MASTER OF SCIENCE
IN
APPLIED PHYSICS

CONSTRUCTION AND TESTING OF COMPACT LOW-NOISE HYDROPHONES WITH EXTENDED FREQUENCY RESPONSE

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A simple low-noise hydrophone design with internal preamplifier is presented. This design is similar to published designs and is a variation of the design developed by former NPS student Miguel Alvarado [2003], except that several improvements are included. These improvements include a simplification of the structure and its modes of vibration, a large reduction in package diameter and the effect its acoustic diffraction has on the sensitivity and an extended upper frequency response of 42 kHz resulting from the simplified structure and reduced diameter. Furthermore, the modified geometry along with its orientation in the water should produce a very omni-directional response in the horizontal plane at the higher frequencies. Finally, a new feedback preamplifier design developed by Hofler and Alvarado is discovered to have some subtle but serious performance problems. These problems are resolved in this research and the resulting preamplifier performance is tested and documented herein.

KEYWORDS: Hydrophone, Sound Receiver, Transducer, Low Noise Preamplifier

DESIGN OF A BORE SIGHT CAMERA FOR THE LINEATE IMAGE NEAR ULTRAVIOLET SPECTROMETER (LINUS)

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The Lineate Image Near Ultraviolet Spectrometer (LINUS) is a spectral imager that works in the ultraviolet region of the spectrum. This thesis describes the latest of several steps in the development of this instrument. Due to the narrow field of view of the instrument, 2.5 x 0.5 degrees, an accurate pointing method is necessary; also, a scheme of quality evaluation of the post-processed spectral image is desirable. A way to achieve both goals is developed by designing and implementing the layout for two visual cameras, wide and narrow field of view, and a method to capture the images in order to perform the subsequent comparison with the processed spectral image. Since this is the first time the system is working in full-automated mode, a new wavelength calibration with the emission lines from a platinum hollow cathode lamp is performed and a new response curve for sulfur dioxide (SO_2) is taken. Finally, laboratory and outdoor field observations are conducted to test the system integration.

KEYWORDS: Sensors, Spectral Imaging, Spectrometer, Remote Sensing

A SELECTIVE AUTOMATIC REPEAT REQUEST PROTOCOL FOR UNDERSEA ACOUSTIC LINKS

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A recent improvement to the Seaweb underwater wireless network was the implementation of a Selective Automatic Repeat Request (SRQ) mechanism. SRQ is a protocol implemented in the Seaweb link layer as a measure for mitigating unreliability inherent in the telesonar physical layer. In January 2004, an experiment was performed in St. Andrew's Bay, Panama City, Florida. The goal was to transmit large data files through the network, in accordance with a Naval Special Warfare need for imagery file telemetry. For three point-to-point test geometries, SRQ was tested with a noisy and variable physical layer. Through the incorporation of SRQ, the unreliability was overcome. A link-budget model, calibrated with the sound channel data collected from the experiment, establishes the benefit of a "SRQ gain."

KEYWORDS: SRQ, Link-budget, Acoustic Communications, FORCEnet, Link Layer, Telemetry, ARQ, Telesonar, Seaweb

ADVANCED TECHNIQUES TO IMPROVE THE PERFORMANCE OF OFDM WIRELESS LAN

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Orthogonal frequency-division multiplexing (OFDM) systems have experienced increased attention in recent years and have found applications in a number of diverse areas, including telephone-line based Asymmetric Digital Subscriber Line (ADSL) links, digital audio and video broadcasting systems, and wireless local area networks (WLAN). OFDM is a powerful technique for high data-rate transmission over fading channels. However, to deploy OFDM in a WLAN environment, precise frequency synchronization must be maintained and complicated frequency offsets must be handled. In this thesis, various techniques to improve the data throughput of OFDM WLAN are investigated. A simulation tool is developed in MATLAB to evaluate the performance of the IEEE 802.11a physical layer. A rapid time and frequency synchronization algorithm using only the short training sequence of the IEEE 802.11a standard is proposed, thus reducing the training overhead by 50%. Particular attention is paid to channel coding, block interleaving, and antenna diversity. Computer simulation shows that drastic improvement in error rate performance is achievable when these techniques are deployed.

KEYWORDS: OFDM, WLAN, IEEE 802.11a, Exponential Channel Model, Packet Detection, Frame Synchronization, Frequency Synchronization, Carrier Offset, Phase Noise, Pilot Phase Tracking, Channel Estimation, Equalization, Scrambling, Convolutional Coding, Interleaving, Maximal Ratio Combining, Selection Diversity, Viterbi Algorithm, Soft Decision Decoding, Puncturing

DIRTY BOMBS: THE TECHNICAL ASPECTS OF RADIOLOGICAL DISPERSION DEVICES

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Considering the ever-rising threat of terrorist attack and disruption of the economy and of daily activity, the potential strength of a radiological dispersion device must be evaluated. A "dirty bomb" is a weapon in the terrorist arsenal that is highly effective in creating chaos, panic, and disruption. All of the immediate deaths caused by a "dirty bomb" are due to blast effects; however, the public association with radiation and nuclear devices is one of fear and hyperbole. The individuals and agencies that respond to this type of event will have the greatest impact on the general public. By looking at case studies and potential scenarios or exercises, the first responder can appreciate the nature of radiation as well as its impact on response. This paper provides first responders with basic information on nuclear physics and exposes relevant issues in responding to a radiological dispersion device. An understandable link between nuclear physics and radiation response does exist.

KEYWORDS: Dirty Bomb, Radiological Dispersion Device, First Responder, Radiation, Weapons of Mass Destruction

THE ELECTROMAGNETIC RAILGUN AND THE FREE ELECTRON LASER

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In this thesis, theory and simulations of the railgun and free electron laser (FEL) are presented, as well as a suggestion for extending the railgun lifecycle. The theory, design, and analysis of an electromagnetic railgun using a numerical model are discussed. The effects of varying electrical pulse formations, rail materials, and geometries are explored. The application of a metallurgical process to mitigate hypervelocity gouging in railgun rails is proposed. This concept, to delay the onset velocity of gouging by laser peening rails surfaces, may significantly increase the velocity at which projectiles acceptably traverse the barrel and extend the useful life of rails. If successful, this process would apply to any pair of materials in sliding contact at high relative velocity, including rocket sled tracks and light gas guns barrels. The status of proof-of-concept tests at Lawrence Livermore National Laboratory (LLNL), University of California, Davis (UC Davis), and University of Texas at Austin (UT) is covered. FEL simulations investigating the effect of electron beam focal point variations on the optical mode within the undulator are also presented.

KEYWORDS: Free Electron Laser, Short Rayleigh Length, Optical Mode, Railgun, Directed Energy, Simulation, Gouging, Hypervelocity Gouging