Dual-User Wireless Heterogeneous Services over a Single Optical Carrier using Optical Frequency Multiplication

A. Maziotis(1), C. Stamatiadis(1), Ch. Kouloumentas(1), K. Vyrsokinos(1) and N. Pleros(2)

1: National Technical University of Athens, 15773 Zographou, Athens, Greece, e-mail: maziotis@mail.ntua.gr
2: Department of Informatics, Aristotle University of Thessaloniki, Greece

Abstract: We demonstrate heterogeneous wireless signal transmission over 25 km standard single mode fiber (SSMF) employing dual-subcarrier optical frequency multiplication (OFM) with phase-shift keying (PSK) transmission and demodulation by a delay interferometer at the antenna site.

1. Introduction

Radio over Fiber (RoF) platforms are developing into a flexible and robust solution for the access network due to their potential for delivering broadband heterogeneous services over a wireless/wireline converged network infrastructure. Within this frame, sub-carrier multiplexing has been one of the main techniques for enabling multiple heterogeneous wireless signal delivery over a single optical channel [1]. In this respect, the Optical Frequency Multiplication (OFM) scheme has proved to be very efficient in generating multiple high-frequency subcarriers over a single wavelength [2] employing phase shift keying (PSK) modulation at a low-frequency microwave carrier and phase-to-intensity conversion with simultaneous microwave frequency multiplication by means of a Delayed Interferometer (DI) at the Central Office (CO). However, this approach has been utilized so far only for single microwave frequency multiplication [3], providing single-user data broadcasting only at multiples of the initial low-frequency microwave carrier.

In this paper, we demonstrate dual-user data generation and dual-subcarrier frequency multiplication over a single optical channel using the OFM technique. Our scheme employs 400Mb/s data carrying 2GHz and 3.2GHz microwave carriers for phase modulating an optical wavelength, yielding a dual-subcarrier PSK signal that is subsequently fed into the Radio-over-Fiber link and transmitted over 25 km standard single mode fiber. Phase-to-intensity conversion with concurrent wireless frequency doubling is achieved at the corresponding antenna site using an appropriate DI element, obtaining in this way 400Mb/s amplitude modulated dual-user data at 4GHz and 6.4GHz microwave frequencies, each one considered to serve a different mobile user. Error-free operation with less than 2.8 dB power penalty compared to single subcarrier transmission is presented, confirming the feasibility for cost-effective multi-user heterogeneous high-frequency wireless data generation relying on the OFM technique.

2. Concept and experimental setup

Fig. 1 illustrates the experimental setup of the 2 sub-carrier multiplexed PSK transmission showing also the concept for the generation of intermediate multiple microwave frequency carriers. Two different 400 Mb/s data signals encoded with 2^7-1 pseudo-random bit sequences are up-converted using RF local oscillators at 2 GHz and 3.2 GHz. These separate electrical signals are combined to form the RF signal shown in inset (i) of Fig. 1. The final 2-subcarrier optical PSK signal is generated by a phase modulator, as it is shown in inset (ii). After 25 km of transmission over standard single mode fiber (SSMF) and signal split into the two respective antenna units via a 3dB optical coupler, the OFM technique is applied at every antenna site by using an appropriate DI element that performs frequency doubling with simultaneous PSK to on-off keying (OOK) format conversion. The relative delay between

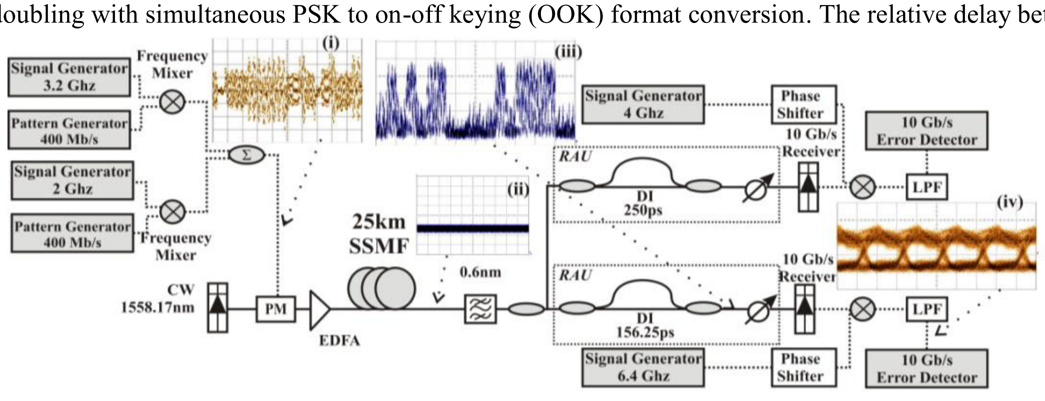

Fig. 1: Experimental setup for performance evaluation of 2 sub-carrier PSK transmission.

the DI branches was 250ps and 156.25ps for the 4GHz and 6.4GHz antenna end, respectively. Following the frequency multiplication and format conversion, both optical signals are individually detected by PIN photodiodes. The RF signals are down-converted by mixers before passing through low pass filters with bandwidth of 600 MHz.

3. Results and discussion

Fig. 2a illustrates the RF-spectrum of the multiplexed signal that drives the phase modulator. Fig. 2b shows the RF-spectrum of the signal generated by the receiver after optical transmission, PSK-to-OOK format conversion by the 156.25 ps DI, and optical detection. Finally, Fig. 2c illustrates the RF-spectrum of the demodulated signal after mixing with a 6.4 GHz local oscillator and low pass filtering. Fig. 3a shows bit error rate (BER) curves for the data signal with 4 GHz and 6.4 GHz final RF carrier. In particular, Fig. 3a illustrates BER curves of the signal after transmission over 25 km of SMF with single as well as two subcarriers, and the respective back-to-back (BtB) measurements. Error free operation was achieved in all cases. Referring to the BtB measurements, the power penalty for the operation with two multiplexed subcarriers was less than 2.8 dB with respect to single subcarrier operation. The power penalty due to the transmission was less than 1.5 dB independently of the number of subcarriers. Fig. 3b(i) and c(i) show eye-diagrams after the (156.25 ps) DI for the case of 1 and 2 subcarrier multiplexing respectively. Finally, Fig. 3b(ii) and c(ii) illustrate the final demodulated electrical signals.

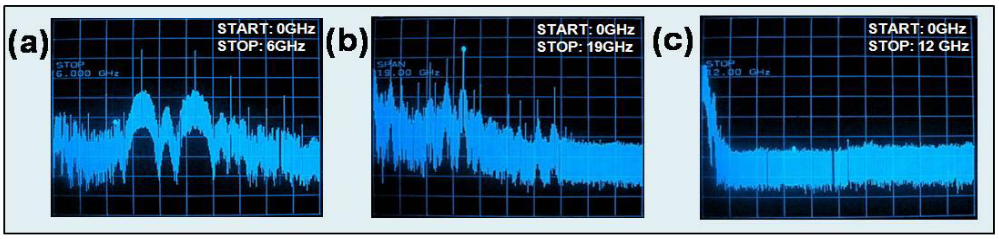

Fig. 2: Electrical spectra of signals. (a) After up-conversion and combination. (b) After receiver. (c) After LPF.

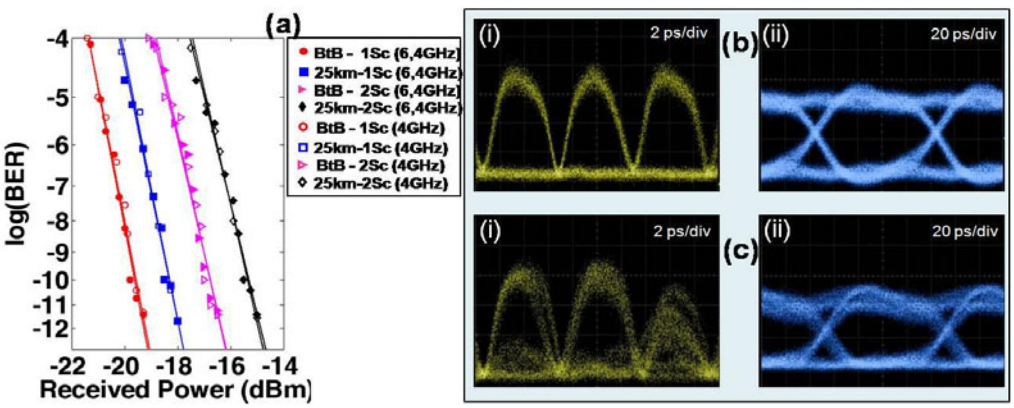

Fig. 3: (a)BER curves at BtB and 25km transmission for single and 2 sub-carrier multiplexing. Optical eye diagrams at 25km transmission for (b)single sub-carrier multiplexing and (c)2 sub-carrier multiplexing.

4. Conclusions

We have reported on 2 sub-carrier multiplexed PSK transmission over 25Km standard single mode fiber employing OFM technique for simultaneous generation of multiple intermediate microwave frequencies. Error-free operation was achieved for both channels with power penalty less than 2.8 dB with respect to single sub-currier multiplexing.

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