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Photonics Conference 2004

November 3 ~ 5, 2004
DaeMyung Condo, Danyang

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전계흡수 변조기의 주파수 하향변환 기능을 이용한 60 GHz 상향 회선 Radio-on-Fiber 시스템

60GHz Uplink Radio-on-Fiber Systems using Frequency Down-Conversion of Electroabsorption Modulator

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Abstract: A simple frequency down-conversion method for radio-on-fiber uplink transmission is experimentally demonstrated by using remotely-fed optical heterodyne signals and nonlinearities of an electroabsorption modulator (EAM). QPSK data signals modulated in 60 GHz-band are frequency down-converted to the 500 MHz IF-band optical signals and demodulated successfully.

I. Introduction

Millimeter-wave radio-on-fiber (RoF) systems have attracted much attention for broadband wireless communications [1-4]. To implement these systems successfully, simple antenna base station architectures are very important due to high transmission loss of the millimeter-wave carrier and expensive base station components. Electroabsorption modulator (EAM) transceivers allow the simple antenna base station architecture for bi-directional RoF links since EAM can perform the dual functions of photo-detection and optical modulation [1-3]. However, the simple EAM modulation of uplink millimeter-wave signals generates double-sideband optical signals and their single-mode fiber transmission causes dispersion-induced signal fading problems [1-3]. Low-frequency data/IF modulated optical signal transmission can lessen such problems. However, expensive millimeter-wave mixers and local oscillators (LOs) are indispensable for the frequency down-conversion from millimeter-wave frequency to IF. To eliminate such RF components, various frequency down-conversion schemes using EAM have been introduced [2, 3].

In this paper, we propose a simple EAM-based millimeter-wave frequency down-conversion method for IF-band optical transmission. Using remotely-fed millimeter-wave optical heterodyne LO signals, the uplink millimeter-wave signals are frequency down-converted to the IF-band optical signals by EAM nonlinearities, whose wavelength is different from that of optical LO. With the proposed frequency down-conversion technique, 60 GHz uplink signal is frequency down-converted to the 500 MHz IF-band with the help of 59.5 GHz optical heterodyne signals. QPSK data transmission in 60 GHz RoF uplink systems is successfully demonstrated.

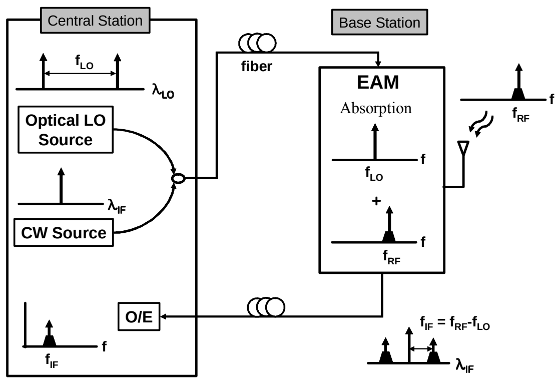

Fig. 1 Operation principles of the proposed frequency down-conversion technique.

II. Principles of Frequency Down-conversion

Fig. 1 shows the schematic operation principles of frequency down-conversion. To obtain an LO signal, optical heterodyne techniques are used. When optical heterodyne signals whose frequency is separated with LO frequency (f_{LO}) are transmitted from the central station, f_{LO} signal is generated by the EAM photo-detection. After then, with the EAM modulated f_{RF} uplink signal, a frequency down-converted IF signal ($f_{IF}=f_{RF}-f_{LO}$) is produced by the EAM second-order nonlinearity. This IF signal is modulated to the λ_{IF} uplink optical carrier and transmitted to the central station without suffering dispersion-induced signal fading problems.

Using this frequency down-conversion method, expensive millimeter-wave-band phase-locked oscillators and mixers can be eliminated at the base station, which makes it possible to reduce the base station cost. Moreover, the optical LO signals from the central station can be shared by each base station and uplink optical wavelength can be selected freely within the EAM modulation range. Especially, using these advantages, the WDM technologies can be easily adopted in the uplink RoF systems.

III. Experiment and Results

The EAM used in this experiment has a multiple-quantum well structure and its polarization dependence is less than 1 dB [4]. The traveling wave electrode was applied and packaged for 60 GHz RoF systems.

Fig. 2 shows the experimental setup for the 60 GHz frequency down-conversion. 59.5 GHz optical heterodyne LO signals were generated by double-sideband with suppressed carrier method. For the uplink optical signal, a DFB laser at 1552.5 nm was used. These two signals were combined by 3 dB coupler and injected into the EAM. For generating 60GHz uplink RF signal, a subharmonic RF mixer is used. The target IF frequency was set to be 500 MHz. Before the photo-detection of the uplink optical signal, an optical bandpass filter for suppressing unwanted optical heterodyne LO signals. Fig. 3 (a) shows the frequency down-converted 500 MHz RF spectrum after photo-detection of the uplink optical signal.

Next, 60 GHz-band uplink data transmission is demonstrated. For the IF data transmission, 10 Mbps QPSK data at 500 MHz is generated from the QPSK signal generator and frequency up-converted to the 60 GHz by the subharmonic mixer. the wavelength of optical heterodyne LO signals was selected to 1560 nm and EAM was biased at -2 V. Fig. 3 (b) shows the 500 MHz QPSK data spectrum down-converted to the IF-band. To demodulate the frequency down-converted QPSK data, the vector signal analyzer is utilized. By using this instrument, the error vector magnitude could be measured, and the resultant value was about 14.7. This value corresponds with the SNR 16.6 dB, from which BER of 10^{-12} could be extracted theoretically. It should be noted that much higher data rate transmission is possible but our experiment was limited by the available QPSK signal generator.

IV. Conclusion

We investigated a simple frequency down-conversion method using remotely-fed millimeter-wave optical heterodyne LO signals and EAM nonlinearities. By using this frequency down-conversion technique, it is possible not only to realize simple and cost-effective base stations but also to transmit IF-band optical signals without dispersion-induced penalty. 60 GHz uplink signals are down-converted to the 500 MHz IF-band signal with the help of 59.5 GHz optical heterodyne LO signals at the EAM. 60 GHz uplink transmission using QPSK modulated signals is also performed successfully.

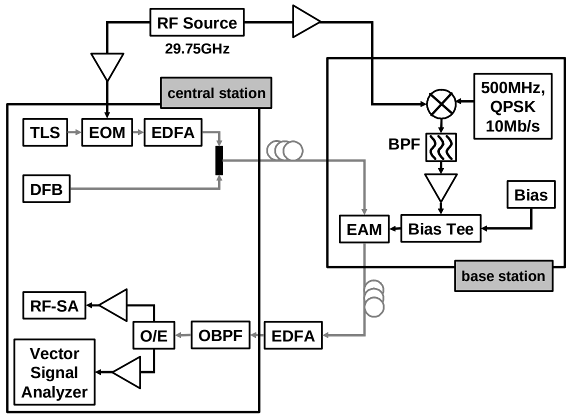

Fig. 2 Experimental setup for 60 GHz frequency down-conversion and uplink data transmission. TLS : Tunable Laser Source, EOM : Electrooptic Modulator, RF-SA : RF Spectrum Analyzer

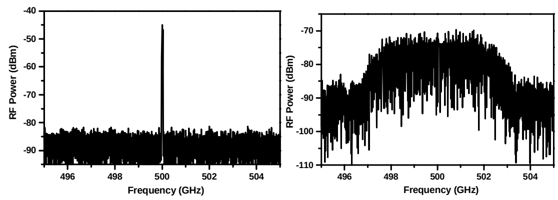

Fig. 3 Down-converted RF spectrum of 500MHz IF signals (a) and 10Mbps QPSK modulated signals (b)

V. References

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