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A Space-frequency Power Allocation Algorithm for MIMO OWC over Low-Pass Channels

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In the last two decades, an unprecedented spread of communication systems has been witnessed. While at the beginning these systems were only able to support a small number of devices with limited data services, they have now matured to high speed networks that are densely populated. Society is increasingly connected, with different types of applications running on, by now Billions of devices, and this trend drives the use of communication systems. The growth is so fast that the Radio Frequency (RF) spectrum is already overcrowded. In future, it is expected that many applications will require speeds far beyond a Gbit/s. In order to achieve this capacity and, at the same time, to off load the pressure on RF system, higher spectral bands and optical frequencies are currently being explored.

Exploring higher frequencies in the electromagnetic spectrum, optical wireless communication (OWC) systems have recently gained great interest [1,2]. Due its many advantages, such as low cost, high energy efficiency, and minimal heat generation, LEDs are commonly used for illumination and are strong candidates to drive data transmission in OWC systems [2-4]. However, the modulation bandwidth of this source is limited and there is still the need to increase data throughput [4,5]. An alternative is to deploy multiple LEDs in a Multiple Input Multiple Output (MIMO) scheme [2-6]. MIMO is a well-known technology which explores the additional spatial dimension in order to provide a degree-of-freedom gain. By transmitting multiple data-streams over the light channel in a Spatial Multiplexing (SM) scheme from multiple spatially separated locations, Distributed-MIMO technology offers higher data throughput without the need of additional power or bandwidth. An important additional advantage of MIMO in OWC systems is that communication still works even when one line-of-sight link is blocked. In further boosting the bits rate, the low-pass frequency response of the LEDs poses further limitations. The low-pass behaviour of this source was pointed out in [6-8], but its impact on the performance of LED-based MIMO OWC systems still not fully addressed.

To compensate the low-pass effect, Orthogonal Frequency Division Multiplexing (OFDM) is often used. OFDM is a robust and effective technology commonly used in RF systems to suppress inter-symbol interference (ISI) and to convert a frequency-selective fading channel into multiple parallel flat-fading, i.e., non-dispersive channels. In an OFDM scheme the spectrum bandwidth is divided into a set of orthogonal subcarriers in order to support high data rates through parallel transmission. By using OFDM, power loading strategies can be used to appropriately distribute power over the subcarriers in order to reduce the performance degradation caused by the low-pass effect of the LEDs [9].

Different power loading strategies are proposed to allocate power resources in the frequency domain, mainly the uniform loading and the optimized waterfilling loading [6-8]. In this paper, we consider the transmission mode of an indoor LED-based MIMO OWC system with SM and OFDM. We present an analytical model for the channel and we investigate the achievable rate of the system considering the exponential low-pass frequency channel responses [6-8]. Based on an indoor LED-based MIMO OWC setup, we investigate through analytical and simulation results the system performance for different power loading strategies. Through simulation results, we point out that the simplified waterfilling loading which consider only the frequency domain is worse than the uniform loading. This is explained by the fact that, as the simplified waterfilling loading is not aware of the spatial domain, it allocates power on bad transmission channels that should be better used on good channels in the spatial domain. Subsequently, we propose a new algorithm considering the spatial and frequency domains to load power over the MIMO channels and OFDM subcarriers. As we can see from Figure 1, the achievable rate can be significantly improved by applying the proposed space-frequency power allocation algorithm compared to the uniform loading.

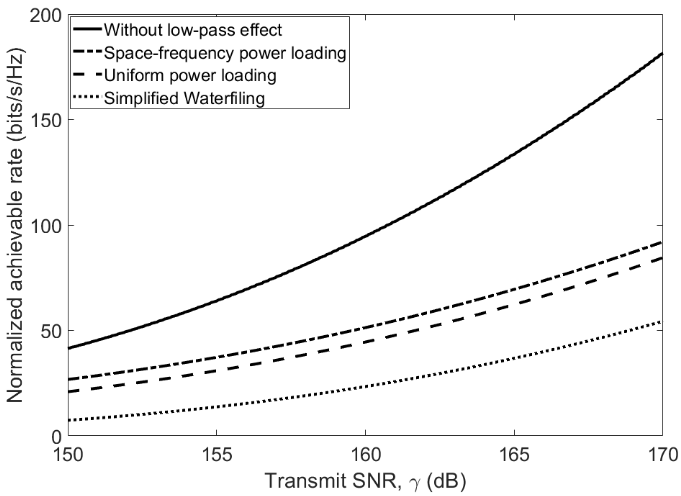

Figure 1 Normalized achievable rate to the corresponding link budget of a 4×4 OFDM-based MIMO OWC system over the exponential low-pass channels.

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