A Microwave Photonic Multiple Frequency System with Tunable Frequency Multiplication Factor of 3-10

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ABSTRACT

A microwave photonic system with a tunable frequency multiplication factor of 3-10 is theoretically analyzed and simulated. The system mainly consists of three dual-parallel Mach-Zehnder modulators (DPMZM). With the use of programmable filter, a fixed-order optical sideband can be accurately obtained as a carrier for secondary modulation. By adjusting the parameters such as the direct current (DC) bias voltage and the radio frequency (RF) drive voltage of each DPMZM in the system, microwave signals with a frequency multiplication factor of 3-10 can be generated. The simulation results show that when the frequency of RF signal is 10GHz, microwave signals with frequencies of 30, 40, 50, 60, 70, 80, 90, 100GHz can be generated with an unwanted harmonic suppression ratio of 20dB. During the frequency multiplication process, the overlap of the signal in the frequency domain is well avoided because of combining an optical programmable filter. In addition, the process of multi-frequency signal generation is theoretically derived, and the effects of several non-ideal factors on the radio frequency spurious suppression ratio (RFSSR) are analyzed.

PRINCIPLE AND SETUP

The setup of the proposed tunable multi-frequency system is shown in Fig.1. Based on the expanded form of the Bessel function, the output signal at point A in Fig.1 can be expressed as :

$$E_{DPMZM1-out}(t)=\frac{1}{4}E_{in}(t)\sum_{n=-\infty}^{\infty}J_n(m)\exp(j\omega_c t+n\omega_m t)\cdot\begin{bmatrix}[1+(-1)^n\exp(jn\varphi_1)]\\+\exp(j\varphi_3)\exp(j\varphi)[1+(-1)^n\exp(jn\varphi_2)]\end{bmatrix}$$

By adjusting the parameters of the two DPMZMs and the programmable filter, the output of point F of Fig.1 can be approximately expressed as:

$$\begin{aligned}E_{F-out}(t)&=\frac{1}{\sqrt{2}}[E_{DPMZM2-out}(t)+E_{DPMZM3-out}(t)]\\&\approx\frac{1}{4}\eta\cdot E_{in}(t)\cdot[J_{-2}(m)\exp(j\omega_c t-j2\omega_m t)\\&\quad+J_2(m)J_1(m)\exp(j\omega_c t+j\omega_m t)]\end{aligned}$$

After coupling the two sidebands through PD, the microwave signal which frequency multiplication factor is 3 can be generated.

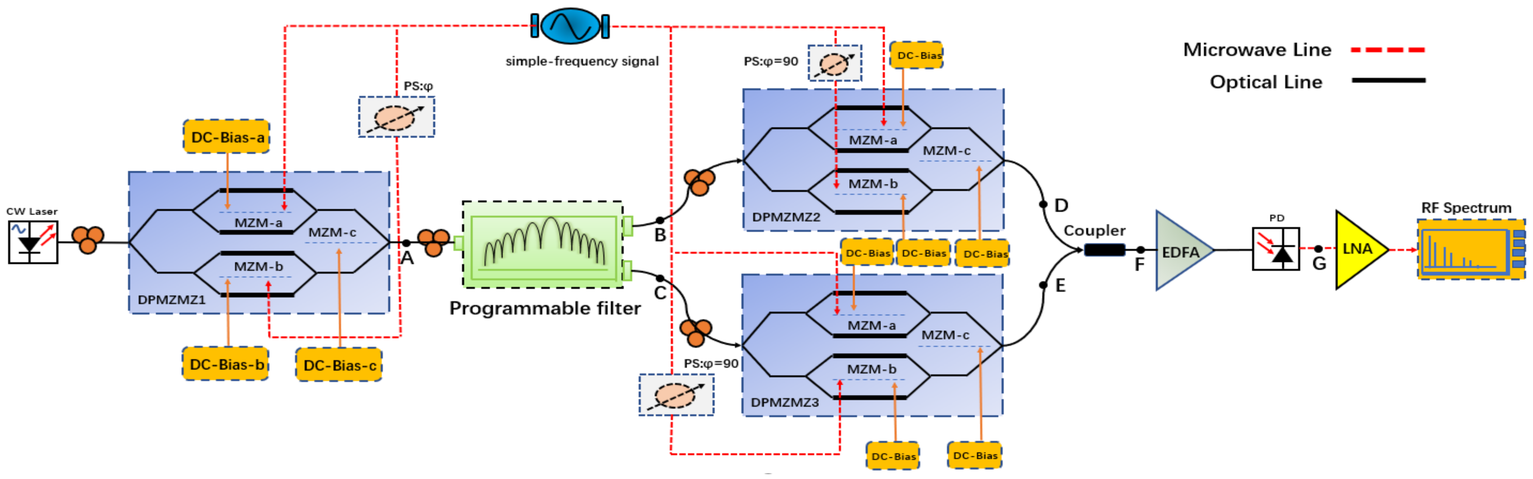

Fig. 1. Schematic diagram of the proposed microwave photonic multiple frequency system.

RESULTS

In order to verify the feasibility of the proposed multi-frequency multiplication system scheme, a simulation system based on Fig.1 was used to testify the proposed process of tunable frequency multiplication factor of 3-10.

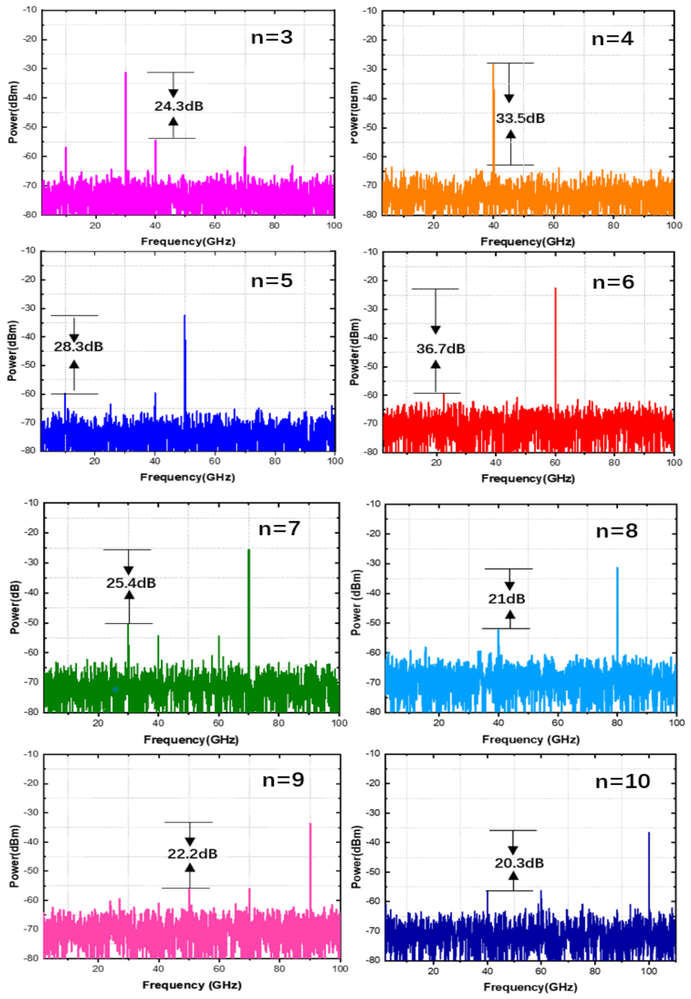

Fig.2. The electrical spectrum of the microwave signal with different frequency multiplication factor (3-10) output after PD.

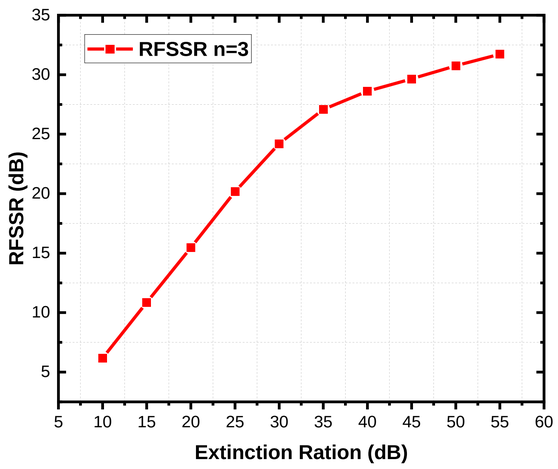

Fig.3. RFSSR of the output microwave signal with different ER.

CONCLUSIONS

In summary, a microwave photonic multi-frequency scheme with a tunable frequency multiplication factor of 3-10 is proposed. The millimeter waves with rare odd frequency multiplication factors and a good tunability of frequency can be obtained. The simulation results show that when the frequency of RF signal is 10GHz, microwave signals with frequencies of 30, 40, 50, 60, 70, 80, 90, 100GHz can be generated as Fig.2. The RFSSR of different frequency multiplication factors are all higher than 20dB, and the maximum is up to 36dB as Fig.3. Through the performance impact analysis, the RFSSR of the output signal of this scheme continuously increase with the ER of modulator within a certain range. It proves that the proposed scheme can cope with the flexible frequency requirements of future communications with a good frequency tunability and stability.