MASTER OF SCIENCE
IN
ELECTRICAL ENGINEERING

AN ELECTROMAGNETIC INTERFERENCE ANALYSIS OF UNINTERRUPTIBLE POWER SUPPLY SYSTEMS IN A DATA PROCESSING ENVIRONMENT

Edward W. Beran-DoD Civilian
B.S.E.E., University of Maryland, 1973
Master of Science in Electrical Engineering-December 2002
Advisor: Richard Adler, Department of Electrical and Computer Engineering
Second Reader: Wilbur R. Vincent, Department of Electrical and Computer Engineering
Donald P. Lyons, National Security Agency

In this thesis, the levels of Electromagnetic Interference (EMI) generated by two standard models of Uninterruptible Power Supplies (UPS) are examined. EMI reduction actions were undertaken on both units. A significant reduction in the level of EMI was achieved using inexpensive, commercially available filters that were properly installed. The principles of proper installation are described. The reduction of EMI to harmless levels at radio-receiving and data-processing sites equipped with UPS is shown to be feasible.

KEYWORDS: Conducted Electromagnetic Interference, Spectrum Analyzer, Analog Filter, Power Line Filters, Uninterruptible Power Supply, UPS

HIGH ENERGY LASERS FOR SHIP-DEFENSE AND MARITIME PROPAGATION

Vasileios Bouras-Lieutenant, Hellenic Navy
B.S., Hellenic Naval Academy, 1993
Master of Science in Applied Physics-December 2002
Master of Science in Electrical Engineering-December 2002
Advisor: William B. Colson, Department of Physics
Co-Advisor: Phillip E. Pace, Department of Electrical and Computer Engineering

High Energy Lasers (HELs) are a new class of weapons that may be of great value to the Navy in the near future. A high-power Free Electron Laser (FEL) is being designed using short Rayleigh-length resonators to increase the spot size at the mirrors and hence avoid mirror damage. Three-dimensional simulations are used to study the effects of an electron beam misalignment (electron beam tilt). This thesis shows that the proposed design is tolerant of typical electron beam misalignments. The performance of a step-tapered undulator is also studied for the 100 kW proposed upgrade of the Jefferson Laboratory FEL. The results of this research show that the gain is above the required threshold for the 100 kW design while the energy spread does not change significantly over any undulator design. The spectrum of the proposed FEL shows that most of the power is concentrated around the fundamental frequency. It is shown in this thesis that smooth FEL pulses can significantly reduce the negative effects of absorption and scattering. Recent HEL science and technology developments are discussed for both Free Electron and Solid-State Lasers.

KEYWORDS: Free Electron Laser, Solid-state Lasers, High Energy Lasers, Short Rayleigh Length, Step-taper Undulator, SSHCL, Laser Propagation

DESIGN OF A MICROSTRIP PATCH ANTENNA FOR THE NPSAT1

Mahmut Erel-Lieutenant Junior Grade, Turkish Navy
B.S., Turkish Naval Academy, 1996
Master of Science in Electrical Engineering-December 2002
Advisor: Jovan E. Lebaric, Department of Electrical and Computer Engineering
Second Reader: Richard Adler, Department of Electrical and Computer Engineering

This thesis presents the design of two circularly polarized patch antennas to operate at 1.767 GHz and at 2.207 GHz (for receiving and transmitting, respectively). Additional design requirements for the antennas of NPSat1 satellite include a SWR of less than or equal to 2:1 and 50Ω input impedance. The study will also include that the development of a three-dimensional antenna model that will be installed on the NPSat1. Also included is the simulation the application of RF energy into the antenna model and analysis of results, based on various outputs of the CST Microwave Studio Finite Difference Time Domain (FDTD) software package.

KEYWORDS: Microstrip Patch Antenna, NPSat1, Narrow-band, Low Power Satellite Antennas, Elliptical Patch, FDTD Electromagnetic Modeling, Patch Antenna Simulation

FREE ELECTRON AND SOLID STATE LASERS DEVELOPMENT FOR NAVAL DIRECTED ENERGY

Aristeidis Kalfoutzos-Lieutenant, Hellenic Navy
B.S., Hellenic Naval Academy, 1993
Master of Science in Applied Physics-December 2002
Master of Science in Electrical Engineering-December 2002
Advisor: William B. Colson, Department of Physics
Second Reader: Phillip E. Pace, Department of Electrical and Computer Engineering

A MW level FEL is being designed with a short a Rayleigh length resonator to increase the spot size at the mirrors and to avoid mirror damage. In this thesis, it is found that it is desirable to focus the electron beam to improve the FEL extraction efficiency. Three-dimensional simulations show that the focused electron beam increases the extraction efficiency far beyond the required value of 0.7%. It is also found in this thesis that shifting the electron beam off-axis less than 0.3 mm, the efficiency remains above the required value. The proposed FEL design uses high power, short optical pulses whose spectrum may cover many absorption lines. The absorbed laser energy can heat up the air resulting in defocusing the laser beam (thermal blooming). This thesis shows that thermal blooming is not an issue for a moderate clear atmosphere when the stagnation zone size remains less than 10 m. A transitional step for the development of a MW level FEL weapon is the proposed 100 kW upgrade of the Thomas Jefferson National Accelerator Facility's FEL. It has also been shown in this thesis that the use of a step-taper undulator slightly improves the performance of the FEL. Finally, the potential of various high average power solid-state laser designs are reviewed.

KEYWORDS: Free Electron Laser, Propagation of High Power Free Electron Laser Pulses, Thermal Blooming, Focused Electron and Optical Beams, Desynchronism, Step-taper Undulator, High Power Solid-state Laser

PERFORMANCE OF *IEEE 802.11A* WIRELESS LAN STANDARD OVER FREQUENCY-SELECTIVE, SLOWLY FADING NAKAGAMI CHANNELS IN A PULSED JAMMING ENVIRONMENT

Irfan Kosa-Lieutenant Junior Grade, Turkish Navy
B.S., Turkish Naval Academy, 1997
Master of Science in Electrical Engineering-December 2002
Advisor: R. Clark Robertson, Department of Electrical and Computer Engineering
Second Reader: Tri T. Ha, Department of Electrical and Computer Engineering

Wireless local area networks (WLAN) are increasingly important in meeting the needs of the next generation broadband wireless communication systems for both commercial and military applications. In 1999, the *IEEE 802.11a* working group approved a standard for a 5-GHz band WLAN that supports a variable bit rate from 6 to 54 Mbps, and orthogonal frequency-division multiplexing (OFDM) was chosen because of its well-known ability to avoid multipath effects while achieving high data rates by combining a high order sub-carrier modulation with a high rate convolutional code. This thesis investigates the performance of the OFDM based *IEEE.802.11a WLAN* standard in frequency-selective, slowly fading Nakagami channels in a pulsed-noise jamming environment. The benefit of such an analysis is to assess the performance of an existing OFDM standard and to gain some insight into how well these systems will perform in military applications when subjected to hostile jamming. Contrary to expectations, the signal-to-interference ratio (SIR) required to achieve a specific P_b does not monotonically decrease when the bit rate decreases. Furthermore, the results show that the performance is improved significantly by adding *convolutional coding* with *Viterbi decoding*, and thus highlights the importance of forward error correction (FEC) coding to the performance of wireless communications systems.

KEYWORDS: *IEEE 802.11a* Standard, WLAN, OFDM, BPSK, QPSK, QAM, Probability of Bit Error, Frequency-selective Fading, Fast Fading, Slow Fading, Nakagami Fading, Viterbi Algorithm, Convolutional Code, Hard Decision Decoding, Soft Decision Decoding, Coding Gain, Pulsed Jamming

FACE RECOGNITION USING INFRARED IMAGING

Diogo C. Pereira-First Lieutenant, Brazilian Air Force
B.S.E.E., Instituto Tecnologico de Aeronautica, Brazil, 1994
Electrical Engineer-December 2002
Master of Science in Electrical Engineering-December 2002
Thesis Supervisor: Monique P. Fargues, Department of Electrical and Computer Engineering
Thesis Co-Supervisor: Gamani Karunasiri, Department of Physics
Thesis Committee Member: Roberto Cristi, Department of Electrical and Computer Engineering

This study investigated an infrared (IR) face recognition system using an uncooled IR camera. A computer-based image collection set-up was designed and used to create a small database of 420 facial images, from 14 volunteers. Manual and automated facial image cropping routines were implemented. Two linear approaches for the dataset dimension reduction and classification were implemented and their resulting classification performances compared: PCA-based and LDA approaches. Results show that the best PCA-based average classification performance is equal to 92.22% while the LDA-based classification performance is equal to 99.40%. These results successfully show that an uncooled IR camera may be used to discriminate between individual subjects obtained from a small database collected under a very controlled environment.

KEYWORDS: Face Recognition, Classification, PCA, LDA, IR, Infrared, Eigenvectors

PERFORMANCE EVALUATION OF A COOPERATIVE DIVERSITY ENHANCED AD HOC NETWORK

Michael A. Tope-DoD Civilian
B.S.E.E., University of Akron, 1984
Master of Science in Electrical Engineering-December 2002
Advisor: John McEachen, Department of Electrical and Computer Engineering
Second Reader: R. Clark Robertson, Department of Electrical and Computer Engineering

Currently, wireless multi-hop ad hoc networks utilize protocols that relay packets of data node-by-node along a path connecting the source node to the sink node. This thesis describes a new methodology called "Cooperative Diversity" where information is relayed from the source to the sink via clusters of neighboring nodes. First, a routing protocol to establish spatially diversified paths through a field of randomly dispersed nodes is described. Second, an idealized configuration called the "Synthetic Waveguide" is introduced and its information theoretic channel capacity is developed. Third, an outage model based channel capacity for the synthetic waveguide operating with a low forwarding latency is derived. The low latency channel capacity is far different from that predicted by traditional channel capacity. Next, a simple modulation called stuttered simulcast is introduced and shown to approach the performance of an optimal distributed space-time code. Finally, a Monte Carlo simulation of the cooperative diversity routing protocol confirms its superior performance in regions of operational interest.

KEYWORDS: Wireless, Ad Hoc Network, Synthetic Waveguide, Cooperative Diversity, MIMO, Channel Capacity, Outage Model

NARROWBAND FILTERING EFFECTS ON FREQUENCY-HOPPED SIGNALS

Kevin A. Waters-DoD Civilian
B.S.E.E., Clemson University, 1996
Master of Science in Electrical Engineering-December 2002
Advisors: R. Clark Robertson, Department of Electrical and Computer Engineering
Kyle E. Kowalske, National Security Agency
Second Reader: Tri T. Ha, Department of Electrical and Computer Engineering

A low complexity solution to remove follower, narrowband tone jamming signals which are randomly dispersed within the bandwidth of a hop without causing non-linear phase distortions in a frequency-hopping (FH) system is explored. Forward and reverse processed narrow stopband, elliptical infinite impulse response (IIR) filters are designed and applied to known audio and digital data. Analysis focuses on narrowband filtering one hop of a FH signal in the absence of noise. The results are compared with the output of equivalent finite impulse response (FIR) filters and equivalent forward processed IIR filters. This analysis demonstrates the effectiveness of forward and reverse narrow bandstop IIR filtering to eliminate unwanted tone jamming signals while preserving the phase of the received FH signal. These results also suggest that a FH system with narrow bandstop filtering can operate reliably in the presence of a high power tone jamming signal.

KEYWORDS: Frequency-hopping, Narrowband Tone Jamming, FIR, IIR, Non-linear Phase Distortion