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Enabling Spatial Assortment and Optical Magnification in Underwater Optical Wireless Communication

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Abstract: This study investigates the performance of Underwater Optical Wireless Communication systems (UOWC) employing optical preamplification as well as multiple receivers to exploit the advantages of spatial diversity. Numerical results are further provided to evaluate the error performance of pre-amplified Single-Input-Multiple-Output (SIMO) UOWC systems when On-Off Keying (OOK) modulation is utilized. Simulation results reveal that the proposed system configuration can indeed offer significant system performance enhancements regarding the available bit error rate.

Key words: Underwater optical wireless communications, spatial diversity, single input multiple outputs, available, enhancements, investigates

INTRODUCTION

Underwater wireless information transfer is of great interest to the military, industry and the scientific community as it plays a major role in tactical surveillance, pollution monitoring, oil control and maintenance, offshore explorations, climate change monitoring and oceanography research. To facilitate all these activities, there is an increase in the number of unmanned vehicles or devices deployed underwater which require high bandwidth and high capacity for information transfer underwater. Although, tremendous progress has been made in the field of acoustic communication underwater, however, it is limited by bandwidth.

All this has led to the proliferation of Underwater Optical Wireless Communication (UOWC) as it provides higher data rates than the traditional acoustic communication systems with significantly lower power consumption and simpler computational complexities for short-range wireless links. UOWC has many potential applications ranging from deep oceans to coastal waters. However, the biggest challenge for underwater wireless communication originates from the fundamental characteristics of an ocean or sea water, addressing these challenges requires a thorough understanding of complex physiochemical biological systems.

Literature review: The mitigation technique involves the utilization of a Semiconductor Optical Amplifier (SOA) that depending on the link arrangement, acts either as regenerator or pre-amplifier. The unbalanced SOA operation serves towards the equalization of the signal power at its output and fades become less severe and of reduced duration (Sagias *et al*., 2015). The impact of fading was investigated on both the signal optical power and the amplified spontaneous emission and derives logical relations that accurately associate the system bit-error-rate with the channel state (Yiannopoulos *et al*., 2015).

The Bit Error Rate (BER) performance of FSO links with spatial diversity over log-normal atmospheric turbulence fading channels assuming both independent and correlated channels among transmitter/receiver apertures. The derived BER expressions quantify the effect of spatial diversity and possible spatial correlations in a log-normal canal (Navidpour *et al*., 2007). The relationship among channel capacity, Signal-to-Noise Ratio (SNR), water types, wind speed and characteristics of transmitter/receiver array such as inter-spacing and link range for downlink Underwater Wireless Optical Communications (UWOC) Multiple-Input-Multiple-Output (MIMO) systems are described (Zhang *et al*., 2015).

Repetition Coding (RC), Spatial Multiplexing (SMP) and Spatial Modulation (SM) are the MIMO algorithms considered. Mainly, a framework was developed to analytically approximate the Bit Error Ratios (BERs) of these schemes and verify the theoretical bounds by simulations (Fath and Haas, 2013). In a multi-hop system, the noise power of each hop contributes to the total noise. The resulting sound of the system is therefore, the statistical sum of the individual noise distributions (Fenton, 1960).

Particular attention is paid to the case in which the input pulse width is comparable to the carrier lifetime, so that, the full gain has time to recover partially before the trailing edge of the pulse arrives (Agrawal and Olsson, 1989). The FSO Multiple-Input-Multiple-Output (MIMO) channel with Q-are Pulse Position Modulation (QPPM) transmit repetition under the assumption of non-ideal photodetection is analyzed regarding its uncoded Bit Error Rate (BER) and ergodic channel capacity (Letzepis *et al*., 2008).

This study also described in Bee inspired agent based routing protocol-primary user (Palanisamy and Mathivanan, 2017). Design and performance analysis of the MIMO-OFDM system using different antenna configurations (Agarwal and Mehta, 2016). Investigation of the optical and electrical properties of Tin Sulfide thin films (Geetha *et al*., 2015).

MATERIALS AND METHODS

The system under consideration employs On-Off Keying (OOK) modulation along with Equal Gain Combining (EGC) at the receiver. Its performance has been evaluated regarding the attainable error-rate for various system parameters and marine propagation environments. Numerically applications have demonstrated that the system above configuration does have a significant impact on the system performance even in this challenging propagation environment.

RESULTS AND DISCUSSION

An optical amplifier is a device that amplifies an optical signal directly without the need to first convert it to an electrical signal. An optical amplifier may be thought of like a laser without an optical cavity or one in which feedback from the cavity is suppressed. Multiple scattering causes the temporal spread of beam pulse characterized by the channel impulse response, h n(t) which results in Inter-Symbol Interference (ISI) and degrades the available Bit Error Rate (BER) performance. Here after it is assumed that the different time channel is modeled as a Finite Impulse Response (FIR) filter with one memory element.

CONCLUSION

The utilization of both spatial diversity and optical pre-amplification are first considered as a means to improve the performance and increase the range of UOWC links. For the proposed system setup, analytical expressions have been derived and its performance has been evaluated for various parameters regarding the propagation environment, the number of receiving apertures and the optical amplifier characteristics. The presented analysis is useful to the system design engineer for performance evaluation of state-of-the-art and future UOWC systems.

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