

# MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

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## PERFORMANCE EVALUATION OF THE AN/USQ-146 JAMMER OVER UNCODED SLOW FH/MFSK MILITARY COMMUNICATION SYSTEMS AND THE IEEE 802.11A WIRELESS LAN COMMERCIAL COMMUNICATION STANDARD

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On the modern battlefield communication is critical. Individual units require a steady flow of accurate information between headquarters and field units to remain effective. Just as important, denying the enemy the same needs of communicating with the help of electronic countermeasures (ECM), is essential to success. Communications jamming and surveillance are critical to achieve information superiority. This thesis evaluates the performance and capabilities of one of the most advanced devices that detects, analyzes, and denies enemy signals: the Rockwell Colins AN/USQ-146 transportable communication jammer. The jammer's best strategy varies with respect to the modulation technique that the hostile communication system uses. As the theoretical analysis and the simulation results indicated, the AN/USQ-146 jammer achieves its best performance over a FH/MFSK system when it selects the repeat multitone jamming strategy. However, when the hostile communication system is the IEEE 802.11a wireless local area network (WLAN) system, the AN/USQ-146 (Rubicon II) jammer must select the partial-band jamming strategy with  $p = 0.1$ . The results of the theoretical analysis and the simulation modeling of the specific jammer for all types of jamming in manual spot and repeat modes over FH/MFSK military communication systems and new advanced wireless standards, such as the IEEE 802.11a, can be used as guidelines to select the most effective jamming strategy for the specific type of hostile waveform encountered.

**KEYWORDS:** Battlefield Communication, Electronic Countermeasures, AN/USQ-146 Transportable Communication Jammer, Jamming Strategy

## DESIGN, CONSTRUCTION, AND TESTING OF A HYSTERESIS CONTROLLED INVERTER FOR PARALLELING

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The U.S. Navy is pursuing an all electric ship that will require enormous amounts of power for applications such as electric propulsion. Reliability and redundancy in the electronics are imperative, since failure of a critical system could leave a ship stranded and vulnerable. A parallel inverter drive topology has been proposed to provide reliability and redundancy through load sharing. The parallel architecture enables some functionality in the event that one of the inverters fails. This thesis explores paralleling current-mode inverters of different power levels and fidelities. A 50 kVA, three-phase hysteresis controlled inverter is designed, built, and tested at low power. The inverter is then tested in parallel with a low frequency, bulk inverter to demonstrate current sharing capability.

**KEYWORDS:** Hysteresis Control, Inverter, Parallel Inverters, Load Sharing

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## LEAST SQUARES AND ADAPTIVE MULTIRATE FILTERING

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This thesis addresses the problem of estimating a random process from two observed signals sampled at different rates. The case where the low-rate observation has a higher signal-to-noise ratio than the high-rate observation is addressed. Both adaptive and non-adaptive filtering techniques are explored. For the non-adaptive case, a multirate version of the Wiener-Hopf optimal filter is used for estimation. Three forms of the filter are described. It is shown that using both observations with this filter achieves a lower mean-squared error than using either sequence alone. Furthermore, the amount of training data to solve for the filter weights is comparable to that needed when using either sequence alone. For the adaptive case, a multirate version of the LMS adaptive algorithm is developed. Both narrowband and broadband interference are removed using the algorithm in an adaptive noise cancellation scheme. The ability to remove interference at the high rate using observations taken at the low rate without the high-rate observations is demonstrated.

**KEYWORDS:** Multirate Filtering, Adaptive Filtering, Multirate Adaptive Filter, Multirate Optimal Filter, Least Squares Filtering

## RADIATION DOSE ANALYSIS OF NPS FLASH X-RAY FACILITY USING SILICON PIN DIODES

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Radiation output of the NPS Flash X-ray facility has been analyzed using commercial silicon PIN diodes. These results have been compared to dosimetry techniques using CaF<sub>2</sub> TLDs (thermoluminescent dosimeters). The silicon PIN diodes were irradiated up with photon energies of approximately 1 MeV and dose rates up to 1010 rad(Si)/s. These techniques and results can be used to provide real time calibration of the Flash X-ray facility.

**KEYWORDS:** Silicon Radiation Detectors, Flash X-ray, Dosimetry, Thermoluminescent Dosimeters

## PHYSICALLY BASED MODELING AND SIMULATION OF A SHIP IN OPEN WATER 3-D VIRTUAL ENVIRONMENT

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This thesis addresses the development of a physically based modeling simulator for a ship in a 3-D virtual environment to be used in naval tactical training systems. The objective is to develop a computer simulation program in which physical models are implemented in order to achieve a realistic representation of a ship in a virtual environment, considering its physical features in the presence of environment conditions including waves, ocean current, wind, fog, and day/night issues. The simulator was developed by integrating five marine models with a virtual ocean environment created with a visual simulation builder tool. The marine models include a maneuvering model, a wave model, a wind model, and an ocean current

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model. The numerical results from another complex wave model were also combined using linear interpolation to increase the realism level of the simulator. The result of this thesis shows that the integration of multiple models from different sources is a feasible approach to meet the application requirements. The result also indicates that the use of the interpolation technique to take advantage of complex models yields a simulator with an acceptable level of realism while imposing very low computational load in the application program.

**KEYWORDS:** Physically Based Modeling, 3-D Virtual Environment, Ship Maneuvering Simulator, Environment Disturbances

## **NETWORK-BASED CONTROL, MONITORING AND CALIBRATION OF SHIPBOARD SENSORS**

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The objective of this thesis is to develop a new calibration system for analog and smart digital pressure sensors, operable by only one person, and capable of calibrating local and remote sensors connected via RS232 cables, Bluetooth, or an 802.11b wireless LAN. It is proposed that the operator uses a portable calibration standard and a tablet PC to conduct the sensor calibration. In order to handle local sensors directly connected to the tablet PC and remote sensors connected to the tablet PC via a network capable application processor (NCAP), a dual module application is proposed and developed using LabVIEW. The application has a Master Module and a Slave Module. Both modules are able to connect to multiple digital sensors at the same time. The Master Module was designed to run on the operator's tablet PC offering an easy-to-use Graphical User Interface (GUI) that allows the monitoring or calibration of any connected sensors. The Slave Module was designed to run on any networked PC, including the operator's tablet and an NCAP. A dedicated Virtual Instrument (VI) was designed for an iterative calibration process based on a least squares fitting method. This VI automatically computes the calibration constants that minimize the measurements errors, and writes the calibration constants to the sensor's RAM or EEPROM. A prototype shipboard sensor test bed was constructed in the laboratory, which consists of a Honeywell PPT digital pressure sensor, an Omega analog pressure sensor, and other 802.11b and Bluetooth wireless LAN components. The newly developed calibration system was successfully demonstrated.

**KEYWORDS:** Network-based Calibration, Wireless LAN, Bluetooth, Datasocket, Labview, Smart Sensors, Pressure Sensors

## **DESIGN AND OPTIMIZATION OF A 600 KJ RAILGUN POWER SUPPLY**

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The purpose of this thesis is to explore the design options for a 1.2-m railgun power supply capable of accelerating a 150-g to 250-g projectile to 1000 m/s. In order to accomplish this task a MATLAB model will be constructed to conduct trade-off studies between various power supply configurations in an attempt to maximize the system performance. The final design shows that by distributing the system capacitance between four equal size banks and firing them sequentially, the total system capacitance can be reduced by more than half. Because the capacitor banks are fired sequentially, the current pulse is lengthened resulting in more efficient use of the barrel. The final benefit of using a multiple-bank system is that the individual bank currents are reduced by a factor of four over the single-bank scenario. By reducing the bank currents, solid-state switches are now an affordable option further improving the system performance. By applying a

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systematic approach to optimizing the power supply, this study has shown that the energy required to accelerate a 172-g projectile to 1000 m/s can be reduced from 1.3 MJ in the single-bank scenario to 600 KJ by distributing the capacitance over four equal sized banks.

**KEYWORDS:** Railgun, Solid-state Switches, Pulsed Power Supply, Electromagnetic Launch, Thyristors, Spark-gap Switches, Naval Railgun

## **COST BENEFIT ANALYSIS OF ADJUSTABLE SPEED DRIVES ABOARD ARLEIGH BURKE CLASS DESTROYER**

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As the U.S. Navy seeks new and innovative ways to maximize its return from a finite budget, an evaluation of its operational practices must be done. Electrical power consumption and fuel efficiency are major factors in the Total Operating Cost (TOC) of naval ships and systems. An evaluation of an alternative means for delivering electrical power to motors and pumps was conducted with the understanding that principles of the findings could be applied to fans as well. Adjustable Speed Drives (ASD) AC induction motors, AC synchronous motors, centrifugal pumps, and positive displacement pumps were examined. The technical challenges associated with ASDs were explored. MATLAB was used to calculate the potential power savings to be gained by introducing ASD technology to the Firemain and Chilled Water Systems. MATLAB was also used to calculate fuel cost savings from reduced consumption of Shipboard power.

**KEYWORDS:** Adjustable Speed Drive, Pulsewidth Modulation, Affinity Laws, AC Induction Motor, Insulated Gate Bipolar Transistor

## **SOFTWARE DEFINED RADIO DATALINK IMPLEMENTATION USING PC-TYPE COMPUTERS**

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The objective of this thesis was to examine the feasibility of implementation and the performance of a Software Defined Radio datalink, using a common PC type host computer and a high level programming language. Dedicated transceivers were used, plugged on the PCI bus of host PCs running Windows 2000. Most of the functionality was programmed using the Microsoft Visual C++ language. The tasks to be performed included the channels configuration (number of active channels, center frequencies, sampling and data rates, choice of the appropriate up and down conversion filters), the management of the data transfer between the host computer and the transceiver, the baseband data modulation and demodulation, and the data organization into packets with appropriate headers in order to achieve phase and time synchronization solely by software. A part of the transceivers' configuration was achieved using a configuration utility running in Excel, provided by the manufacturer. Several combinations of M-PSK modulation schemes, channel numbers and datarates were tested in order to measure the performance limits of the system and its ability to perform the required tasks in real-time. The received data streams were further analyzed with the use of Matlab in order to verify the proper functionality of the communication scheme.

**KEYWORDS:** Software Defined Radio, Communications, Datalink, WaveRunner