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WDM over POF for D-MIMO LiFi system

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Optical Wireless Communication (OWC) is an important alternative option that could ease the pressure on the radio spectrum that is now in use for communication. There are several OWC technologies that offer a promising solution for indoor wireless broadband communication over a distance up to a few meters. Potentially, OWC is suitable for very high bandwidth communication over these distances. OWC can exploit an enormous amount of yet unregulated spectrum and can reuse this huge spectrum densely by spatial multiplexing, because the signal range is limited and in most cases confined to a room. One of the most promising OWC solutions is (Visible) Light Communication (VLC/LC). VLC typically builds on the existing Light-Emitting Diode (LED) ambient illumination system and reuses the LEDs for data modulation with the target bit rate of 1 Gbit/s. The first generation of LC products are already on the market, generally referred to with the term LiFi. To bring the broadband data to LiFi access points, we can use the existing inbuilding cable infrastructure such as Ethernet, powerline, coax and twisted pair. While Ethernet follows the IEEE standard 802.3, the other three media can be used via the ITU-T standard G.hn which defines a common MAC layer and a reconfigurable PHY with different propagation properties. This paper, as a result of the EU H2020 project ELIoT [1], will focus on the use of 1 mm core size Plastic Optical Fibre (POF) for interconnecting LiFi Access Points (APs) because of its immunity to electromagnetic interference and low-cost deployment. In addition, a Distributed Multiple-Input and Multiple Output (D-MIMO) concept for indoor communication is increasingly important not just to increase the total network throughput and reliability but also to provide a consistent link performance for high mobility and high user densities. Using POF, this D-MIMO concept can relatively easily be accommodated by using either multiple fibres with spatial division multiplexing [2] or by a single fibre with multiple colours or wavelength division multiplexing [3]. Here, we elaborate more on the feasibility of WDM over POF for the analogue fronthaul of LiFi. Figure 1 shows the schematic of a simple 2x2 MIMO where each MIMO channel is realized by a colour of POF transmitter feeding an Optical Front-End (OFE). Multiple such OFEs offer D-MIMO LC.

The WDM transmission system requires a multiplexer (MUX), to combine the different optical MIMO streams onto one fibre, and a demultiplexer (DMX), to separate these and to feed the POF OFEs. As the performance of the MUX/ DMX directly impacts the throughput of the overall system, different strategies are considered, taking aspects into account such as costs and performance. There are several off-the-shelf approaches for the MUX/DMX. The challenge of implementing the WDM over POF is to develop a compact, functional and high-performance MUX/DMX. Specifically, we implemented a in dichroic filter 45-degree incidence [3,4]. This approach was chosen for its low losses and its scalability. Moreover, each component of the system plays an important role and their characteristics directly affect the transmission rates of the overall system.

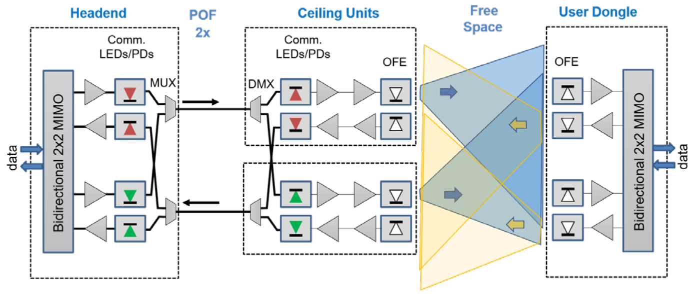

Fig. 1. General representation of the 2x2 WDM over POF feed D-MIMO system.

An important issue that arises from the use of multiple optical carriers is the optical crosstalk from the spectral overlapping between adjacent channels either in the optical fronthaul due to insufficient side-channel rejection or in the free space due to overlapping coverage areas. Crosstalk between colours in POF will lead to performance degradation, hence should be minimised by crosstalk cancelation. Light comes from different LiFi APs for MIMO application can be useful for increasing either Signal-to-Noise Ratio (SNR), when the same data stream is sent to LiFi APs or throughput, when parallel data streams are sent to LiFi APs. With intelligently designed MIMO receivers, possible crosstalk, interference or imperfections on the channel can be efficiently mitigated. Here, MIMO is deployed end-to-end in order to improve outage-reliability and throughput and to efficiently suppress crosstalk. MIMO also brings the possibility to relax the specs of the system components, including in the POF link, as some degree of crosstalk power can be tolerated without major deterioration of the achievable throughput [6]. In addition, in the free-space link, MIMO makes the LiFi system robust to blockage/shadowing.

This manuscript presents a LiFi system with 2x2 distributed MIMO. Plastic optical fibre (POF), multiplexer and demultiplexer are used to realize wavelength division multiplex (WDM) and make it feasible to implement D-MIMO in the LiFi system, to obtain high data rates, high Quality of Service(QoS), high reliability, high mobility and high user densities.

References

[1] V. Jugnickel et al., "Enhance Lighting for the Internet of Things," *2019 Global LIFI Congress (GLC)*, Paris, France, 2019, pp. 1-6, doi: 10.1109/GLC.2019.8864126.

[2] S. M. Kouhini, E. A. Jarchlo, R. Ferreira, S. Khademi, M. G., B. Siessegger, D. Schulz, J. Hilt, P. Hellwig and V. Jungnickel, "Use of Plastic Optical Fibers for Distributed MIMO in Li-Fi Systems," *in 2019 Global LiFi Congress (GLC)*, Paris, 2019.

[3] C. R. Correa, F. Huijskens, E. Tangdiongga and A. Koonen, "POF feeding in Li-Fi Systems with MIMO approach," *in 24th annual IEEE Pothonics BENELUX Symposium*, Amsterdam, 2019.

[4] M. Jončić, R. Kruglov, M. Haupt, R. Caspary, J. Vinogradov and U. H. P. Fischer, "Four-Channel WDM Transmission Over 50-m SI-POF at 14.77 Gb/s Using DMT Modulation", *in IEEE Photonics Technology Letters*, vol. 26, no. 13, pp. 1328-1331, 2014.

[5] A. Nuwanpriya, S. Ho and C. S. Chen, "Indoor MIMO Visible Light Communications: Novel Angle Diversity Receivers for Mobile Users," *IEEE Journal on Selected Areas in Communications*, vol. 33, no. 9, pp. 1780-1792, 2015.

[6] T. E. Bitencourt Cunha, J. M. G. Linnartz and X. Deng, "Throughput of Optical WDM with Wide LED Spectra and Imperfect Color-detecting Filters," *2020 29th Wireless and Optical Communications Conference (WOCC)*, Newark, NJ, USA, 2020, pp. 1-6.