WDM/Radio-on-Fiber Distribution using Remote Photonic Frequency-Upconversion

Y-K. Seo, J.-H. Seo, C.-S. Choi and W.-Y. Choi
Department of Electrical and Electronic Engineering
Yonsei University, Seoul, Korea
Tel: +82-2-2123-2874, Fax: +82-2-312-4584, E-mail: wchoi@yonsei.ac.kr

Abstract

We present a novel remote photonic frequency-upconversion scheme based on SOA cross-gain modulation. Using the scheme, we successfully demonstrate 60GHz radio-on-fiber distribution of two 622 Mbps WDM channels.

The fiber-optic transmission of millimeter-wave signals has attracted much attention for broadband radio access system applications [1-4]. For the increase of the total data traffic capacity, linking radio-on-fiber systems to the existing wavelength division multiplexing (WDM) networks is an important issue. For this, several schemes have been demonstrated using either Mach-Zehnder modulators [3] or nonlinear photo-detection of photo-diodes (PD) [4], where WDM data signals at different wavelengths are frequency-upconverted to the desired millimeter-wave frequency. We have proposed and experimentally demonstrated an efficient photonic frequency-upconversion scheme using a semiconductor optical amplifier (SOA) [5].

This paper deals with the remote photonic frequency up-conversion of 622 Mbps WDM data signals with optical heterodyne 60 GHz local oscillator (LO) signals using an SOA for the WDM / broadband radio-on-fiber system applications. Fig. 1 shows the system configuration for our investigation, where optical 60 GHz millimeter-wave LO signals from the central station are distributed to base stations and WDM data are wavelength-selectively transmitted to base stations. The optical LO signals have two optical sidebands separated by the desired LO frequency (f_{LO}) and are shared among base stations. Photonic frequency-upconversion of the WDM data to the desired millimeter-wave frequency is achieved with SOA cross-gain modulation and square-law photo-detection. We demonstrate the distribution of the frequency-upconverted 622 Mbps WDM data in the radio-on-fiber link. In Fig. 1, optical heterodyne 60 GHz LO signals are produced by the optical sideband injection locking technique employing three DFB-lasers [6].

For WDM / broadband 60GHz radio access demonstration, two WDM channels are realized by directly modulating two DFB lasers by 622 Mbps NRZ digital data and multiplexed with the optical LO signals of 60GHz. After passing through 20-km standard single-mode fiber, they are demultiplexed with AWG. Each WDM channel is assigned to a base station along with the optical LO signals. Fig. 2(a) shows the optical spectra of the WDM channel and optical LO signals at two base stations. At each base station, photonic frequency upconversion of WDM signals with optical LO signals are performed in an SOA and PD. The frequency-upconverted millimeter-wave signals are electrically amplified and transmitted in the 3-meter wireless link using 60 GHz horn antennas. The transmitted signals are demodulated by direct-detection. The demodulated signals are electrically filtered with the OC-12 low pass filter and eye-diagrams are observed as shown in Fig. 2(c). Eye-diagrams of the original baseband WDM channels are given in Fig. 2(b) for comparison. Clearly, both base stations show good eye-openings. Although the present demonstration has only two WDM channels, more WDM channels linking to more base bands are possible as long as all the optical wavelengths are within the SOA optical gain wavelength bandwidth.

Reference

[1] A. J. Seeds, "Microwave Photonics," *IEEE Trans. on Microwave Theory and Techniques*, vol. 50, no. 3, pp. 877-887, 2002.

[2] A. Hirata, M. Harada, and T. Nagatsuma, "3.0 Gbit/s Wireless Links Using 120-GHz Millimeter-Wave Photonic Techniques," *IEICE Trans. Electron.*, Vol. E85-C, no. 7, pp. 1516-1518, 2002.

[3] R. A. Griffin, P. M. Lane, and J. J. O'Reilly, "Crosstalk Reduction in an Optical mm-Wave/DWDM Overlay for Radio-Over-Fibre Distribution," in *Tech. Dig. MWP'99*, pp. 131-134, 1999.

[4] M. Tsuchiya, and T. Hoshida, "Nonlinear Photodetection Scheme and Its System Applications to Fiber-Optic Millimeter-Wave Wireless Down-Links," *IEEE Trans. on Microwave Theory and Techniques*, vol. 47, no. 7, pp. 1342-1350, 1999.

[5] Y.-K. Seo, C.-S. Choi and W.-Y. Choi, "All-optical signal up-conversion for radio-on-fiber applications using cross-gain modulation in semiconductor optical amplifiers," *IEEE Photon.Technol. Lett.*, vol. 14, no. 10, pp.1448-1450, 2002.

[6] R.-P. Braun, G. Grosskopf, D. Rohde, and F. Schmidt, "Low phase-noise millimter-wave generation at 64 GHz and data transmission using optical sideband injection locking," *IEEE Photon. Technol. Lett.*, vol. 10, no. 5, pp. 728-730, 1998.

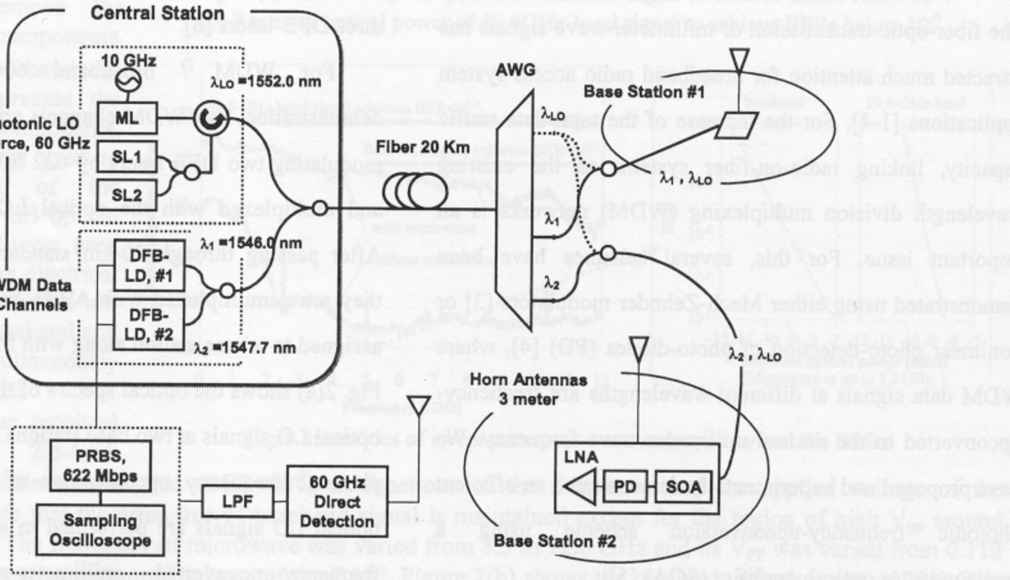

Fig. 1 WDM / broadband radio-on-fiber access distribution utilizing remote photonic frequency-upconversion.

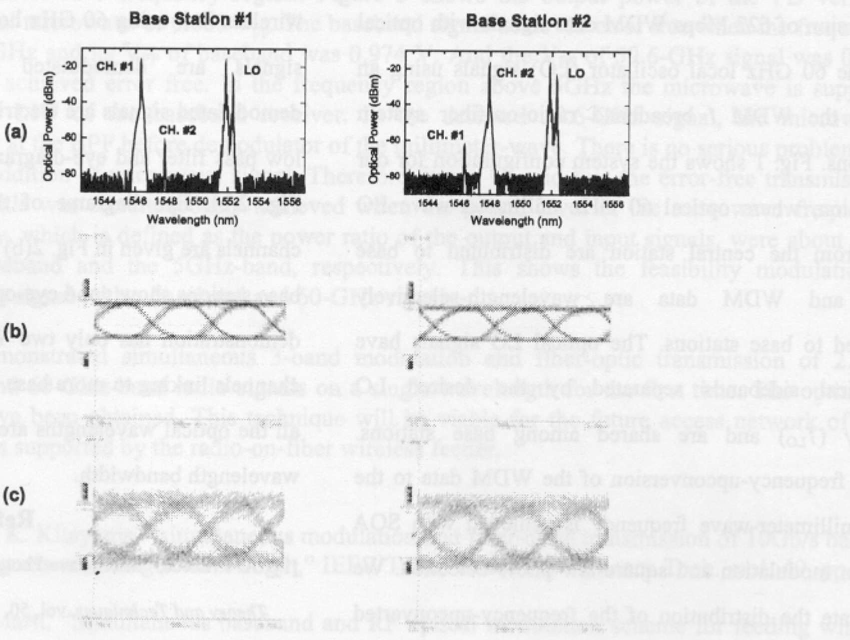

Fig. 2. Measured optical spectra (a) and eye-diagrams of original (b) and recovered (c) 622 Mbps NRZ data at base stations.