Simulation of Multi-Band OFDM UWB Radio Over Multimode Fibre Using Pre-distortion Technique

H. Yang, Y.Zheng, H.-D. Jung, E. Tangdiongga and A.M.J. Koonen

Eindhoven University of Technology, PT11.27, PO Box 513, Eindhoven, MB NL 5600, The Netherlands

We propose a multi-band orthogonal frequency division multiplexing (MB-OFDM) ultra-wide-band (UWB) radio over multi-mode fibre (MMF) transmission system, employing the pre-distortion technique. Firstly we characterize the transfer function of the multi-mode fibre, then the distorted MB-OFDM UWB signal is calculated in such a way that the spectrum of the signal fits well with the band-pass characteristics of the MMF. By doing so, the sidebands of the MMF frequency response are utilized to transmit the signal, leading to a largely improved data capacity in the radio-over-fibre systems, compared to the systems without such pre-distortion techniques.

Introduction

The converged radio-over-fibre (RoF) technique is becoming very attractive nowadays since most of the radio processing which was previously in the antenna site is moved to the central station when using RoF, resulting in a simplified and compact radio access unit (RAU) in the access network. This cost-effective method combines the advantages of the very large capacity of fibre and the wireless access flexibility, and brings a potentially low-cost solution to future wireless access networks [1]. For the wireless personal area networks (PANs) and in-building communication networks, ultra-wide band (UWB) technologies are very competent technology to provide end users with high performance and large bandwidth connections within the short range. UWB employing multi-band orthogonal frequency division multiplexing (MB-OFDM) is particularly interesting for such wireless services due to its ability to minimize fading effects on the wireless signals at potentially low-cost infrastructures [2]. UWB-over-fibre is an effective technology to increase the coverage of UWB signals by connecting the antenna's by fibres. This is especially beneficial when deployed in multi-mode fibres (MMFs), which are easily installed in in-building access networks.

However, the modal dispersion in the MMF leads to a very limited bandwidth in the frequency response. Therefore, the existing RoF transmission technology either makes use of the baseband of the transfer function of the MMF or only excite fundamental mode to avoid such small bandwidth of MMFs. The wide bandwidth of the MB-OFDM UWB signal (which is around 1 GHz) would make the transmission over MMF especially challenging. In this paper, we propose a pre-distortion scheme to overcome the impairments introduced by the MMF. As preliminary results we show the simulation of an OFDM band of the UWB signal over MMF. According to the choice of frequency band, we present the calculated constellation diagram and error vector magnitude of the received signal.

Theory of Pre-distortion

Figure 1 shows the general schematic illustrations of the systems for transmiting MB-OFDM UWB signal over MMF without and with pre-distortion. In Fig. 1(a), the MB-OFDM signal $s(t)$ is generated according to EMCA-368 standard [2], in the frequency domain, the three sub-bands are allocated at 3.432, 3.960 and 4.488 GHz, respectively. The total bandwidth of the UWB signal is 1.584 GHz. The transfer function of the MMF is presented by $H(\omega)$, which is exported from VPI MMF model [3]. It is seen in Fig 1(a) that the spectral of the signal is corresponding to one of the tranmission null point of the MMF transfer function, therefore the signal is largely degraded by the MMF. By using the pre-distortion method, the intial signal $s(t)$ is pre-distorted to $g(t)$, which is calcalated in such a way that its spectral $G(\omega)$ has three discrete sub-band. The three sub-band fit into the three slope of the MMF transfer function, as illustrated in Fig. 1(b). At the output the fibre, a reversed calcaluation is needed to post-compensate the mathmetical operation from $s(t)$ to $g(t)$, in order to decode the intial information.

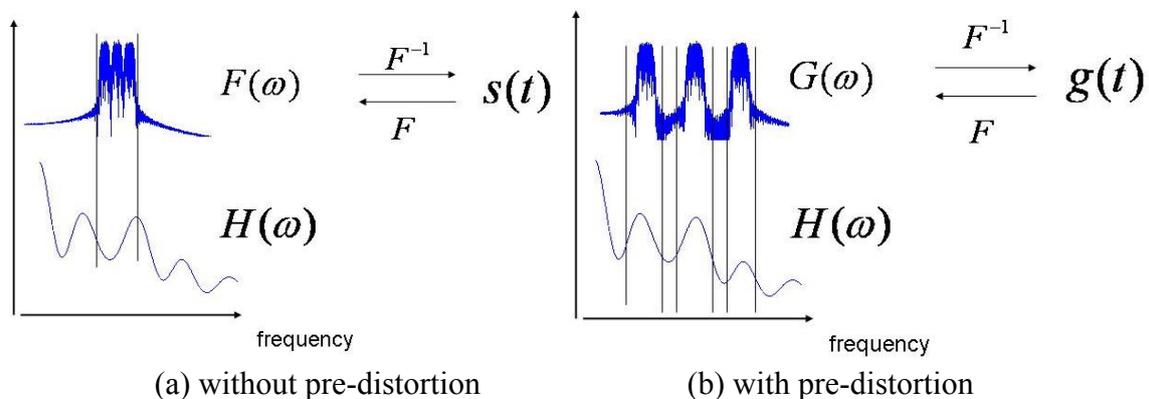(a) without pre-distortion   (b) with pre-distortion

Figure 1. Schematic illustration of the system (a) without pre-distortion and (b) with pre-distortion.

Preliminary Simulation Results of OFDM-over-MMF

To implement a simulation model for the proposed pre-distortion system, we start to investigate the influence of the MMF on the OFDM signal for certain carrier frequency. Figure 2 presents the calculated 16-QAM OFDM signal (with 256 sub-carriers) at central frequency of 1 GHz and of 300 MHz bandwidth. Figure 3 shows the attenuation of the MMF up to 6 GHz. This is characterized over 500 m graded index (GI) MMF for 6 μm offset launch condition. In figure 4, we also present the constellation diagram after
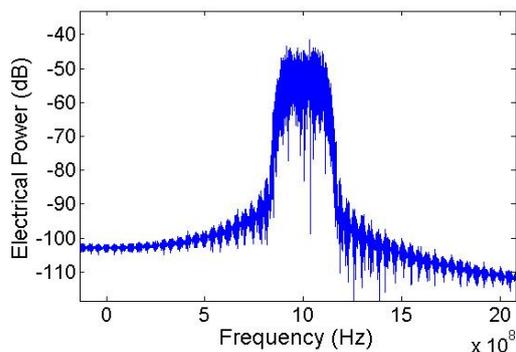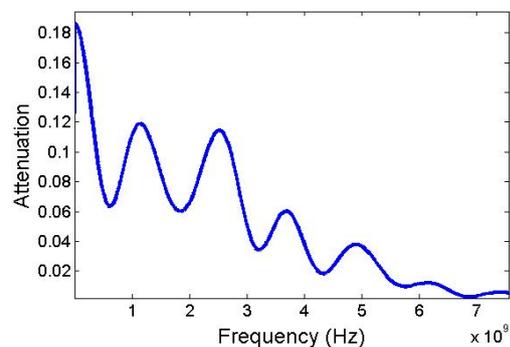

Figure 2. OFDM spectrum   Figure 3. Transfer function of MMF

transmission of 500 m MMF. The OFDM signal is centered at 1.2 GHz. From Fig. 3 we can see that 1.2 GHz is approximately the central frequency of the first slope of the MMF transfer function.
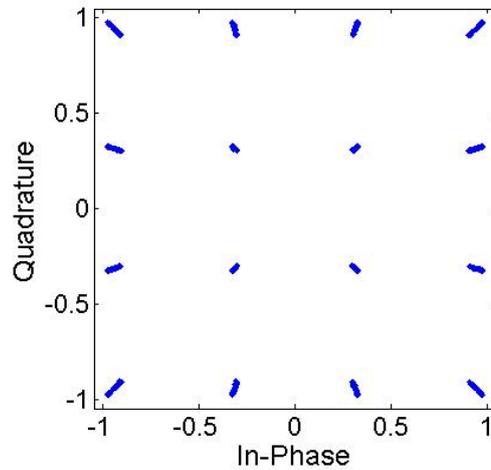

Figure 4. Demodulated OFDM data, after 500 m MMF

In figure 4, we can observe that all the degradation of the signal come from the amplitude error in the constellation, which is caused by the fact that we only simulate the attenuation feature of the MMF, instead of phase shift of MMF. Finally, we change the central frequency of the OFDM signal and study the influence of the matching between the transfer function of the MMF and the signal spectrum. Two sets of OFDM bandwidth are used, which are 300 and 600 MHz respectively. By comparing Fig. 4 and Fig. 3, we can conclude that the better system performance can be achieved when the OFDM carrier frequency is chose as the central frequency of the MMF slope in the
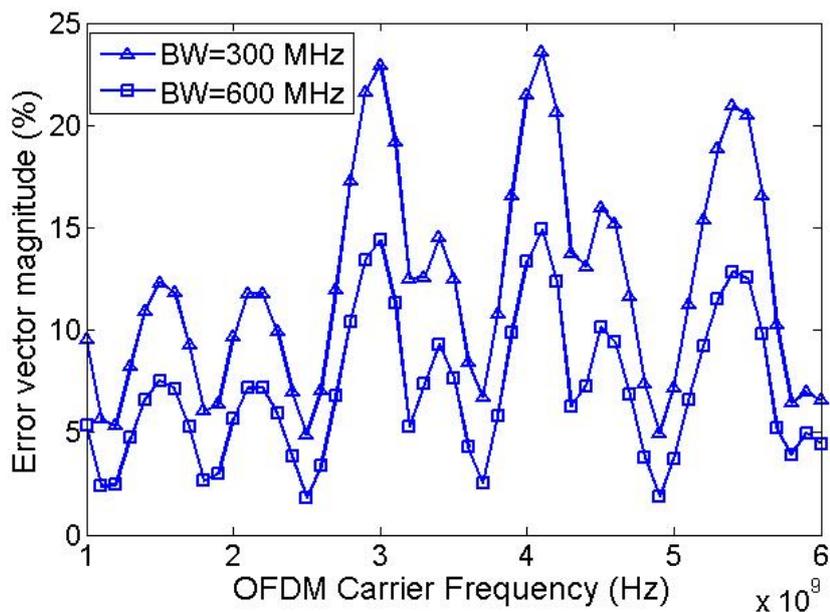

Figure 4. EVM as a function of data carrier frequency

transfer function. The reason is that, at those frequencies, the spectral of the OFDM data

fit into the MMF transfer function, leading to a much better performance compared to the other choice of data frequency. This result gives us the clue to predict the results of the future work.

Conclusion and Future Work

We have proposed a method to improve the system performance by pre-distorting the electrical data signal before launching into MMF of the RoF links. By preliminary results, we have shown that carefully choosing the central frequency of the OFDM signal has a critical impact on the system performance. At every null point of the MMF transfer function, which matches the central frequency of the OFDM signal, we have the less degradation of the signal. Future work will be focused on how to split the three sub-bands of the MB-OFDM UWB signal into three individual bands and how to demodulate the signal at the receiver end. We believe the most challenge task lies in the demodulator part. However, all the difficult calculations are in the software level, and by using an arbitrary waveform generator (AWG) and digital sampling osoliscope (DSO) we can easily realize the off-line data processing and benefit from the pre-distortion transmission system.

Acknowledgement

Reference

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