MASTER OF SCIENCE
IN
ENGINEERING ACOUSTICS

DESIGN OF A MINI THERMO-ACOUSTIC REFRIGERATOR

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A miniature thermoacoustic refrigerator is being developed for the purpose of cooling integrated circuits below their failure temperature when used in hot environments. The development of an electrically powered acoustic driver that powers the thermoacoustic refrigerator is described. The driver utilizes a flexural tri-laminar piezoelectric disk to generate one to two Watts of acoustic power at 4 kHz in 15 bar of He-Kr gas mixture. This thesis is the second of two driver development theses, which includes the information on the assembly of three drivers and their quantitative performance with a pressurized test resonator. A maximum acoustic power output of 0.5 Watt, was achieved with the third driver.

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: Thermo-acoustic Refrigerator, TAR, Thermo-acoustic Refrigerator Driver, Microchip Cooling

BANDWIDTH OPTIMIZATION OF UNDERWATER ACOUSTIC COMMUNICATIONS SYSTEMS

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Current underwater acoustic communication systems operate in the frequency band of 1-10 kHz and utilize various forms of signal processing to improve data rates. In this work, the influence of the environment on long-range propagation of acoustic signals was examined over the band of 1-5 kHz. Three methods of evaluation (transmission loss, temporal coherence, and spatial coherence) were employed.

Transmission loss (TL) has been studied for many years and was included as a fundamental measure. It can be shown that TL is related to the transmission power required for a specific signal to noise ratio required for reception. Temporal coherence relates the received pressure signals as a function of time for varying bottom roughness and source motion. Similarly, spatial coherence compares the received pressure signal as a function of frequency and of depth for varying bottom roughness and source motion. Both spatial and temporal coherence evaluate the degradation of the arrival structure.

Based on the relationships observed for transmission loss, temporal coherence, and spatial coherence, it appears that the optimization of the communications bandwidth is highly dependent on the characteristics of the environment. In this study, the dominant influence on signal level and coherence appeared to be the introduction of roughness on the bottom interface. Source motion relative to this roughness (i.e. displacement) appeared to cause significant signal degradation at higher frequencies. However, Doppler effects due to source motion did not seem to appreciably influence signal coherence. Furthermore, the

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influence of the bottom roughness was clearly affected by the presence, or lack of, a sound channel. Specifically, if a sound channel existed which limited the amount of bottom interactions, then the source motion (doppler or displacement) did not seem to significantly affect signal coherence. It is expected that similar conclusions would be obtained by introduction of a rough surface.

Given the conditions considered here, if the sound velocity profile generates significant bottom interactions, then the optimal frequency bandwidth appears to be the lowest possible, particularly at ranges beyond approximately 1 km. For weak bottom interacting profiles, higher frequencies that can increase data transfer rates would be optimal. The limitations of such higher frequencies would predominantly be in TL, but even this did not exhibit appreciable frequency dependence for ducted propagation.

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

KEYWORDS: Underwater Acoustic Communication, Bandwidth Optimization, Signal Coherence