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Converged Service Transport over 1 mm Core GI-POF for In-Home Networks

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Abstract: Currently the plethora of delivery infrastructure to convey current/emerging wired and wireless services complicates the in-home consumer experience. Large core plastic optical fibers have the potential to minimize installation and maintenance costs whilst conveying the variety of signals envisaged for in-home networks. A proof of concept experiment to demonstrate the delivery of 2.2 Gbit/s DMT and a 528-MHz 200 Mbit/s UWB to represent wired and wireless signals respectively is presented.

1. Introduction

Currently, a plethora of delivery methods exist for conveying different services, e.g., coaxial cable for video broadcast, twisted pair cable for wired telephony, and wireless LAN for Internet. Such multiple network infrastructures lead to a complicated infrastructure and high servicing costs. A single common backbone infrastructure is required to provide a simplified and easily upgradable in-home network. Whilst single-mode fiber has been considered as a future-proof transmission medium for optical networks, the associated hardware, installation and maintenance costs are prohibitive for mass deployment. Hence, for cost-sensitive in-home networks other solutions should be considered. Plastic optical fiber (POF) is potentially a cost-effective solution, especially when sharing the existing electrical ducts with electrical power line cables [2]. Specifically, \varnothing 1 mm core poly-methyl-metacrylate (PMMA) POF is becoming increasingly important, due to the high potential for “do-it-yourself” installation, easy maintenance and tolerance to bending. A comprehensive study on large-core POF systems has been carried out to achieve multi-gigabit transmission [3], and to transport broadband wireless signals [4]. The successful transmission of a broadband baseband DMT signal at a data rate of 2.2 Gbit/s and a radio frequency signal

comprising of WiMedia-compliant multi-band (MB) OFDM UWB radio signal at 200 Mbit/s over a 50 meters link of $\varnothing 1\text{mm}$ core PMMA graded-index (GI) POF is demonstrated

2. Experimental setup and results

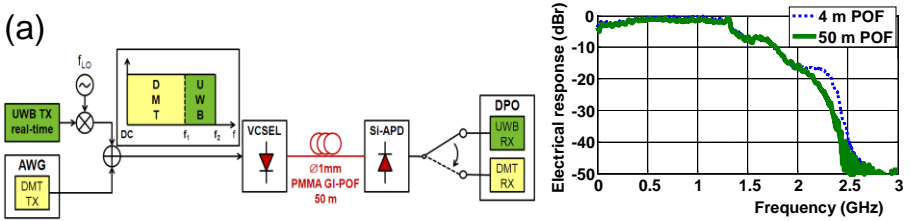


Fig 1: (a): Experimental setup (b): Spectrum after 4 m and 50 m POF

The experimental setup is depicted in Fig. 1a. We split the available bandwidth into two separate spectra; for DMT (~ 0 to 0.8 GHz) and UWB (0.8 to 1.4 GHz) signals. A WiMedia-compliant UWB transmitter generates a real-time MB-OFDM signal centered at 3.96 GHz (TFC6: 3.696 - 4.224 GHz). The proposed system is based on a simple intensity-modulated direct-detection (IM-DD) optical link. The main bandwidth limitation of the system attributed to the POF link bandwidth and the optoelectronic receiver has a 3 dB level bandwidth of only 1.4 GHz. In order to fit within the limited low-pass bandwidth of the POF, down-conversion of the UWB signal from the RF to an intermediate frequency band (0.836 - 1.364 GHz) is required. To demonstrate the potential of real implementation, a low sampling speed of 1.6 GSamples/s is used at the arbitrary waveform generator (AWG) to generate the DMT signal. A bit and power-loading algorithm is used to adjust the signal constellation format per subcarrier.

The electrically combined signal is used to directly modulate a VCSEL at 667 nm with optical emitted power of 0 dBm. The VCSEL is followed by $\varnothing 1\text{mm}$ core PMMA GI-POF of 50 m and a photo-receiver based on a $\varnothing 230\ \mu\text{m}$ Si-APD, followed by a 2-stage electrical amplifier with a gain of 40 dB. The detected signal is fed to a digital phosphor oscilloscope (DPO) in

order to capture a time-window of the received signal for off-line performance evaluation. The maximum data rate at a bit-error-rate (BER) below 10^{-3} for DMT and error vector magnitude (EVM) for UWB is measured.

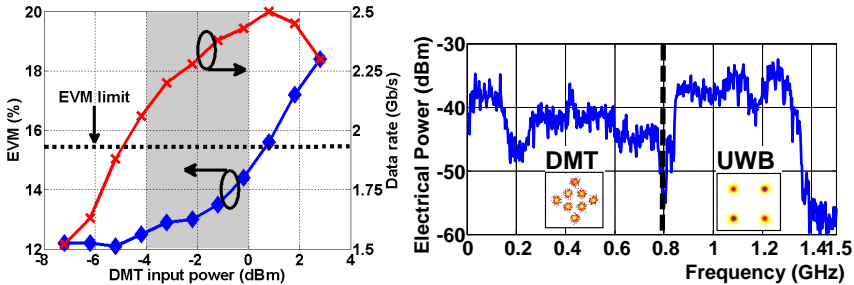


Fig. 2: (a) performance of the two signals

(b) received constellation for the subcarriers of the DMT signal with 3 bits

Fig. 2(a) shows the performance of the two signals with UWB power fixed to -1 dBm while for the DMT power several values are considered. For DMT power below 0.8 dBm, the UWB EVM performance complies with the standard EVM limit of 15.5%. The recommended operating region is where the difference between the two curves is the largest, i.e. between -4 and 0 dBm. With DMT power fixed to -3.2 dBm, In particular, we set the DMT and UWB signal power to -3.2 and -1 dBm, respectively, to achieve 2.2 Gbit/s DMT transmission with the UWB EVM below 13%. In Fig. 2b, the received constellation for the subcarriers of the DMT signal with 3 bits allocated is shown. In addition, the QPSK constellation of the demodulated UWB signal is shown. Both constellation plots indicate the excellent quality of the received signals.

Conclusion

We have experimentally demonstrated for the first time a combined transmission of wired and wireless signals over $\varnothing 1$ mm core 50 m PMMA GI-POF. Two broadband signals are simultaneously transmitted: 2.2 Gbit/s DMT signal with BER $< 10^{-3}$, and a 528-MHz WiMedia-compliant UWB signal with EVM $< 13\%$.

This work validates the use of $\varnothing 1$ mm POF links as a common infrastructure for in-home networks capable of transmitting wired and wireless in-home services. In addition, implementation costs are minimized by employing simple transceivers, IM-DD optical systems, and advance modulation formats.

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