Underwater Acoustic Modem

Technical Overview Document

# Background

Underwater communications has a wide range of application involving offshore explorations using ROVs, underwater sensor networks, fisherman information system, scuba diver assistance etc. The simplest way of establishing communication between two remote underwater users is through a tethered cable between the transmitter and the receiver. It is expensive to setup and restricted in use. Also, the repair and maintenance is difficult and it is practically impossible to connect users which are several kilometers apart especially in oceanic environments. The principle of underwater acoustic communication involves using sound waves to transmit signal wirelessly in the underwater channel. The underwater acoustic channel is said to be nature’s most unforgiving wireless communication medium and imposes several design challenges in terms of reliability and range. The underwater modem we propose to design targets a 2x (in our region of operation, 7-8Kbits/s) increase in the data rate and range for a given BER compared to the state of the art modems available today by implementing adaptive transmissions using spread spectrum based modulation and coding schemes suitable for the specific purpose.

# Technology in Market

The evaluation parameters such as the Bit Error Rate, data rate etc., very much depend on other application specific factors such as the depth of operation, range, direction of operation (vertical/horizontal/intermediate), frequency etc., Parameter ranges for current state of the art technologies in the market in our regions of interest (depth of 2000m and range of 8000m) are as given follows: BER of less than (frequency range of 7-17kHz with the horizontal mode of operation) and a data rate of 7-8 Kbits/s. There is always a tradeoff between the data rate and the range for the given power levels. For example, modems in market with an operating range of around 6000m, have a data rate of up-to 10Kbits/s. Modems available in the market have a wide range of specifications and parameters mentioned above and the choice of a modem really depends on the kind of application, operating ranges and cost. We aim to build a scheme which can be generalized for multiple applications. The modem aims to address wireless control of underwater ROVs which currently rely on tethered connection for operation. The modem is also intended for use by scuba divers to send emergency signals in case of distress situations. However, we aim to build a modem which can be generalized for multiple applications.

# Innovation

There are four aspects of the UWA channel that are of primary concern: ambient noise, transmission loss due to geometrical spreading and absorption, reverberation due to multipath, and Doppler spreading due to relative motion. Spread spectrum techniques are being considered for resolving these problems because spread spectrum signals resist multipath, de-correlate impulsive noise, resist jamming interference, and provide some immunity to frequency selective fading. The Chirp Slope Keying (CSK) modulation uses long frequency modulated pulses in which the frequency changes continuously in one direction without reversal for the duration of the pulse. Simulations results in underwater channels using conventional correlator based receiver suggests that the performance of CSK is better (2 dB SNR) compared to BPSK modulation schemes in terms of SNR required for a particular BER (10-3). We consider underwater acoustic transmissions of information symbols that are carried over M-ary (here, Quaternary) chirp waveforms. This would increase the number of bits transmitted per symbol and thereby increasing the data rate.

The proposed Chirp Slope Keying based modem would work in synergy with existing Janus based communication scheme. The function of the Janus would be to establish the link between the users wanting to communicate with each other. Reliable data rates achievable using Chirp Slope Keying is expected to be higher than Janus based modulation and coding schemes under favorable channel conditions. The modem is expected to be designed so as to switch between the Janus and Chirp Slope Keying schemes depending on the adversity of the channel in terms of the temperature, salinity, Doppler shift and multipath fading parameters. The modem will also be incorporated with latest developments in Error Correction Codes namely Turbo Codes and Fountain Codes for more reliable transmission of information.

# Features

* Data Rate- 2x increase in the data rate of currently available modems in the range of 5-10 km (10-15 kbits/s)
* Operating Range-5-10 km; Depth-2 km
* Robust performance (BER < ) via state-of-the-art error correction techniques (Turbo codes, Fountain codes)
* Adaptivity: Switching between 2 modes based on measuring and modelling channel conditions.

1. QCSK- favorable channel conditions and higher data rates
2. Janus (BFSK based)- adverse channel conditions and low data rates

* Unique attempt to combine channel awareness and adaptivity to optimize UWA performance.

# References

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