# MASTER OF SCIENCE
# IN
# ELECTRICAL ENGINEERING

---

**SIMULATIONS TO PREDICT THE COUNTERMEASURE EFFECTIVENESS OF USING PYROPHORIC TYPE PACKETS DEPLOYED FROM TALD AIRCRAFT**

**Mihail Demestihas-Lieutenant, Hellenic Navy**
**B.S., Hellenic Naval Academy, 1988**
**Master of Science in Electrical Engineering-September 1999**
**Advisors: Ronald J. Pieper, Department of Electrical and Computer Engineering**
**R. Clark Robertson, Department of Electrical and Computer Engineering**

Manned aircraft that are intended for surveillance or to complete a bombing mission will very likely be engaged by surface to-air-missiles having guidance systems based on infrared (IR) technology. The objective of this study was to characterize via simulation the amount of "cover" that can be obtained by dropping from a pre-launched, unmanned tactical air launched decoy (TALD) a sequence of pyrophoric materials to create an IR cloud, analogous to the interference created by microwave chaff, that would protect the manned aircraft from the missile. The performance analysis is based on a simple reticle based model in which the two-dimensional (2D) image is reduced to either a composite signal, created by the aircraft, or a composite noise, created by the pyrophoric expandable. The analysis leads to a computer simulation model producing time and space dependent signal-to-noise ratios. It is demonstrated that the simulation model can answer questions such as how long the materials need to burn, how much intensity is needed, what wavelength range is most effective, which pyrophoric packets should be dropped, and how many. A visual model of the time dependent IR pyrophoric cloud has also been created.

**DoD KEY TECNOLOGY AREA:** Electronic Warfare

**KEYWORDS:** Pyrophoric, Flare, Infrared (IR)

**THE DESIGN AND IMPLEMENTATION OF A DIGITALLY PROGRAMMABLE GIC FILTER**

**Adam R. Kubicki-Captain, United States Marine Corps**
**B.S.M.E., Marquette University, 1993**
**Master of Science in Electrical Engineering-September 1999**
**Advisor: Sherif Michael, Department of Electrical and Computer Engineering**
**Second Reader: Todd Weatherford, Department of Electrical and Computer Engineering**

In this research, the design and implementation of an integrated-circuit, digitally programmable, analog-to-analog filter are presented. By functioning in the analog domain the quantization errors and hardware requirements of analog-to-digital, and digital-to-analog, conversion are eliminated. The filter design of this project utilizes switched-capacitors and the Generalized Immitance Converter (GIC) to eliminate resistors and inductors. The resulting design is therefore suitable for fabrication by modern integrated-circuit technology. The design also features digital programmability, so that the filter can easily interface with modern digital systems. The overall filtering circuit is programmable in filter topology, quality factor, and cutoff (or center) frequency, making it useful in a wide range of applications.

**DoD KEY TECHNOLOGY AREA:** Electronics

**KEYWORDS:** GIC, Analog Filter, VLSI, Switched Capacitor, Programmable Filter

**DISTRIBUTED CONTROL FOR PARALLELED PULSE-WIDTH MODULATED (PWM) INVERTERS IN THE DC ZONAL DISTRIBUTION SYSTEM**

**Mark L. Marinac-Lieutenant, United States Navy**
**B.S., University of Texas, Austin, 1992**
**Master of Science in Electrical Engineering-September 1999**
**Advisors: John G. Ciezki, Department of Electrical and Computer Engineering**
**Robert W. Ashton, Department of Electrical and Computer Engineering**

The modular DC Zonal Electrical Distribution System (DC ZEDS) offers many advantages over traditional radial shipboard electrical distribution. The advantages of DC ZEDS will be exploited in the next class of surface combatants. Part of the development research for DC ZEDS includes the design of autonomous DC-to-AC inverter modules having robust load sharing capability. This thesis will focus on these DC-to-AC inverters.

Paralleled inverters in the DC ZEDS must be flexible and modular. The optimum flexibility is achieved when an electrical system can automatically reconfigure after the number of operating inverters changes. A distributed control system for paralleled inverters is investigated to achieve this flexibility and increase the system's battle damage survivability. Modularity of the system design allows for simplified testing and a reduction in cost through bulk purchasing. Unique distributive control methods are developed in this thesis that will allow isolated inverters in separate watertight compartments to coordinate their actions without interconnections between the units.

**DoD KEY TECHNOLOGY AREAS:** Electronics, Modeling and Simulation

**KEYWORDS:** DC-to-AC PWM Inverter, Synchronous Reference Frame Analysis, Power Line Communication, Droop-Based Load Sharing, Paralleling, ACSL

**HIGH EFFICIENCY SOLAR CELLS: A MODEL IN SILVACO**

**Darin J. McCloy-Major, United States Marine Corps**
**B.S.G.E., United States Naval Academy, 1987**
**Master of Science in Electrical Engineering-September 1999**
**Advisor: Sherif Michael, Department of Electrical and Computer Engineering**
**Second Reader: Ronald J. Pieper, Department of Electrical and Computer Engineering**

This thesis develops a model in Silvaco International's Virtual Wafer Fabrication (VWF) environment to assist advanced solar cell developers in designing more efficient solar cells intended for use in space. The complete model is intended to accurately predict the properties and characteristics of an existing state-of-the art multiple junction solar cell. This model should also be robust yet flexible in order to facilitate future modification and expansion. A specific dual junction cell, constructed of $GaInP_2$/GaAs/Ge and displaying 24-26% efficiency at Air Mass Zero sun equivalency, was chosen as the baseline for this model and the characteristics of this cell and the materials that comprise it are explored and discussed. Basic building block models are constructed and displayed. Additionally, the intended structure of the eventual model is displayed and possibilities for future work are described.

**DoD KEY TECHNOLOGY AREAS:** Space Vehicles, Computing and Software, Electronics, Materials, Processes, and Structures, Manufacturing Science and Technologies (MS&T), Modeling and Simulation

**KEYWORDS:** Solar Cells, Indium Phosphide Related Materials, Semiconductor Computer Modeling, Gallium Arsenide Related Materials, Silvaco

### FEATURE EXTRACTION OF INTRA-PULSE MODULATED RADAR SIGNALS USING TIME-FREQUENCY ANALYSIS

**Ioannis Moraitakis-Lieutenant, Hellenic Navy**
**B.S., Hellenic Naval Academy, 1989**
**Master of Science in Electrical Engineering-September 1999**
**Advisors: Monique P. Fargues, Department of Electrical and Computer Engineering**
**Ralph D. Hippenstiel, Department of Electrical and Computer Engineering**
**Second Reader: Jovan Lebaric, Department of Electrical and Computer Engineering**

This thesis applies time-frequency transformations to radar signals. Specifically, it considers the feasibility of applying time-frequency transformations to extract the intra-pulse modulation parameters of radar signals. In this work, we consider radar signals with analog pulse compression; specifically linear or hyperbolic intra-pulse modulation. Several time-frequency transformations are investigated to identify which one gives the most accurate image representation for signals in noisy environments. Next, image processing techniques are applied in conjunction with an adaptive curve fitting method, for the hyperbolic modulation scheme, to extract the parameters of the frequency equation. Results show that for the linear chip case the frequency equation can be estimated with small error down to SNR equal to –10dB. The proposed method for the hyperbolic chirp modulation is less immune to noise degradation and it can be used down to SNR level equal to 2dB.

**DoD KEY TECHNOLOGY AREAS:** Electronic Warfare, Modeling and Simulation

**KEYWORDS:** Time-frequency Representations, Pulse Compression, Radon Transform

### EQUIVALENT IMPEDANCE OF ROUGH SURFACE AT LOW GRAZING ANGLES

**Marcelo Jorge de Assis Motta-Lieutenant Commander, Brazilian Navy**
**B.S.E.E., University of São Paulo, 1990**
**Master of Science in Electrical Engineering-September 1999**
**Advisor: Ramakrishna Janaswamy, Department of Electrical and Computer Engineering**
**Second Reader: David C. Jenn, Department of Electrical and Computer Engineering**

Equivalent impedance of a rough surface is determined by solving the problem of radiowave propagation over rough random surface by using the parabolic equation method. Horizontal polarization was considered and assumed the rough surface, defined by discrete points, to be perfectly conducting. This assumption has minimum effects for frequencies in the VHF band and above. The essential point of this thesis is to solve numerically a Volterra integral equation of the second kind for the surface current. Because the computation becomes very intense for long ranges, a multiple sections solution is presented, where the solution procedure is successively repeated for smaller ranges. The numerical results are compared with results available in the literature. Finally, the technique to determine the equivalent impedance of a sinusoidal random rough surface by comparing the resulting normalized field to the field of a 2-ray model over a constant impedance plane was applied.

**DoD KEY TECHNOLOGY AREAS:** Battlespace Environments, Electronic Warfare, Sensors

**KEYWORDS:** Radiowave Propagation, Volterra Integral Equation, Low Grazing Angle, Propagation On Rough Random Surface, Equivalent Impedance Determination

**SIMULATION OF A MULTITARGET, MULTISENSOR, TRACK-SPLITTING TRACKER FOR MARITIME SURVEILLANCE**

**Mark A. Olson-Lieutenant, United States Navy**
**B.S., United States Naval Academy, 1992**
**Master of Science in Electrical Engineering-September 1999**
**Advisors: Harold A. Titus, Department of Electrical and Computer Engineering**
**Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering**

This study adapts some established target tracking techniques for use in the maritime surface surveillance role and tests them with computer generated data. Computer simulation of a track splitting tracker capable of operating in this undersampled and asynchronous environment is presented. The tracker uses standard and extended Kalman Filter algorithms to estimate target state from latitude and longitude or line of bearing position measurements. Prior to state estimation, all measurements are processed to retain only those that meet feature and geographic gate thresholds. All measurements passing these criteria will update the target state and be scored based on a goodness of fit with the model. The state estimate with the best score is selected as the correct one for display purposes, while all state estimates continue to be processed with subsequent measurements. Several runs of the simulation are discussed here to illustrate the performance of track splitting and the effect of several key tracker parameters.

**DoD KEY TECHNOLOGY AREAS:** Command, Control, and Communications, Sensors

**KEYWORDS:** Multitarget Tracking, Track-Splitting Tracker, Kalman Filters

**SHAPING ROUTER DYNAMICS IN LARGE-SCALE NETWORK MANAGEMENT (U)**

**Douglas A. Powers-Lieutenant, United States Navy**
**B.S., Drexel University, 1990**
**Master of Science in Electrical Engineering-September 1999**
**Advisors: John C. McEachen, Department of Electrical and Computer Engineering**
**Vicente C. Garcia, National Security Agency Cryptologic Chair**

This research analyzes the dynamic behavior of an essential element of large-scale network management: inter-domain routing. The intent is to contribute to an overall concerted effort to shape network performance in large-scale network management. Currently, the accepted standard for inter-domain routing at the main Internet exchange points is Border Gateway Protocol, Version 4 (BGP-4). This research examines BGP-4's architecture, the design of its algorithm and the elements associated with the BGP-4 finite state machine. The performance of BGP-4 in both small and large networks is analyzed in an effort to develop a thorough understanding of the protocol's strengths and weaknesses during routine operation at the main network exchange locations in the Internet. The author theorizes, tests and recommends several engineering approaches for optimum management of BGP-4's routing dynamics in order to contribute to an overall large-scale network management plan.

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

**KEYWORDS:** Network Management, Internet Security, Computer Internetworking, Routing Protocols, Information Warfare, Information Operations

**ANALYSIS OF AN EMULATED IT-21 LAN OVER A SIMULATED SHIP-TO-SHORE SATELLITE LINK**

**Joseph R. Prisella-Lieutenant, United States Navy**
**B.S.E.E., Virginia Polytechnic Institute and State University**
**Master of Science in Electrical Engineering-September 1999**
**Advisors: John C. McEachen, Department of Electrical and Computer Engineering**
**Murali Tummala, Department of Electrical and Computer Engineering**

The Navy's IT-21 philosophy when applied to the Navy-wide Intranet poses a significant problem: how to best adapt to the requirements of the new standard and still make the most of the currently installed network. The integration of Asynchronous Transfer Mode (ATM) backbone and desktop networks with legacy equipment and applications is considered in this thesis. The most current solution to this dilemma is the use of Local Area Network Emulation (LANE). The focus of this thesis is the implementation of LANE over a simulated ship-to-shore satellite link. Data throughput is monitored and analyzed to determine the optimum configuration. Testing is conducted to examine the advantages of routed Emulated Local Area Networks (ELANs) and non-routed ELANs. An inport scenario that benchmarks the two ELAN configurations against the Ethernet Virtual LANs (VLANs) is discussed.

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

**KEYWORDS:** Asynchronous Transfer Mode, ATM, LAN Emulation, LANE, Emulated LAN, ELAN

**TRANSIENT RESPONSE TO SINGLE EVENT UPSET IN AlInAs/GaInAs HETEROJUNCTION BIPOLAR TRANSISTORS**

**Peter K. Schiefelbein-Captain, United States Marine Corps**
**B.S., United States Naval Academy, 1993**
**Master of Science in Electrical Engineering-September 1999**
**Advisor: Todd Weatherford, Department of Electrical and Computer Engineering**
**Second Reader: Ronald J. Pieper, Department of Electrical and Computer Engineering**

AlInAs/GaInAs heterojunction bipolar transistors (HBTs) on an InP substrate have been fabricated and tested at frequencies up to nearly 60 GHz. Their most promising high-speed application is in emitter-coupled logic (ECL) circuits. In space-based applications, however, single event effects (SEEs) are a significant threat to the proper operation of these devices at high speeds. This particular HBT was modeled in an ECL differential pair and radiation effects due to cosmic rays were simulated. The results show where and how excess carriers are collected. Insertion of a short-lifetime buffer layer in the device and substrate was simulated. Various levels of radiation hardness can be obtained for single event upset (SEU).

**DoD KEY TECHNOLOGY AREAS:** Electronics, Other (Indium Phosphide, Radiation Hardened)

**KEYWORDS:** Electronics, Indium Phosphide, Radiation Hardened

**IMPLEMENTING A LOW-COMPLEXITY, ADAPTIVE, LAYERED VIDEO CODER FOR VIDEO TELECONFERENCING**

**Steven J. Skretkowicz-Lieutenant, United States Navy**
**B.S., Memphis State University, 1992**
**Master of Science in Electrical Engineering-September 1999**
**Advisor: Murali Tummala, Department of Electrical and Computer Engineering**
**Second Reader: Robert E. Parker, Jr., Department of Electrical and Computer Engineering**

Real-time interactive video applications, such as video teleconferencing, present difficult challenges to network designers due to strict quality of service constraints and the limitations of traditional video compression schemes. These limitations reveal themselves notably in two areas: poor error robustness and a lack of flexibility when dealing with multicast scenarios over heterogeneous networks.

A more promising approach that improves error robustness while also offering a solution to the network heterogeneity problem is to employ a layered video coder. This thesis presents the implementation of a new layered video coder scheme. Block updating coupled with an aging algorithm is used in this scheme to select macroblocks for transmission. Block updating selects macroblocks that have changed due to scene motion, and the aging algorithm ensures that an entire frame is transmitted within a set time interval. Layering is accomplished through application of the fast Haar transform and/or the discrete cosine transform. Layer assignments are made by grouping bands of coefficients with similar variances. Quantization and encoding for motion video employs both an industry standard and uniform quantization with a custom variable length coding table. For static slides, uniform quantization and a second custom variable length coding table are employed. Rate control is accomplished via the reduction of a four-dimensional operational distortion surface to a one-dimensional optimal curve implemented as a simple table lookup of quantizers.

**DoD KEY TECHNOLOGY AREAS:** Command, Control, and Communications, Computing and Software

**KEYWORDS:** Video Teleconference, Layered Video Coder

**DESIGN AND IMPLEMENTATION OF A ZERO-VOLTAGE-SWITCHING, PULSE-WIDTH-MODULATED, HIGH-FREQUENCY, RESONANT BUCK CHOPPER**

**Clifton C. Turner, Jr.-Lieutenant, United States Navy**
**B.S., Old Dominion University, 1993**
**Master of Science in Electrical Engineering-September 1999**
**Advisors: Robert W. Ashton, Department of Electrical and Computer Engineering**
**John G. Ciezki, Department of Electrical and Computer Engineering**

As the Navy moves toward a modular DC Zonal Electrical Distribution System (DC ZEDS) to reduce both cost and weight over traditional radial shipboard distribution, there is a need to capitalize on technological advances currently available. The 21st century shipboard power distribution system calls for a DC bus architecture to eliminate the need for large transformers and thousands of pounds of cable through the use of high-speed semiconductor converters. In order to realize dramatic reductions in the size and cost of shipboard components through the use of high-speed switches, switch designs must be thoroughly investigated and tested.

This thesis examines the use of soft-switching techniques for use in the future dc-to-dc power converter modules of the DC ZEDS. Soft-switching is analyzed here primarily with a DC down-converter (buck chopper). A low voltage buck chopper is simulated utilizing PSPICE and modeled in the lab. A voltage feedback control algorithm is developed and utilized with the PSPICE model. A comparative study of circuit efficiency is done between a single-source and a two-source soft-switched topology. Finally, recommendations are made for further simulation and modeling to evaluate soft-switching, high-voltage performance capabilities.

**DoD KEY TECHNOLOGY AREAS:** Electronics, Modeling and Simulation

**KEYWORDS:** DC-to-DC Buck Converter, Zero-Voltage-Switching, Pulse-Width-Modulation

**GUARANTEEING FAIR ACCESS FOR MULTIMEDIA TRAFFIC USING THE SMART ALGORITHM FOR MULTICAST ATM CONNECTIONS**

**Randolph R. Weekly-Lieutenant Commander, United States Navy**
**B.S., University of Southern California, 1989**
**Master of Science in Electrical Engineering-September 1999**
**Advisor: Murali Tummala, Department of Electrical and Computer Engineering**
**Second Reader: Robert E. Parker, Jr., Department of Electrical and Computer Engineering**

The cornerstone of the US Navy's implementation of network centric warfare is the Information Technology for the 21st Century (IT-21) Intranet. The IT-21 Intranet relies on Asynchronous Transfer Mode (ATM) backbones for data transfer. An essential service provided by the IT-21 Intranet is video teleconferencing (VTC). However, the current ATM standard does not support the multipoint-to-multipoint multicast requirements for robust VTC applications.

This work builds upon the SMART algorithm, an existing protocol that provides support for ATM multipoint-to-multipoint multicast over a single virtual channel (VCC), and modifies it to ensure that each source has fair access to the VCC. Fair access is ensured to multiple sources through the use of a metric that takes into account the relative magnitude of each source's queue size and cell age. The improved SMART algorithm is modeled using the MIL3's Optimized Network Engineering Tool (OPNET). Fair access to each source is shown using both audio and video source models. VCC utilization is examined and shown to improve for the video case as the number of sources increase. The increased overhead due to the use of Resource Management (RM) cells is also examined.

**DoD KEY TECHNOLOGY AREAS:** Command, Control, and Communications, Computing and Software, Modeling and Simulation

**KEYWORDS:** Video Teleconferencing, Asynchronous Transfer Mode, Multicast, Networks

**DEVELOPMENT OF VISUAL C++ VERSION OF THE BROADBAND CROSS-CORRELATION TIME DELAY TRACKER MODULE FOR S2K**

**Rafael A. Widow-Lieutenant, Chilean Navy**
**B.S., Chilean Naval Polytechnic Academy, 1993**
**Master of Science in Electrical Engineering-September 1999**
**Advisors: Charles W. Therrien, Department of Electrical and Computer Engineering**
**Murali Tummala, Department of Electrical and Computer Engineering**

This work is part of an ongoing effort to integrate the separate BEARTRAP post mission analysis tools into a system residing in a Microsoft Windows NT environment. This thesis develops the module responsible for tracking the time-of-arrival difference of a sound wave at two different but closely spaced sonobuoys. The broadband cross-correlator tracker module processes all the data coming from the sonobuoys by dividing it into small segments in order to produce a time dependent observation. The module displays its output in a graphical representation of the time delay by plotting its probability density function versus time. This work describes the algorithms, development, and testing of this module for the BEARTRAP Post Mission Processing System 2000 (S2K) using Microsoft Visual C++ as the implementation language.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Sensors

**KEYWORDS:** Time Delay, BEARTRAP, DSP, Broadband, Cross-Correlation

**INTRODUCTION TO HIDDEN MARKOV MODELS AND THEIR APPLICATIONS TO CLASSIFICATION PROBLEMS**

**Michail Zambartas-Lieutenant, Hellenic Navy**
**B.S., Hellenic Naval Academy, 1990**
**Master of Science in Electrical Engineering-September 1999**
**Advisors: Monique P. Fargues, Department of Electrical and Computer Engineering**
**Roberto Cristi, Department of Electrical and Computer Engineering**

This thesis presents an introduction to Hidden Markov Models (HMM) and their applications to classification problems. HMMs have been used extensively to model the temporal structure and variability of speech and other signals in the last decade. We selected to write our own HMM implementation in MATLAB. We tested our software on a limited isolated 4-word recognition. We also applied our implementation to the recognition of mine-like objects buried in shallow sand, using seismo-acoustic data obtained from an on-going project at the Naval Postgraduate School. Initial results indicate that the HMM-based classifier can recognize the type of mine-like object, independent of the object weight with a 97% accuracy. Results also indicate that it can recognize the object type at different distances with a 100% accuracy. However, the experiments were conducted with very few data, and further work needs to be done to confirm these initial findings by using a larger data set. Finally, we benchmarked our results against those obtained using a back-propagation neural network implementation, which were found to be similar, but slower than the HMM-based implementation.

**DoD KEY TECHNOLOGY AREAS:** Electronics Warfare, Modeling and Simulation

**KEYWORDS:** Hidden Markov Models, Vector Quantization, Speech Recognition, Seismo-acoustic Sonar, Mine Detection