

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

TRANSIENT FIELD VISUALIZATION FOR ULTRA-WIDEBAND ANTENNA DESIGN

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Impulse antennas are specifically designed to transmit and/or receive very short bursts of electromagnetic energy. By their very nature, these short time-duration bursts (impulses) require ultra-wideband transmitting and receiving antennas. This thesis investigates a number of UWB antenna designs to determine their feasibility in receiving an impulse having a 1000:1 bandwidth (10 MHz to 10 GHz) with virtually no distortion.

As a tool in aiding the design of such an antenna, this thesis presents original software that was developed to visualize an impulse propagating in the near-field region of the antenna being considered. Such software will significantly reduce the workload and time required for antenna design and provide unique capabilities for heuristic understanding of the physics involved.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: Impulse Antenna, Wideband Antenna, Ultra-Wideband, Near-Field, Software

EVALUATION OF RADIATION INDUCED HOLE TRAPPING MODEL FOR SIMULATING BACK-CHANNEL LEAKAGE CURRENT IN AN EDGELESS SOI nMOSFET

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This thesis is part of a larger project that is attempting to address the decline of foundries producing radiation-hardened electronics for military space applications. The principal aim is to improve the radiation tolerance of commercial-off-the-shelf (COTS) electronics by developing wafer substrate designs that contain an SiO₂ isolation layer for Complementary Metal Oxide Semiconductor (CMOS) fabrication processes. It has been shown that this layer reduces single-event and dose-rate sensitivity. A manufacturer could then build radiation-tolerant commercial devices on these wafer substrates with little or no changes in the manufacturing process. This thesis contributes to the overall goal of substrate development by evaluating the performance of the Technology Computer Aided Design (TCAD) base hole trapping simulation in modeling back-channel leakage current caused by total dose irradiation after the addition of an initial charge density in the buried oxide (BOX).

DoD KEY TECHNOLOGY AREAS: Electronics, Modeling and Simulation, Other (Silicon-on-Insulator, Radiation Hardened)

KEYWORDS: Electronics, Silicon-on-Insulator, Modeling and Simulation, Radiation Hardened

RECOVERY OF UNKNOWN CONSTRAINT LENGTH AND ENCODER POLYNOMIALS FOR RATE $\frac{1}{2}$ LINEAR CONVOLUTIONAL ENCODER

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It is sometimes useful to recover convolutionally encoded data without knowing the encoder parameters. The necessary first step is to recover these parameters so that a suitable decoder can be selected. In this study an attempt is made to recover the unknown constraint length K and the convolutional code polynomials for a feedback-free rate $\frac{1}{2}$ encoder from a received data stream. It will be shown that the output of such an encoder uniquely characterizes it and permits unambiguous identification of both K and the polynomials if the input data stream is sufficiently exciting and if the received encoded stream is both abundant and is free of transmission error.

The encoder output can be collected and collated in a manner that permits synthesis of an impulse response. Even though such an impulse input has not occurred, from the synthesized sequence one may derive the encoder parameters. The application of this synthetic impulse response algorithm with noisy data is then explored, and directions for further research are identified.

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: Encoder Parameters, Convolutional Code Polynomials

CONNECTION UTILIZATION MASKING IN ATM NETWORKS

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A technique for connection utilization masking in ATM networks is presented, modeled and analyzed. Specifically, a cell injection mechanism is modeled with a two-state Markov Modulated Poisson Process (MMPP) to study its autocorrelation and power spectral density properties and the queue response to the arrival process. The Cruz bound is used to determine injection source traffic parameters. Cell injection is implemented on a permanent virtual channel with a bursty Variable Bit Rate (VBR) source. The result is also VBR traffic having a new set of user-defined statistics. Traffic traces representing before and after injection scenarios are collected and further processed to define autocorrelation and power spectrum density functions. The results are used to compare and justify analytical results. The cell-injected stream shows strong correlation over a long duration, an indication of the removal of burstiness. Cell Transfer Delay, Cell Loss Rate, and Cell Inter-arrival time statistics are collected to evaluate the injection's effects on Quality of Service (QoS) parameters. Cell injection causes more mid- and high-frequency traffic power to be shifted towards the low frequency region in the frequency spectrum, representing an increase in the mean arrival rate.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (High Speed Computer Networks)

KEYWORDS: Asynchronous Transfer Mode, ATM, Cell Injection, Cruz Bound, MMPP, AX/4000

ELECTRICAL ENGINEERING

DESIGN AND DEVELOPMENT OF THE EER MODULE FOR BEARTRAP POST MISSION PROCESSING SYSTEM 2000

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This work is intended to support an Extended Echo Ranging (EER) addition to the BEARTRAP post mission Processing System 2000 (S2K). S2K is an analysis tool programmed using Microsoft Visual C++ and residing in a Microsoft Windows NT environment. Both BEARTRAP and EER missions are Anti-Submarine Warfare (ASW) missions and are able to be analyzed on the same hardware system due to the use of the same recording media. This thesis develops a design framework for the S2K EER module, which is the software support needed to perform post mission processing for the EER mission. Two submodules of the design are also developed. First is the Virtual Buoy Repositioning submodule, which uses acoustic data to correct errors in sonobuoy locations that are caused by aircraft navigational errors. Second is the Detection and Classification submodule, which processes the acoustic data to identify signal returns from the target. A preliminary analysis of incoming signals is performed using current techniques and exploring a new technique for signal classification.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Sensors

KEYWORDS: Acoustics, BEARTRAP, EER, DSP, ASW

DESIGN OF ADVANCED ANALYSIS SOFTWARE FOR IT-21 COMPLIANT NETWORKS

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The cornerstone to achieving battlefield dominance, as defined by Joint Vision 2010, is establishing and maintaining information superiority. This new paradigm of network centric warfare has shifted computer networking from an administrative support system to a tactical necessity. Recognizing this critical requirement for interoperable networking, the Department of the Navy promulgated the Information Technology for the Twenty-First Century (IT-21) computing standards. This thesis investigates the synergetic interactions between application software, the WindowsTM NT operating system, and the underlying networks. The insight gained is then exploited to develop performance analysis software in C++. The resulting application provides a valuable asset for examining, troubleshooting, and optimizing IT-21 information systems.

DoD KEY TECHNOLOGY AREA: Other (High Speed Computer Networks)

KEYWORDS: Asynchronous Transfer Mode, ATM, IT-21, Winsock

ELECTRICAL ENGINEERING

ANALYSIS, SIMULATION, AND FABRICATION OF CURRENT MODE CONTROLLED DC-DC POWER CONVERTERS

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A modular DC Zonal Electrical Distribution System (DC ZEDS) offers advantages in both cost and weight over traditional radial shipboard distribution. In order to equip the next class of surface combatant with DC ZEDS, preparation research includes the design of autonomous DC-DC power converter modules having robust load sharing capability. This thesis examines the utility of current-mode switch control applied to high-voltage DC-DC power converters. A state-space representation for a current-mode controlled buck converter is developed. The system is modeled dynamically using the Advanced Continuous Simulation Language (ACSL). System stability and frequency response is modeled using MATLAB. A hardware controller is fabricated to implement current-mode control using available laboratory equipment.

DoD KEY TECHNOLOGY AREAS: Electronics, Modeling and Simulation, Other (Power Conversion)

KEYWORDS: DC-to-DC Buck Converter, Current-Mode, ACSL

ASYNCHRONOUS TRANSFER MODE AND LOCAL AREA NETWORK EMULATION STANDARDS, PROTOCOLS, AND SECURITY IMPLICATIONS

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A complex networking technology called Asynchronous Transfer Mode (ATM) and a networking protocol called Local Area Network Emulation (LANE) are integrated into many naval networks without any security-driven naval configuration guidelines. No single publication is available that describes security issues of data delivery and signaling relating to the transition of Ethernet to LANE and ATM. This thesis provides: (1) an overview and security analysis of standardized protocols relating to ATM and LANE; (2) an overview and security analysis associated with integrating a Fore Systems Inc., LANE-based ATM network, with an accredited Cisco Systems Inc., Ethernet Virtual LAN (VLAN) network; and (3) associated security-related suggestions for network design and configurations. This thesis identifies possible negative security-related capabilities associated with ATM- and LANE-related protocols; however, many are mitigated using the identified network design guidelines. Qualitative analysis suggests that the introduction of an ATM/LANE backbone into an existing TCP/IP network does not increase the probability of incorrect destinations receiving and processing corrupted frames. It is hoped that this seminal document will assist in the development of standard security-driven implementation guidelines associated with ATM/LANE-based networks, as well as inform those required to prepare, and review associated network Risk Assessments.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control, and Communications, Other (High Speed Computer Networks)

KEYWORDS: Asynchronous Transfer Mode, ATM LAN Emulation, LANE, Emulated LAN, ELAN, Security, Private Network Network Interface, PNNI, User Network Interface, UNI

ELECTRICAL ENGINEERING

DARK CURRENT ANALYSIS AND COMPUTER SIMULATION OF TRIPLE-JUNCTION SOLAR CELLS

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This thesis reports the steps taken to characterize the semiconductor properties of triple-junction solar cells. Chemically etching the solar cells exposes each of the three energy producing junctions, InGaP, GaAs and Ge, to probes. Dark current measurements reveal the diode ideality factors of each junction, and these results are compared to current theories on diodes and solar cells. Calculations performed on experimentally obtained values from previous studies and measured values from this research for individual junctions show an expected diode ideality factor for the entire solar cell of 6.2 to 6.4, which is close to the actual production cell value of 5.9. Silvaco International's semiconductor simulation software was used to model the solar cell under dark and illuminated conditions. The simulated dark current yields an ideality factor of 3.45—lower than expected. A spectral analysis equating wavelength of light to current production for each junction within the solar cell is presented, and methods to better match the current produced from each junction are investigated. A current-versus-voltage-curve comparison equates simulated results to actual manufactured cell performance under illumination conditions; simulated values were within 10% for V_{OC} and 15% for I_{SS} in the better performing junctions.

DoD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Solar Cell, Multijunction, Tunneling, Software Simulation, Dark Current, GaAs, InGaP, GaInP, Ge

ANALYSIS OF RADIO FREQUENCY COMPONENTS FOR SHIPBOARD WIRELESS NETWORKS

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Computers and computer networks are generally viewed as tools that allow personnel to increase productivity. However, due to the limitations of traditional local area networks (LANs), the Navy has not been able to efficiently leverage commercial computer technology for general shipboard applications. Recent advances in wireless LANs (WLANs) now permit mobile users to employ network applications to manage and share information. Mobile computers can be used by the crew to supplement damage control reports and reduce the strain on the over-taxed voice circuits. Watchstanders can make log entries into a central data base that utilizes automated data trend analysis algorithms to detect deteriorating components and schedule maintenance to correct the problem prior to component failure. The advantages to using WLANs onboard naval vessels are nearly endless.

This thesis evaluates commercially available wireless networking components for use onboard naval vessels. Installing such equipment would enable mobile watchstanders to access services provided on LANs. The theories and principles governing the operation of WLANs are discussed. Then, current commercially available components are evaluated in a laboratory setting. Finally, the most promising component evaluated is tested in the hangarbay of an aircraft carrier and throughout the inhabitable compartments of a Los Angeles class submarine.

ELECTRICAL ENGINEERING

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control and Communications, Other (Wireless Communications)

KEYWORDS: Wireless Local Area Networks, Spread Spectrum, Mobile Computers

TARGET TRACKING IN THE AUTOMATIC QUICK LOOK SYSTEM

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This work is part of an ongoing effort to implement the Automatic Quick Look (AQL) system and integrate the separate BEARTRAP post mission analysis tools into a single desktop system residing in a Microsoft Windows environment. This new integrated system will contain software modules designed to replace and enhance the diverse array of processing systems which comprise the AQL system. This thesis examines the target tracking module which provides an estimated target track solution based on received acoustic data from a known sonobuoy pattern. Output from the target tracking module provides essential target aspect information for further sound pressure level (SPL) analysis. This work presents the development and conversion of the Enhanced Multi-Segment Tracking (EMST) algorithm from the original FORTRAN environment to a MATLAB environment. The MATLAB module will provide a development and testing platform for future implementation using Microsoft Visual C++.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Sensors, Modeling and Simulation

KEYWORDS: DSP, Narrowband, BEARTRAP

DAMAGE CONTROL AND LOG TAKING JAVA APPLICATIONS FOR SHIPBOARD WIRELESS LANs

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Damage control communications and watchstander log taking practices onboard submarines and ships need to be improved. Currently, damage control relies on a slow, error prone process involving sound powered telephone talkers and a grease pencil annotated white board. Also log taking practice suffers from similar problems. Logs are taken on paper forms, collected daily, and filed in cabinets. Wireless network and mobile computing devices can be a solution to improve the efficiency of these practices.

In this thesis, a distributed Java prototype software is developed to utilize the benefit of an onboard Intranet consisting of wireless LANs and pen-based handheld computers. For both practice areas, data could be entered into a handheld computer and then wirelessly transmitted to a database server. Those data can be processed by powerful main platforms and different supervisors can review them any time in parallel. An applet and a servlet program module are created to provide small, user friendly, platform independent electronic forms. Since handheld computers have some limitations like screen dimensions, computing power, and Java Virtual Machine, features of these software approaches are tested on a few different handheld computers to find the best software approach and computer product.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles - Ships and Watercraft, Computing and Software

KEYWORDS: Wireless Local Area Network, Mobile Computing, Java, Pen-Based Computing

DC CHARACTERIZATION OF EFETs GROWN ON BULK GaAs AND OVER BUFFER LAYERS OF LOW TEMPERATURE GROWN GaAs(Be)

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This thesis is part of a larger project that is attempting to address the drastic decline of foundries producing radiation hardened electronics for mil-aerospace applications. Wafer substrates containing certain buffer layers are known to improve the radiation tolerance of circuits built on them. Manufacturers potentially can use these substrates to build radiation tolerant devices with minimal or no changes to the design of a COTS device. This research documents the *DC* characteristics of standard Vitesse *EFETs*. Using a computer model built with Silvaco software, predictions for the *DC* operation of Vitesse *EFETs* built on a substrate with layers of *AlGaAs* over *LT GaAs(Be)* are made. Finally, an equation expressing the fermi level as a function of *Be* doping in *LT GaAs(Be)* is developed.

DoD KEY TECHNOLOGY AREAS: Electronics, Other (Radiation Effects)

KEYWORDS: Electronics, Radiation Hardened Electronics, Gallium Arsenide

DETECTION OF WIRELESS LOCAL AREA NETWORKS IN AN URBAN TACTICAL ENVIRONMENT

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Interest in portable, high-bandwidth digital communications methods spans the world and presents a formidable challenge to the Defense Department of the United States. While anxious to use new communications equipment, the armed services are wary of the vulnerabilities they expose. This thesis examines the vulnerability of wireless local area networks (WLANs) when used by tactical units in an urban setting.

The U. S. Marine Corps experimented with WLANs during Exercises Urban Warrior '99 and Kernel Blitz '99. Samples of exercise transmissions were collected and recorded in support of this thesis. Two direct sequence spread spectrum (DSSS) WLAN detectors were designed and implemented to analyze the data. One is an optimal detector and the other is non-optimal. This thesis details the design of the detectors and presents an analysis of the performance of the non-optimal detector.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Battle Space Environments, Other (High Speed Computer Networks)

KEYWORDS: Wireless Local Area Networks, WLAN, 802.11, Detection and Estimation, Computer Networks

