101 Gb/s 2×2 End-to-End MIMO Fiber-Wireless System in W Band Using WDM Radio-over-Fiber

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***Abstract*— We demonstrate an end-to-end multiple-input multiple-output (MIMO) seamless fiber–wireless system in the W band using an optical self-heterodyne wavelength-division multiplexing radio-over-fiber technique. Satisfactory performance is experimentally confirmed for 2×2 MIMO FBMC/OQAM signal transmission with a total capacity of approximately 93.5 Gb/s and 101 Gb/s using antenna in the same and different polarization, respectively. The system is scalable for large-scale MIMO signal transmission and can be a promising solution for future mobile networks.**

Keywords—Seamless fiber–wireless; radio-over-fiber; mobile fronthaul; 5G and beyond

I. INTRODUCTION

The evolution of radio access technologies (RATs) in 5G and beyond networks poses significant challenges to the transport networks, especially the fronthaul systems for transporting radio signals from a cloud in a center office to ultra-dense antenna sites [1]. To make use of RATs in the high frequency bands, many small cells will be installed to increase service coverage. For transporting radio signals to new antenna sites, the use of conventional fiber-optic based mobile transport system will not be sufficient owing to the difficulty and high cost of fiber link installation. Wireless transport systems would be an attractive alternative owing to its easy and fast installation. Free-space optical (FSO) wireless transport system is very promising owing to its large available bandwidth and readiness to reuse available devices and transmission technologies in conventional fiber-optic communications. To take advantage of wavelength-division multiplexing (WDM) for multiple signal transmission and/or to increase the system capacity, a seamless fiber–FSO system with an automatic tracking and coupling technique should be used [2]. Nevertheless, it is still not easy and cost-effective to develop such a system for practical applications. The use of wireless communications in the high frequency band using seamless fiber–wireless systems is more reliable and cost effective. Moreover, besides being used for mobile transport networks, seamless fiber–wireless systems can also play as a new radio access in future mobile networks where radio access signals in very high frequency bands will be used [3]. In these systems, wireless signals will play the role of radio access while the fiber links play the role of mobile fronthauling. In both cases, a large multiple-input and multiple-output (MIMO) seamless fiber–wireless system will be required to increase the transport capacity and/or to support large-scale MIMO radio signals in future mobile networks.

To realize seamless fiber–wireless systems, radio-over-fiber (RoF)-based transmission has been considered. For MIMO seamless system transmission, a WDM intermediate frequency-over-fiber (IFoF) system can be promising owing to the simplicity in the generation of multiple IFoF signals [4, 5]. Nevertheless, the system, especially the antenna sites, is quite complex due to the use of electrical signal up-conversion. The system performance is also affected by the signal-to-signal beating interference in the single-sideband direct-detection IFoF links. For applications that require simple antenna sites, RoF-based fiber–wireless system should be considered. To realize MIMO signal transmission, the optical polarization-division multiplexing (PDM) RoF systems have been demonstrated using either optical heterodyne [6] or optical self-heterodyne technique [7]. However, PDM-based RoF system can support only a 2×2 MIMO signal transmission. For a larger MIMO signal transmission, a combination of WDM-PDM RoF system will be promising. In these systems, however, the use of the optical heterodyne method is not suitable because the independent frequency fluctuation [8] in each channel will make the estimation and compensation of carrier frequency offsets of MIMO signal complicated. In addition, interference between the channels having high frequency fluctuations and random phase noises will make the MIMO signal synchronization and channel estimation very challenging. Therefore, optical self-heterodyne WDM RoF-based systems [9] should be considered for a large-scale MIMO signal transmission to reduce the complexity in the digital signal processing at the receiver.

In this paper, we demonstrate a 2×2 MIMO fiber–wireless transmission using an optical self-heterodyne-based WDM RoF system. In addition, different with previous works [6, 7, 10] that demonstrated emulated PDM MIMO systems, in this study, we demonstrate an end-to-end MIMO system in which a precoded MIMO signal is transmitted over the seamless system. We successfully transmitted approximately 93.5 Gb/s and 101 Gb/s 2×2 Filter Bank Multicarrier (FBMC)/OQAM signal over the seamless system in the W band using radio antennas in the same and different polarization, respectively. The system can be scaled for transmission of large-scale MIMO signals by adding new RoF channels and/or combining with PDM RoF technique.

978-4-88552-331-1/20/$31.00 @2020 IEEE