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 burst 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 (10MHz 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 and impulse propagating in the near-field region of the antenna being considered. Such software would 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

LOSS PERFORMANCE IN AN ATM CELL CAPTURE ENVIRONMENT
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Analysis of an Asynchronous Transfer Mode (ATM) cell capture system in a heterogeneous source environment is presented. Specifically, a two-stage queuing system is developed, fed by a multiplexed Constant Bit Rate (CBR) source and a Poisson distributed source. The resulting D+M/D/1 waiting time tail distribution is approximated analytically using a weighted M/D/1 queuing system and is used to verify the behavior of a computer model simulation. Cell loss encountered in the second stage is then observed for a variety of interarrival rates from the Poisson source. Based on observed results, the region of primary interest occurs where the arrival rate of the CBR stream is greater than 160 percent the mean arrival rate of the Poisson stream. It is concluded that under certain circumstances, the capture system can still effectively function with a low probability of cell loss. Further, a solid analytic foundation is developed for further theoretical analysis of the cell capture stage.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Cell Capture, Waiting Time Distribution, Heterogeneous Traffic Streams, D+M/D/1 Queue, M/D/1 Queue

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RADIATION PATTERNS OF ANTENNAS INSTALLED ON AIRCRAFT

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This thesis presents a study of radiation patterns for low-gain antennas installed on aircraft. With the aid of the computer program APATCH, a simulation of the radiation patterns for a given antenna located at various points on an aircraft structure can be evaluated. The program uses a technique referred to as Shooting and Bouncing Rays (SBR), which is valid for structures that have typical dimensions of ten wavelengths or more. A Cessna 172 aircraft with a quarter-wavelength monopole antenna and an F-18 aircraft with a telemetry antenna are analyzed.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Modeling and Simulation

KEYWORDS: Radiation Pattern, Aircraft, Physical Optics (PO), Geometrical Optics (GO), Shooting-and-Bouncing Rays (SBR), APATCH

SPACE-BASED INFORMATION OPERATIONS (U)

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This thesis investigates the different aspects of Information Operations. Each area is discussed, emphasizing the places where satellites may contribute. An assessment of capabilities is presented in detail, and conclusions are formed as to the feasibility of a Space-Based Information Operations System.

DoD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Information Operations, Space

A SIMULATION OF M-ARY PHASE SHIFT KEYING (MPSK) COMMUNICATIONS SYSTEM PERFORMANCE IN THE PRESENCE OF WIDEBAND NOISE AND CO-CHANNEL INTERFERENCE

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The purpose of this thesis is to model digital communications systems in the time domain using MATLAB Simulink and the Communications Toolbox as well as to determine and verify system performance in the presence of additive noise and co-channel interference. While the theoretical results are available for the effect of wideband gaussian noise on the performance of digital communications systems, determining the performance of a system in the presence of noise and co-channel interference is best done by computer simulation. Time domain modeling allows the visualization of the communication signal at various stages, and "Monte Carlo" type simulations establish the bit error rates under realistic conditions of noise and co-channel interference as well as for different transmitter/receiver parameters, different channel parameters, and different types of interfering signals. It should be noted that the simulation does not account for system non-linearities.

DoD KEY TECHNOLOGY AREAS: Electronics, Modeling and Simulation

KEYWORDS: Simulink, Matlab, Noise and Interference, Probability of Bit Error

THE CLOSED-LOOP CONTROL OF A THREE-PHASE INVERTER USING DSPACE DS1102 DSP BOARD

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Due to enhanced reliability, reductions in cost, and ease of maintenance, the U.S. Navy has decided to shift from radial electrical distribution to DC zonal distribution for shipboard use. Correspondingly, the construction of newer classes of combatant vessels will replace bulky transformers with semiconductor switching DC-DC converters and DC-AC inverters. Electrical Control Units, ECUs, control these converters and inverters. Development of an ECU begins with a prototype design, used by the engineer to test the ability of an experimental algorithm to control a physical system. This thesis research examines the use of the DSPACE DS1102 DSP board as a prototype ECU for a three-phase inverter. A DS1102 monitored currents at the output of a three-phase power MOSFET bridge, performed the signal processing, and accordingly provided the MOSFET gating signals. This research compared several different algorithms, time steps, and integration methods implemented by the DSP board. In the experiments, the inverter powered a simple RL lead and an induction motor. For the closed-loop control of the induction motor, a speed control algorithm provided command inputs to the previously tested inverter. This thesis research demonstrates that the DS1102 can quickly and effectively prototype the signal processing and control units of the electrical power distribution systems of future U.S. Navy ships.

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

KEYWORDS: Electronic Control Unit, Control Prototyping, DC-AC Inverter, Power Electronics, Electrical Distribution System, Induction Motor, Digital Signal Processing

SINGLE-EVENT ANALYSIS OF A HIGFET UTILIZING Be-DOPED LOW TEMPERATURE GROWN GaAs BUFFERS

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There is a growing demand for the use of electronics in radiation environments such as space. Gallium Arsenide (GaAs) semiconductors are well suited to be used in these environments due to their lower power-speed products than silicon technology. Their main drawback is that they are susceptible to errors from Single Event Upsets (SEUs). SEUs' are the result of high-energy particles passing through "off" transistors, and turning them "on" thus, causing temporary errors in flip-flops and memory circuits. This thesis examines the Motorola CGaAs^{TM} Heterostructure Insulated Gate Field Effect Transistor (HIGFET) device but with the addition of a beryllium(Be) doped low temperature grown GaAs buffer layer to reduce excess charge by utilizing the buffer's ultra short electron trapping properties. The proposed transistor is modeled in 2-D for threshold shifts induced by the buffer layer. Additionally, a transient simulation is performed on a circuit to examine charge collection internal to the transistor. Simulation results correspond to measured device performance.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Manufacturing Science and Technology, Electronics

KEYWORDS: Heterostructure Insulated Gate Field Effect Transistor, Single-Event Upsets, Gallium Arsenide, Aluminum Gallium Arsenide, Indium Gallium Arsenide

A CORRECTION ALGORITHM TO COUNTER THE EFFECTS OF TIME-VARYING DOPPLER ON CYCLIC SPECTRAL ANALYSIS

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It has been found that there is a direct relationship between inherent time-varying Doppler developed as a result of collector motion and the smearing of features produced from cyclostationary processing. An effective algorithm has also been developed that can counter such effects. This thesis explains how the time-varying Doppler is developed, presents the effects of time-varying Doppler on cyclic spectral analysis through the means of an example, and finally develops and applies a correction algorithm to counter the effects of the time-varying Doppler.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Time-Varying Doppler, Cyclic Spectral Analysis, Cyclostationarity

EVALUATION OF AND METHODS TO REDUCE CO-CHANNEL INTERFERENCE ON THE FORWARD CHANNEL OF A CDMA CELLULAR SYSTEM

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The large volumes of information necessary to support today's warfighter require the development of new technology to provide this type of secure, high-data rate communication. The flexibility of cellular communications makes it an excellent choice for this purpose. Currently available cellular communications systems are narrowband; that is, they cannot support high data rate applications such as video, full Internet connection, and teleconferencing. Simply increasing the bandwidths of the existing systems will result in severe degradation due to frequency-selective fading, resulting in loss of quality and reliability. Instead, a new wideband cellular system can be used featuring a multicarrier, code division multiple access (CDMA) method. This type of system minimizes the effects of frequency-selective fading while reducing the probability of detection and interception. The limiting factor in this type of system is co-channel interference. This thesis focuses on analyzing the co-channel interference on the forward channel of the proposed CDMA cellular system and analyzing methods such as sectoring and microzoning in an effort to reduce that interference.

DoD KEY TECHNOLOGY AREA: Other (Communications)

KEYWORDS: Cellular Communications, Co-Channel Interference, CDMA, Interference Reduction

DESIGN RULES FOR RADIATION TOLERANT BULK CMOS INTEGRATED CIRCUITS

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The requirement to develop radiation tolerant Integrated Circuits (ICs) components for government and military satellite systems is conflicting with the drive to use commercial-off-the-shelf (COTS) components. In this research, a method was developed to make commercial Bulk CMOS processes more tolerant of radiation. There are two primary problems with Metal Oxide Silicon Field Effect Transistor as they relate to total dose radiation, namely subthreshold leakage current and threshold voltage shift. To solve the first issue a chip developed previously was tested, showing that by adding a second polysilicon layer gate structure to the transistor the post irradiation subthreshold current can be reduced to the order of 1 pA. This compensating structure proved successful in reducing to pre-radiation levels the subthreshold leakage current in the Orbit 2 μm processes. Addressing the second issue an additional chip was designed and fabricated, also in the Orbit 2 μm processes, to attempt to control the threshold voltage shift of the transistor via the body effect. At the same time a second chip was also developed that incorporated the two new design layout rules mentioned above. This second chip design will be used to determine if the lifetime of the IC can be increased in the space environment.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Computer and Software, Electronic, Manufacturing Science and Technology

KEYWORDS: Radiation, Bulk CMOS, Design Rules

FAULT TOLERANT COMPUTING TESTBED: A TOOL FOR THE ANALYSIS OF HARDWARE AND SOFTWARE FAULT HANDLING TECHNIQUES

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Operating computers in space requires the use of very expensive radiation hardened microelectronics devices. Unfortunately, the United States radiation hardened market is rapidly shrinking and makes up a very small percentage of the commercial market. For these reasons, and the fact that commercial-off-the-shelf (COTS) devices are cheaper, more capable, readily available, and software availability is much greater, the use of COTS devices in future space systems is fast becoming a reality. A significant disadvantage of COTS devices is their susceptibility to radiation induced single event upsets (SEU), among other radiation effects that are detrimental to electronic systems.

This thesis focuses on the board level design of a tool which enables the analysis of fault tolerant computing techniques in a laboratory environment in the presence of radiation induced SEU. When implemented, this tool will be beneficial to the study of using COTS devices in space. The tool will provide the capability to analyze the performance of hardware redundancy techniques and software algorithms intended to improve the performance of COTS microprocessors in this environment prior to their use in designs intended for actual space applications. Cadence Concept™ design schematics, associated Verilog® code and simulation results are presented to develop this concept.

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

KEYWORDS: Fault Tolerant Computing, Triple Modular Redundancy (TMR), Commercial-off-the-Shelf (COTS) Devices, Single Event Upsets (SEUs), Cadence Concept Schematic, Verilog

TIME DOMAIN SIMULATION OF M-ARY FREQUENCY SHIFT KEYING COMMUNICATIONS SYSTEM PERFORMANCE IN THE PRESENCE OF WIDEBAND NOISE AND CO-CHANNEL INTERFERENCE

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In this thesis, models of MFSK digital communications systems were developed using Matlab Simulink and Communications Toolbox. The models were employed to verify MFSK performance in the presence of additive noise and predict MFSK performance for additive noise and co-channel interference. Results are presented for bit-error rate as functions of the signal-to-noise and signal-to-interference power ratios. The results for coherent detection of MFSK (M=2,4,8) in the presence of additive white Gaussian noise show excellent agreement with the theory. On the other hand, simulation results for the probability of bit error for non-coherent detection of MFSK differ (–21% average) from the theory suggesting a possible "systematic" error in the Communications Toolbox implementation of the non-coherent MFSK detection.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Simulink, Communications Toolbox, M-ary Frequency Shift Keying (MFSK), Coherent-Non-Coherent Detection

MULTIPLE ROBOT COMMAND AND CONTROL ARCHITECTURE DEVELOPMENT

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The military use of autonomous vehicles or robots will increase as national security planners seek to maintain strategic deterrence and preserve U.S. interest in spite of reduced resources. Cooperative group behavior among large numbers of robots will be required to complete various missions. Communication schemes for command, control, and coordination of multiple robots is one of the required capabilities. This thesis evaluates the Simplified Lisp-like Expression Evaluation Paradigm (SLEEP) for implementation as a development tool and a communications scheme. SLEEP enables the dynamic group formation of robots that are best qualified for a task. The SLEEP concept is tested and evaluated using a testbed built from Nomadic SCOUT mobile robots and a socket interface. Results from simulation and physical experiments validate the effectiveness of SLEEP for multiple robot coordination.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation, Sensors, Other (Robotics)

KEYWORDS: Autonomous Agents, Multiple Robots, Cooperative Behavior, Dynamic Addressing