16Gbit/ s Radio OFDM Signals over Graded-Index Plastic Optical Fiber

Jianjun Yu[1], Dayou Qian[1], Mingfang Huang[1, 2], Zhensheng Jia[2], Gee Kung Chang[2], and Ting Wang[1]
1) NEC Laboratories America, Princeton, NJ 08540, USA , jianjun@nec-labs.com
2) School of Electrical & Computer Engineering, Georgia Institute of Technology, GA 30332, USA

Abstract

A broadband access system with a record bandwidth of 16Gbit/s radio OFDM signals transmission over 50m GI-POF at 1310nm has been designed and experimentally demonstrated for the first time.

Introduction

The demand of bandwidth for Internet traffic and high-quality communication services in next generation optical access network is rapidly increasing. It is believed that orthogonal frequency-division multiplexing (OFDM) technology has become one of the most promising techniques in various broadband communication systems because of its high spectral efficiency and the resistance to various dispersion effect including chromatic dispersion (CD) and polarization-mode-dispersion (PMD) [1-4]. Using 120GHz carrier, people have realized 10Gbit/s wireless regular non-return-to-zero (NRZ) data transmission [5, 6]. Recently, researchers have demonstrated up-conversion of 3Gbit/s regular NRZ signals on 240GHz optical carrier and transmitted the signals over 1km of single mode fiber (SMF). Nevertheless, glass optical fiber (GOF) suffers from high connectionzation cost compared to copper or wireless solution. It is difficult to lay down single mode GOF for very-short-reach (VSR) optical networks such as in-building LAN. Recently, graded index plastic optical fiber (GI-POF) has emerged as a useful medium for access network and datacenter connections. The GI-POF has large core diameter (~ 500μm) and small bending radius (~ 5mm) which enables easy connection with other devices without expensive connectors and enough flexibility to be utilized in office and home networks [7, 8]. Furthermore, the bandwidth of the GI-POF can be enhanced by controlling its refractive-index distribution. Previously, 1550nm transmission over GI-POF has been proposed [9]. However, loss of GI-POF at 1550nm is high and the preferable transmission wavelength range is 800-1350nm. Although some experiments with low-speed OFDM (<1Gbit/s) over POF have been demonstrated [10-12], here we will experimentally demonstrate the transmission of upconverted 16Gbit/s OFDM signals on 24GHz microwave carrier over 50m GI-POF at 1310nm.

Experimental Setup and Results

The experimental setup of the proposed OFDM signals transmission over GI-POF is shown in Fig. 1. The lightwave from the DFB laser-diode (LD) at 1310nm

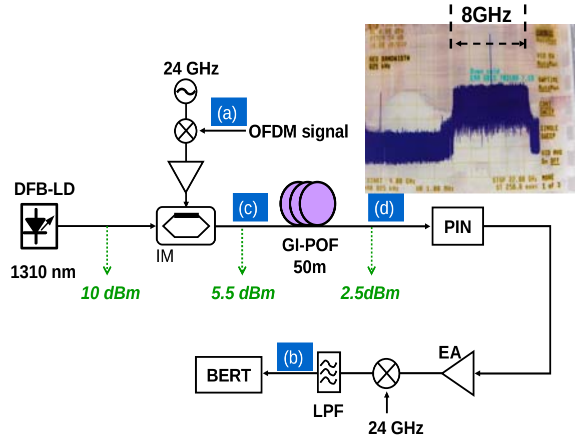

Figure 1: Experimental configuration for 16Gb/s OFDM transmission over GI-POF. EA: electrical amplifier; IM: intensity modulator; GI-POF: graded-index plastic optical fiber; PIN: receiver; LPF: low pass filter. Inset: electrical spectrum of the OFDM signal after up-conversion.

with the output power around 10dBm is modulated by an intensity modulator (IM) driven by up-converted OFDM signals. The 16Gbit/s OFDM signals are generated by OFDM transmitter and then up-converted to 24GHz to realize RF-OFDM signals via an electrical mixer. The upconverted spectrum is inserted in Fig. 1. We can see that the bandwidth of the OFDM signal is 8GHz. The OFDM baseband signal is generated offline and uploaded into a Tektronix AWG7102. The waveforms produced by the arbitrary wave generator (AWG) are continuously output at a sample rate of 20GHz (8bits DAC, 4GHz bandwidth). The FFT size is 256, from which 200 channels are used for data transmission, 55 channels at high frequencies are set to zero for over-sampling, and one channel in the middle of the OFDM spectrum is set to zero for DC in baseband. 10 training sequences are applied for each 150 OFDM-symbol frame in order to enable phase noise compensation. At the output of the

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AWG, the low-pass filter (LPF) with 5GHz bandwidth is used to remove the high-spectral components. Subsequently, the RF-pilot tone is created by inserting a small DC offset before an analogue I/Q mixer is used to up-convert the OFDM signal from the baseband to an 8.5GHz intermediate frequency (IF). The electrical spectrum of the original signal is shown in Fig. 2(a)

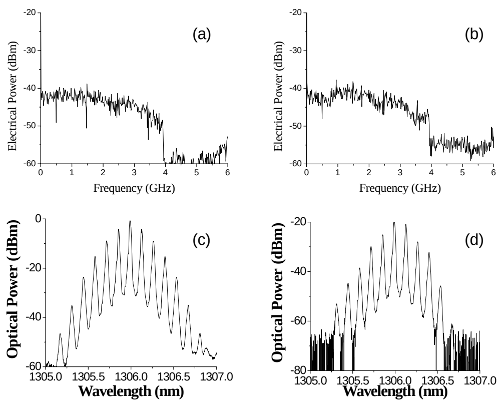

Figure 2: Received electrical spectra: (a) after arbitrary waveform generator, (b) after LPF; received optical spectra with 0.01nm resolution: (c) before, and (d) after GI-POF at the point (a)-(d) in Fig. 1, respectively.

that was measured at the point (a) in Fig. 1. The IM is driven by the OFDM signals to create double sideband (DSB) optical signals. The bias and the power of the RF signals are carefully adjusted to obtain proper power ratio between the optical carrier and the first-order sideband signals. The optical spectrum with 0.01nm resolution after the intensity modulator is shown in Fig. 2(c). After IM, the signal was launched into 50m of commercially available GI-POF for transmission. The core of the GI-POF is 50 μm with 60dB/km attenuation at 1300 nm. The signal power launched and output of GI-POF was 5.5 and 2.5dBm. The optical spectrum after transmission is presented in Fig. 2(d). A PIN receiver is used in the receiver side with the bandwidth of 29GHz and a 50μm multimode-coupled input. Before low pass filter (LPF), a 24GHz electrical LO signal is mixed to down-convert the electrical signal to its baseband form. The down-converted signals are sampled with a real-time oscilloscope (Tektronix 6154C) and processed off-line. The electrical spectrum of down-converted signals is shown in Fig. 3(b). The measured BER of back-to-back and after transmission is shown in Fig. 3 and the constellation figure after 50m GI-POF is inserted. One million bits have been evaluated for all values of BER reported in this work. We can see that there exists signal degradation after 50m GI-POF. But the BER is still lower than $1x10^{-3}$, which is below the limitation of forward error correction (FEC) at $2x10^{-3}$. The main reason is the degradation of optical signal-to-noise- ratio (OSNR) from the fiber with an insertion loss of 3dB and modal dispersion.

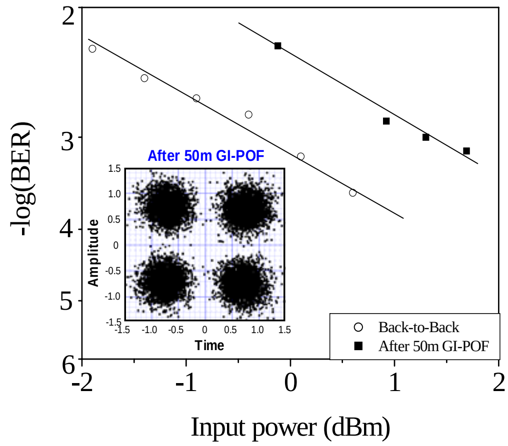

Figure 3: Measured BER curves and the constellation figure of back-to-back and after 50m GI-POF.

Conclusions

We have proposed and experimentally demonstrated a transmission system with ultra-bandwidth up to 16Gbit/s OFDM signals over 50m GI-POF. The experimental results illustrate that the transmission over GI-POF degrades the optical signal performance due to the reduction of OSNR in the fiber link. However, this system still can realize error-free transmission when the FEC is used. To our best knowledge, it is the first time to experimentally demonstrate over 1Gbit/s OFDM signal transmission over GI-POF.

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