Indoor Pico-cellular Network Operation Based on a Simple Optical Millimeter-wave Generation Scheme

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Abstract: Experimental demonstrations of modulated signal transmission and pico-cellular network operation at millimeter-wave frequencies, which are based on a simple technique for millimeter-wave generation using an optical phase modulator and optical filtering, are reviewed.

OCIS codes: 060.2330 Fiber optics communications, 060.5625 Radio frequency photonics

1. Introduction

Radio over fiber has been proposed for the support of pico-cellular millimeter-wave frequency systems as it can simplify the numerous remote antenna units required in such systems [1]. To minimize the effects of fiber dispersion, it is necessary to use optical single sideband (OSSB) or optical double sideband with carrier suppression (ODSB-CS) generation and transport for the millimeter-wave signals [1]. In these schemes, the millimeter-wave signal at the photoreceiver can be seen as resulting from the heterodyne detection of two optical components, such that dispersion causes only phase changes to the millimeter-wave signal but no fading, as results from the beating of multiple components. In this paper, we review a simple scheme for the generation of millimeter-wave modulated optical signals, data transmission using such a scheme over optical (radio over fiber) and wireless paths, and the demonstration of "live" wireless network operation.

2. Phase modulation and optical sideband selection

As a millimeter-wave generation technique, we have proposed the use of an optical phase modulator [2]. Mach Zehnder intensity modulators biased at their null or transmission points have also been proposed for frequency doubling and quadrupling (respectively) in the generation of the millimeter-wave signal. In the case of the former, no optical filtering is necessary, although this may become desirable for higher modulation depths. With an optical phase modulator, optical filtering is necessary. The major advantage over intensity modulators is that the device operation is bias independent; intensity modulators require strict bias control.

The fundamental purpose of the optical filter in a millimeter-wave generation scheme using an optical phase modulator is removal of the carrier or one sideband [2]. By using an optical notch filter to remove the carrier, and a bandpass optical filter to remove higher order sidebands, millimeter-wave signals over a wide and continuous frequency range can be generated [3]. Fig. 1 shows the setup for wideband millimeter wave generation over a frequency range from 75 to 140 GHz, and the results are shown in Fig.2 [3].

3. Picocellular wireless network performance

As, shown in Fig.3, for data transmission, the phase modulator and optical filtering millimeter-wave generation scheme is followed by a lower bandwidth intensity modulator to which is applied the modulated data at an intermediate frequency [4]. The wireless transmission in this case was at 25 GHz, due to the availability of RF components, although previous work had examined transmission at 60 GHz [5]. Both single carrier quadrature phase shift keying (QPSK) and quadrature amplitude modulation (QAM) signals and orthogonal frequency division multiplexing (OFDM) signals were used. System operation with the required error vector magnitude (EVM) has been demonstrated over most of our 90m^2 laboratory, even at 30 MSps (up to 180 Mbps) [4]. This operation was achieved with no system adjustment, demonstrating a dynamic range wide enough to allow for simple remote antenna units (with no gain control). Also, the operation was with the RAU antenna purposely placed in the corner of the room to observe the limitations, instead of the center of the room. Separate experiments have confirmed that by using multiple IF signals to modulate the MZM, separate subcarrier multiplexed channels can be transported [5].

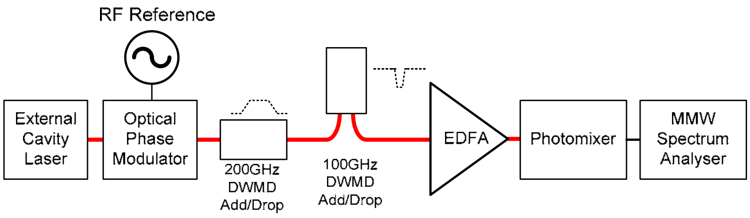

Fig.1 Setup for continuously tunable optical millimeter-wave generation. EDFA:Erbium Doped Fiber Amplifier.

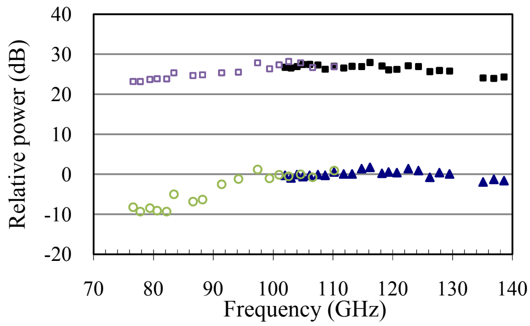

Fig. 2 Relative power of the generated millimeter-wave signal after calibration for the photomixer response.
□ W-band photomixer, with EDFA; ■ F-band photomixer, with EDFA
○ W-band photomixer, without EDFA; ▲F-band photomixer, without EDFA

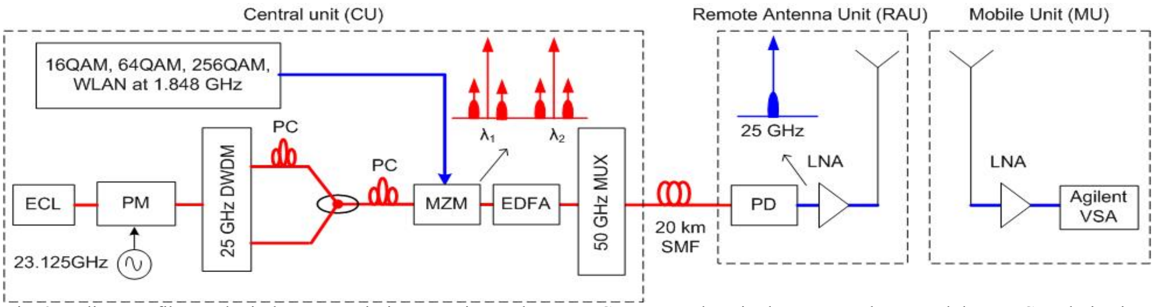

Fig. 3 Radio over fiber and wireless transmission experimental setup. ECL: External cavity laser, PM: Phase Modulator, PC: Polarization Controller, MZM: Mach Zehnder Modulator, EDFA: Erbium doped Fiber Amplifier, PD: Photodiode, LNA: Low Noise Amplifier

"Live" wireless LAN demonstration has been carried out by applying the signal from a wireless LAN access point to the MZM in the downlink [7]. A wireless transceiver located at the laptop provided for reception at 25 GHz and re-transmission at 2.4 GHz, to enable the laptop to receive the signals. In this case the uplink operated directly using the standard wireless LAN transmissions at 2.4 GHz. Again, operation throughout our 90m^2 laboratory was demonstrated with the RAU antenna placed in the corner of the room, with very little throughput degradation [6].

4. References

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