Proceedings of the 15th Conference on Optoelectronics and Optical Communications

ISSN 1738-2661

COOC 2008

제15회 광전자 및 광통신 학술회의 논문집

VOL.15 NO.1

일시 2008년 5월 14일(수)~5월 16일(금)

장소 부산 해운대 한화리조트

공동주최

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Fiber-Supported 60-GHz Band Self-Heterodyne Wireless System with a Self-Oscillating Harmonic Optoelectronic Mixer

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Abstract

We present a fiber-supported 60-GHz band self-heterodyne wireless system with a self-oscillating harmonic optoelectronic mixer (SO-HOM), which is based on a CMOS-compatible avalanche photodetector. The SO-HOM executes photodetection and frequency up-conversion at once. In order to demonstrate the feasibility of the system, downlink data transmission of 5 MS/s 32 QAM signals in 60-GHz band is achieved well.

There is growing interest in using 60-GHz band for broadband wireless network applications due to the availability of about 7 GHz of license-free band around 60 GHz. Furthermore, due to low-loss, large bandwidth, and a flexible medium of fiber-optic technology, fiber-supported millimeter-wave systems have been extensively studied for next generation broadband communication systems [1]. In this paper, we demonstrate a fiber-supported 60-GHz band self-heterodyne wireless system with a self-oscillating harmonic optoelectronic mixer (SO-HOM) based on a CMOS-compatible avalanche photodetector (CMOS-APD). 5 MS/s 32 QAM data transmission is performed well in the 60-GHz band.

Fig. 1 shows the schematic of the proposed system. Using a self-heterodyne method, a simple mobile terminal is possible by eliminating a phase-locked oscillator because RF data signals are transmitted with a local oscillation (LO) signal at the same time [2]. At an antenna base station, the SO-HOM consists of a CMOS-APD and feedback circuits including a band-pass filter (BPF), an amplifier, and a coupler. CMOS-APD provides photodetection and optoelectronic mixing which is owing to the nonlinear characteristic of avalanche process. The detailed device structure and characteristics of the fabricated CMOS-APD can be found in [3]. By feeding back the output of CMOS-APD to its input using the coupler, the SO-HOM is realized. Oscillation frequency is determined by the bandwidth of the BPF, and the loop-gain must be larger than unity. The SO-HOM can simultaneously perform oscillation, photodetection, and optoelectronic mixing, so the simple antenna base station can be realized.

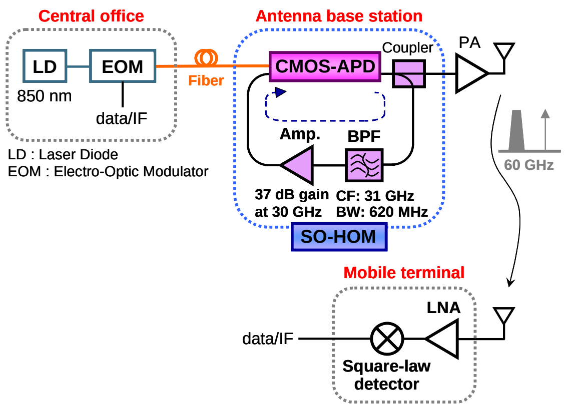

Fig. 1. Fiber-supported 60-GHz band self-heterodyne wireless system with the SO-HOM.

Downlink data transmission of 5 MS/s 32 QAM signals in 60-GHz band was demonstrated. As shown in Fig. 1, 850 nm optical signals were modulated by electrical 950 MHz IF data signals at the central office and transmitted to the antenna base station on 2-m long multimode fiber. The transmitted optical IF data signals were photodetected by CMOS-APD and upconverted to the 60-GHz band by the second order harmonic of the SO-HOM. Fig. 2 shows the spectrum of upconverted double sideband signals and second order harmonic of the SO-HOM. The input optical power was about 1 dBm, and the reverse bias voltage

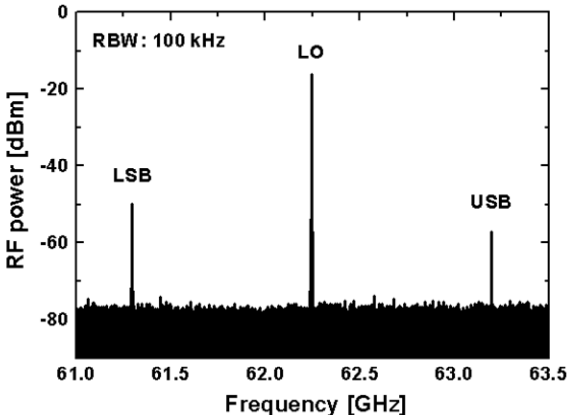

Fig. 2. Spectrum of upconverted signals and LO signal.

of 10.3 V was applied to CMOS-APD. The antenna base station sends out the RF data signals with a LO signals to the mobile terminal through 1-m free space by a 24-dBi gain antenna. The wireless link loss is about 68 dB in 60-GHz band, and a 26-dB gain power amplifier was used to compensate the free-space loss. At the mobile terminal, received data and LO signals were amplified by a 36.5-dB gain low-noise amplifier. Then, the data signals were downconverted to 950 MHz IF band using a square-law detector and analyzed by a vector signal analyzer. Fig. 3 shows the spectrum of downconverted data signals, and Fig. 4 shows the constellation and eye diagram of demodulated 5 MS/s 32 QAM data signals. The eye was clearly open and the measured error-vector magnitude was about 1.83 %, which corresponds to the 30.7 dB signal-to-noise ratio. We believe this should be adequate for most wireless applications.

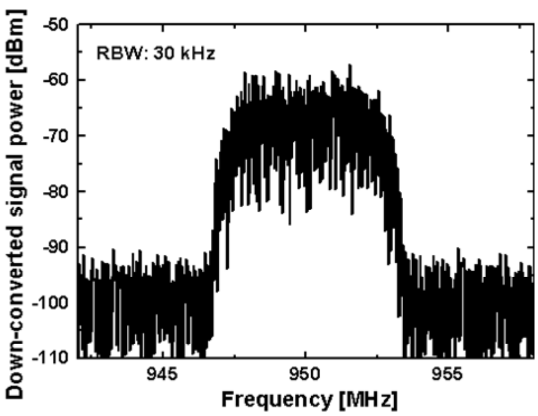

Fig. 3. Spectrum of downconverted signals.

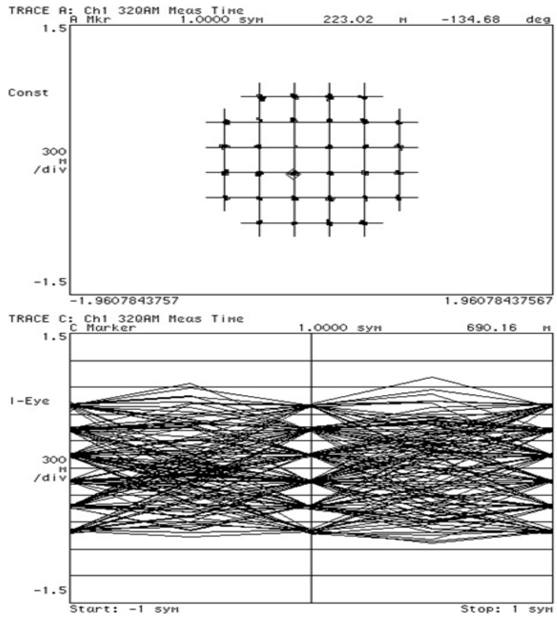

Fig. 4. Constellation and eye diagram of demodulated 5 MS/s 32 QAM data signals.

In summary, we presented the fiber-supported 60-GHz band self-heterodyne wireless system with the SO-HOM, which performs oscillation, photodetection, and optoelectronic mixing at the same time. To manifest the feasibility of our system, downlink data transmission of 5 MS/s 32 QAM data signals successfully performed in 60-GHz band. Although the feedback loop was executed by discrete components in this work, the SO-HOM can be realized by monolithic integration of CMOS-APD and required CMOS circuits.

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