4th URSI AT-RASC, Gran Canaria, 19-24 May 2024

5G New Radio Signal Transmission over Free-Space Optical and Terahertz Wireless Fronthaul Links

Pham Tien Dat [(1)], Zu-Kai Weng[(1)], Toshimasa Umezawa[(1)], Atsushi Kanno[(1), (2)], Tetsuya Kawanishi[(1), (3)], and Kouichi Akahane[(1))]
(1) National Institute of Information and Communications Technology, Tokyo, Japan (ptdat@nict.go.jp)
(2) Nagoya Institute of Technology, Aichi, Japan
(3) Waseda University, Tokyo, Japan

Radio access networks (RANs) in the high-frequency bands, such as the millimeter-wave (mmW) band, are being considered and standardized for the fifth generation (5G) and beyond networks. Particularly, the frequency range in the 24.25 to 40 GHz band is the most widely discussed spectra for 5G new radio (NR) RANs. The use of high-frequency radios significantly increases the number of antenna sites, thus poses considerable challenges to the mobile transport networks. Simplification of antenna sites is crucial to reduce the cost, power, and system complexity for ultra-dense small-cell networks. Analog radio-over-fiber systems are promising for transporting mmW radio signals owing to the simple antenna sites and low optical bandwidth and transmission latency. Nevertheless, the use of fiber cables may be limited due to high costs and challenges associated with the installation of fiber cables, especially in dense urban areas. Free-space optical (FSO) communications in which lightwave signal are transmitted over free space without using any cables can be an alternative solution [1]. In addition, wireless transport systems in the high-frequency band, such as the terahertz (THz) band, are promising for mobile fronthauling in ultra-dense small cell networks. In this case, radio signals in the mmW bands can be encapsulated on the THz links for low latency and small bandwidth transmission to the antenna sites [2]. In both cases, convergence with fiber-optic links is crucial to support signal transmission over long distances.

In this presentation, we present the transmission of 5G NR standard-compliant signals over a fiber-FSO and fiber-THz system. In the first case, a seamless fiber-FSO system in which optical signal from free-space is directly coupled into the fiber core was employed to realize transparent signal transmission. We evaluated the signal performance under different losses in the transmission links and confirmed the successful transmission of 5G signal in the 28-GHz band even when the additional link loss was increased to approximately 9 dB (Fig. 1(a)). In the second case, 5G NR signal in the 38 GHz band was successfully transmitted over a converged fiber-THz system using a simple optical heterodyne method at the transmitter and direct detection at the receiver (Fig. 1(b)). Satisfactory performance was confirmed for both 256 and 64 QAM signals. The proposed systems can facilitate the deployment of mmW RANs in high-frequency bands in 5G and beyond networks.

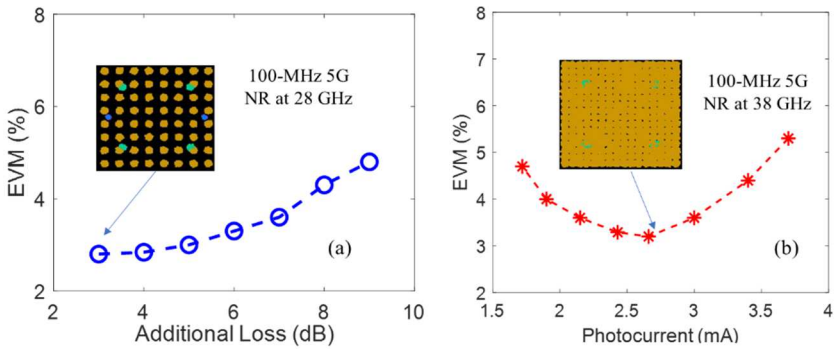

Figure 1. 5G NR signal performance over: (a) fiber-FSO system; (b) fiber-THz system.

This work was partly supported by JST SICORP Grant Number JPMJSC22E1, Japan.

1. P. T. Dat et al., "Radio-over-Free-Space Optical System for Simultaneous Transmission of 5G NR mmW and sub-THz RAT Signals," Proc. ECOC 2023, Th.A.7.1.

2. P. T. Dat et al., "5G NR millimeter-wave radio signal transmission over a seamless fiber–terahertz mobile fronthaul system for ultra-dense small cell network," Opt. Lett., vol. 47, no. 19, 5188-5191, Oct. 2022.