Tunable Microwave Photonic Filter for Millimeter-wave Mobile Fronthaul Systems

Run-Kai Shiu[1], Siming Liu[2], Peng-Chun Peng[1], Wei-Chieh Tang[1], Shuyi Shen[2], Qi Zhou[2], and Gee-Kung Chang[2]

[1]Department of Electro-Optical Engineering, National Taipei University of Technology, Taipei, Taiwan
[2]School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, USA
E-mail: pcpeng@ntut.edu.tw

Abstract: In this paper, a tunable microwave photonic filter for millimeter-wave mobile fronthaul systems is proposed and experimentally demonstrated. With the aid of the proposed filter, we can improve and centrally control the system transmission efficiency and decrease the complexity of the mobile fronthaul systems.

Introduction

Microwave photonic filters have attracted much more attention than their electrical counterparts due to their advantages of lossless, compact, broad bandwidth and immunity to electromagnetic interference. Since conventional electronic microwave filter cannot provide large tunability and high Q-factor as all optical microwave photonic filters do, they become a highly promising alternative to the electronic one in optical signal processing, optical and wireless communication, radar systems, and phase-array antenna systems [1-2]. Recently, to enable the excellent end-to-end performances, high-quality macro/small cells employing millimeter-wave wireless transmissions are proposed [3]. Millimeter-wave, especially at 28 GHz, do not suffer from significant additional path loss caused by atmospheric absorption if cell sizes are on the order of 200 m. Only 7 dB/km of attenuation is expected due to heavy rainfall rates of 1 inch/hr for cellular propagation at 28 GHz, which translates to only 1.4 dB of attenuation over 200 m distance [4].

In this paper, a tunable microwave photonics filter based on a polarization modulator (PolM) for 28 GHz mobile fronthaul systems has been proposed and experimentally demonstrated. The frequency of tunable microwave photonics filter can be tuned by adjusting a polarization controller. The experimental results show that the proposed cost-effective microwave photonics filter has potential in millimeter-wave mobile fronthaul systems. Moreover, the experimental results match simulative results.

Experimental Setup and Results

Fig. 1 shows the schematic diagram of the proposed tunable microwave photonic filter. The distributed feedback laser is employed as the light source and then launches into polarization controller1 (PC1) prior to polarization modulator. By properly adjusting PC1, the polarization direction of lightwave is set to an angle of 45° relative to one principal axis of the PolM and thus the lightwave is equally projected onto the two orthogonal polarization directions of the PolM. In the PolM, the lightwave projected on two principle axes of PolM are modulated separately by wireless signals from arbitrary waveform generator (AWG). Then, PC2 is used to align its principal axis that orients at an angle of α to one principal axis of the PolM. By rotating PC2, the frequency response of tunable microwave photonics is changed [5-6]. Hence, we can realize frequency-division multiplexing (FDM) system by manually rotating PC2 that distributes the data with different frequencies by adjusting the angle of α to different users. In order to demonstrate the functionality of tunable microwave photonic filter, the lightwave is modulated by wireless signals at 27 and 28 GHz generated by AWG and fed into single mode fiber (SMF) before photo detector (PD). The optical signal is converted into electrical signal through PD and then captured by an oscilloscope. As shown in Fig. 2 and 3, either 27 or 28 GHz wireless signals is filtered out by the proposed microwave photonic filter. Moreover, the simulation result of frequency response of proposed microwave photonic filter matches the experimental result pointing out our proposed microwave photonic filter is theoretical correct. Through digital signal processing offline work, we obtain BER performance as demonstrated in Fig. 4. According to all the experimental and simulative results, the 27GHz and 28GHz signals are successfully filtered by our proposed microwave photonic filter and transmitted though SMF with good BER performance.

Conclusion

A tunable microwave photonic filter based on polarization modulator have been proposed in this paper. The frequency of tunable microwave photonics filter can be tuned by adjusting polarization controller. The experimental results show that the proposed cost-effective microwave photonics filter has potential in millimeter-wave mobile fronthaul systems. Moreover, the experimental results match simulative results.

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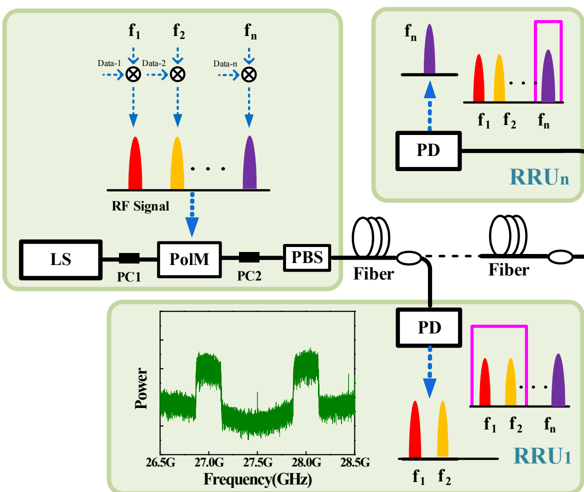

Fig. 1. Schematic diagram of the proposed scheme. (LS: laser source; PC: polarization controller; PBS: polarization beam splitter; PolM: Polarization modulator; PD: photo detector; RRU: remote radio unit)

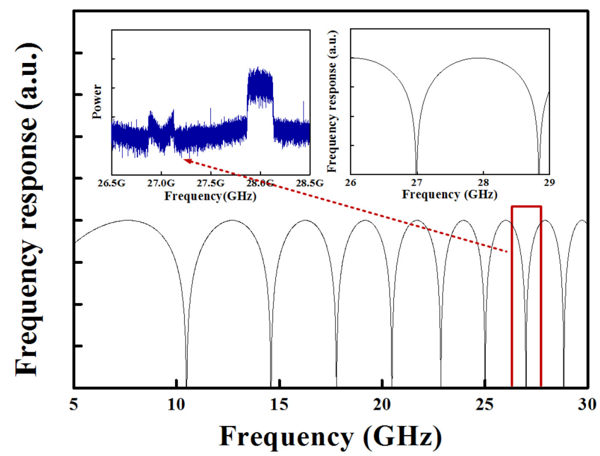

Fig. 2 Electrical spectrum and simulative result of the proposed microwave photonic filter with notch at 27 GHz

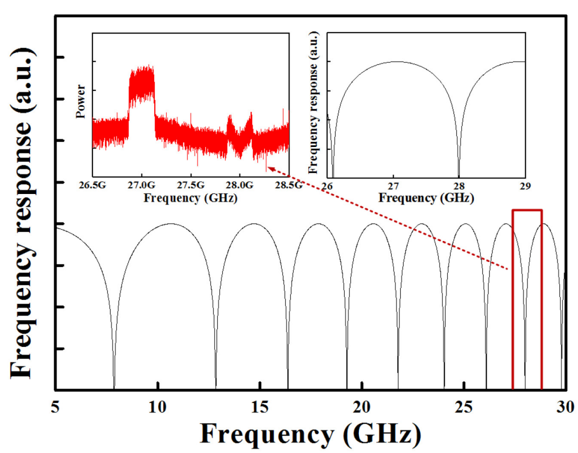

Fig. 3 Electrical spectrum and simulative result of the proposed microwave photonic filter with notch at 28 GHz

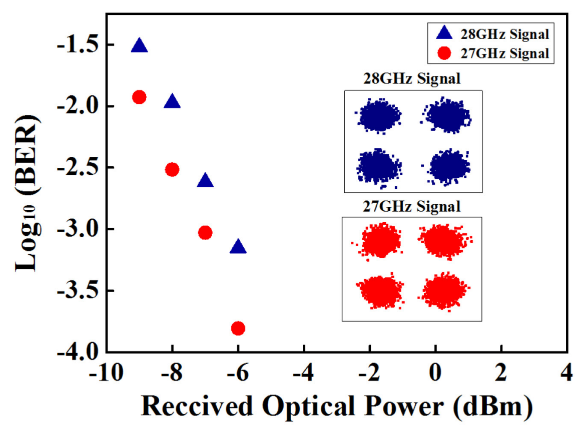

Fig. 4 BER performance of the proposed microwave photonics filter.