shaped flat blade antenna with a capacitive load on the end.

DESIGN, IMPLEMENTATION, AND TESTING OF A HIGH PERFORMANCE SUMMATION ADDER FOR RADAR IMAGE SYNTHESIS

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This thesis documents the schematic design, simulation, and fabrication mask layout of a high-speed 16-bit summation adder to be integrated into the Digital Image Synthesizer (DIS) Application Specific Integrated Circuit (ASIC). The DIS is a single-chip false target radar image generator to be used in countering wide band imaging radars. The DIS will calculate the false target image in 512 range bins. Each range bit utilizes two identical 16-bit binary adders. The 16-Bit Adder must compute the sum of two 16-bit numbers, providing a 16-bit sum, carry output, and overflow detection bit. The stated goal is for this adder to perform all of these functions in one pipeline stage while being clocked at 600 MHz. The first part of the design process includes an extensive analysis to utilize the fewest gates in designing the simplest adder that can achieve the 600 MHz goal. SPICE net lists are extracted from these schematic designs and simulations conducted to verify logic functionality and propagation speed. Mask layout of the verified design is constructed using a CMOS 0.18 micron process utilizing deep sub-micron technology with six metal interconnect layers. The mask layout design is verified by ensuring all design rule checks (DRC) and layout versus schematic (LVS) checks are satisfied. In addition, conclusions and recommendations are provided to assist other DIS project members in using this adder and the aforementioned design process for additional components of the DIS ASIC.

WEB-BASED TESTING TOOLS FOR ELECTRICAL ENGINEERING COURSES

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This thesis presents a distance-learning tool, which provides a self-sufficient application that allows one to implement online courses for electrical engineering. A major emphasis is placed on replacing simplistic multiple-choice or true-false test questions. A system named, Distance Learning Tools for Online Tests (DLTOT) is designed, modeled and implemented.

The implementation is based on the Java programming language, using Servlets and Java Server Pages (JSP), three-tier technology and Commercial Off-the-Shelf (Costs) products, namely, an Apache web server, Tomcat Application server, Microsoft Access, Mathematica, WebMathematica and JSP/ Servlet technology.

DLTOT is able to control student access, to allow interaction with the student during the course, and to present a challenging test, which is easily graded by the application itself.

EXPLOITATION OF TRANSMISSION CONTROL PROTOCOL ERROR HANDLING AS A MEANS OF COVERT COMMUNICATIONS

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Steganography is the “art” of hiding information so that the information’s very existence is not detected. As a method of covert communications, steganography is used to hide information within other communications media. This thesis examines the various techniques of hiding information within Local Area Network (LAN) or Wide Area Network (WAN) communications traffic, with special emphasis on typical internetwork traffic using the Transmission Control Protocol (TCP) and Internet Protocol (IP). Current means of steganography within network traffic is limited in terms of throughput and robustness. A novel means of covertly transmitting data within TCP segments is presented which demonstrates how manipulating TCP error handling should increase the effective throughput of covertly transmitted data significantly. A new TCP data hiding application was developed to embed the hidden information into the cover media, and to retrieve the information at the receiving end. A flexible testing architecture was designed and implemented that may also be used to test other steganographic techniques. Error handling techniques for the hidden information were identified for the steganographic protocol, to increase the robustness of the hidden information. Finally, steganalytic techniques and tools have been identified to counter the use of this technique by unfriendly forces.

IMPLEMENTING THE CROSS AMBIGUITY FUNCTION AND GENERATING GEOMETRY-SPECIFIC SIGNALS

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The first purpose of this thesis is to implement an efficient Cross Ambiguity Function (CAF) algorithm to compute the Time Difference of Arrival (TDOA) and Frequency Difference of Arrival (FDOA) between two sampled signals. Two CAF-related MATLAB functions were written and analyzed. One implements a “coarse” mode and a “fine” mode to accurately compute the TDOA and FDOA. The second plots different views of the resulting three-dimensional CAF surface.

The second purpose is to develop a program to generate geometry-specific signals. Some software packages can artificially embed constant TDOAs and FDOAs between two signals. In real-world emitter-collector geometries (one emitter and two separate collectors), however, movement of the emitter and/or collectors causes time-varying TDOAs and FDOAs. A MATLAB function was written to generate pairs of Binary-Phase-Shift-Keying signals according to user-defined signal parameters and Cartesian geometries. The resulting signal pairs have realistic TDOAs and FDOAs that vary with time according to geometry and relative motion.

Several signal pairs with different geometries are generated and input into the CAF functions, and the results are compared with theoretical TDOA and FDOA calculations. Finally, signals with low signal-to-noise ratios are generated to evaluate the CAF's ability to find Low Probability of Detection signals.

AN INVARIANT DISPLAY STRATEGY FOR HYPERSPECTRAL IMAGERY

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Remotely sensed data produced by hyperspectral imagers contains hundreds of contiguous narrow spectral bands at each spatial pixel. The substantial dimensionality and unique character of hyperspectral imagery requires display techniques that differ from those provided by traditional image analysis tools. This study investigated techniques enabling the display of hyperspectral images without the interference of in-scene characteristics that lead to biased representations depending on the content of every image under analysis. Utilizing the Principal Components Analysis transformation it is possible to simplify the representation requirements while maintaining the information contained in the scene. The introduction of an external eigenvector, containing few spectral characteristics, into the original scene data removes most of the spectral bias allowing for an accurate detection of the constituent elements. The subsequent shift of the resulting data to match the respective hue directions in the dataspace allows for image color fidelity based on the true composition of the image while all the environmental influence has been removed and the final outcome is readily perceived by the human vision.

ULTRA-WIDEBAND, COMBAT WEARABLE INTEGRATED (COMWIN) ANTENNA DESIGN FOR THE JOINT TACTICAL RADIO SYSTEM (JTRS)

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The Ultra-Wideband, Combat Wearable Integrated (COMWIN) antenna is a 54 to 500 MHz antenna integrated into the protective flak vest worn by infantry Marines or soldiers. This COMWIN antenna was designed to support the Joint Tactical Radio System (JTRS), and is part of an antenna system developed at NPS that incorporates wideband antennas into combat equipment. The concealed design presented in this thesis would eliminate the traditional visual profile associated with radio operators in infantry units by eliminating the vertical whip antenna. In this thesis, a conformal vest antenna was designed with an approximate 10:1 bandwidth (54-500 MHz). The antenna's performance was predicted through computer simulation. A prototype was built and its performance was measured. Measurements on the prototype showed a good fit with the theoretical predications. The antenna's VSWR is less than 3:1 between 54 and 500 MHz. Simulation results at 54 MHz, 164 MHz, and 500MHz showed that the radiation patterns were omni-directional at lower frequencies and became more directional at higher frequencies, concentrated in the sector from the horizon to 60˚ elevation.

THE DESIGN, SIMULATION, AND FABRICATION OF A BICMOS VLSI DIGITALLY PROGRAMMABLE GIC FILTER

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This thesis used a previously designed programmable GIC filter as a basis in which to incorporate a BiCMOS operational amplifier. An NPN bipolar transistor layout was designed and incorporated into an opamp layout, which was a modified version of a CMOS-only design. The BiCMOS opamp was simulated using Silvaco SmartSpice and showed considerable improvement over its CMOS equivalent. Additional improvements were made to the GIC filter to include a passgate with reduced resistance, and a correction was made to the capacitor layout. Simulations were also performed on a switched-capacitor bilinear resistor and a switched-capacitor variable bilinear resistor. Results from the bilinear resistor simulations require further study and testing. Finally, a VLSI layout of the filter was accomplished using LASI and has been submitted to MOSIS for fabrication.

CAPABILITIES AND LIMITATIONS OF ORTHOGONAL FREQUENCY-DIVISION MULTIPLEXING IN WIRELESS APPLICATIONS

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Orthogonal frequency-division multiplexing (OFDM) is a transmission scheme that, unlike conventional transmission schemes that send only one signal at a time over one radio frequency, sends a high-speed signal concurrently on a number of different frequencies. This allows for a robust and efficient use of bandwidth. These characteristics make OFDM particularly suitable for wireless local area network communications that are susceptible to noise, interference and distortion. In this paper, concepts are introduced along with their applications to high speed data transmission. In addition, a technique to exploit OFDM systems, based on exploitation techniques for direct sequence spread spectrum systems, is developed.

ANALYSIS AND EVALUATION OF THE ELECTROMAGNETIC COMPATIBILITY OF COTS WIRELESS LAN COMPONENTS ONBOARD SUBMARINES

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Wireless Local Area Networks (WLANs) have become increasingly popular in recent years both in the civilian and military sectors. A series of theses have been produced at the Naval Postgraduate School to provide a Commercial-Off-The-Shelf (COTS) component WLAN system for the New Attack Submarine (NSSN) Program. However, the environment of a submarine is a complicated, electromagnetically noisy place. The Electromagnetic Compatibility (EMC) standards regulating electromagnetic emissions and electromagnetic susceptibility differ greatly between the civilian and the military sectors. Any electromagnetic incompatibility between systems can be disruptive to their operation. A great deal of EMC analysis must be accomplished in order to introduce components from one regulatory world into another.

The goal of this thesis is to verify that the Aironet 4800 DS WLAN component suite meets the military regulatory standard with regard to electromagnetic compatibility for submarine systems. This verification was accomplished by first analyzing Federal Communication Commission EMC reports on the 4800 series components. The 4800 series then underwent several EMC tests mandated by the military

standard governing EMC, MIL-STD-461E. CE102 and RE102 tests were conducted at the Naval Postgraduate School in Monterey, CA. CS101 and RS103 tests were conducted at the EMC laboratories of Electric Boat in Groton, CT. Each test is representative of one aspect of the EMC environment. Based on this limited testing of conducted emissions, radiated emissions, conducted susceptibility and radiated susceptibility, it appears that these commercial components meet the MIL-STD-461E standard with respect to submarines.

MODELING AND PERFORMANCE ANALYSIS OF CELLULAR CDMA CHANNEL WITH RAKE RECEIVER

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In this thesis, a cellular CDMA reverse channel model was established which incorporates a time-invariant discrete multipath Nakagami-fading channel in a multiple-cell system. The effects of intra and inter-cell interference, perfect power control, lognormal shadowing and RAKE receiver with varying number of taps are investigated. For performance improvement forward error correction and smart antenna techniques are incorporated into the model. Expressions for probability of bit error are developed under a range of operating conditions and the model is tested using Monte Carlo Simulation.