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Optoelectronic Oscillator Design Ideas In Photonic Integrated Circuit (PIC) Technology

ABSTRACT

The use of low-noise and high-frequency microwave sources has many applications be it radar, wireless communications, or modern instrumentation. However, recent advancements in microwave photonics having integration and compatibility with CMOS technology has paved the way for future RF devices that can provide low noise and facile fabrication at a much lower cost. The motivation behind our study is the use of low noise circuitry and to show the potential of fully integrated optoelectronic oscillator(OEO) systems in a single chip which is a huge technological leap as compared to its analog counterparts.

Fig. 1(a)

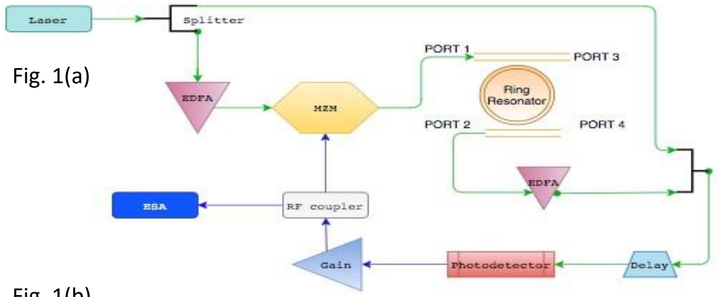
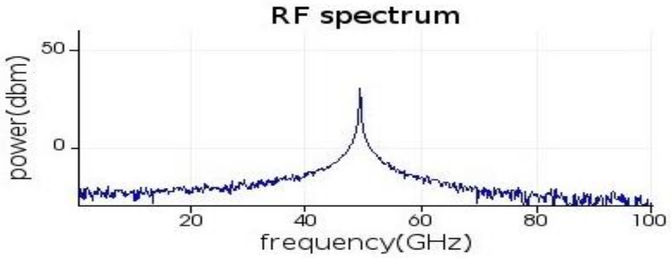


Fig. 1(b)



OBJECTIVE

This work demonstrates the to show the potential of fully integrated OEO systems in a single chip which is a huge technological leap as compared to its analog counterparts. We have successfully designed a 49.2 GHz silicon add-drop ring as a microwave photonic band-pass filter in an OEO system and a 60.1 GHz OEO system using Frequency Mixing in Ring Resonators(RR). Other elements like photo-detectors for optical to electrical conversions can be fabricated in the CMOS lines. Our study elucidates two designs for the generation of Microwaves using Photonics.

Fig. 2(a)

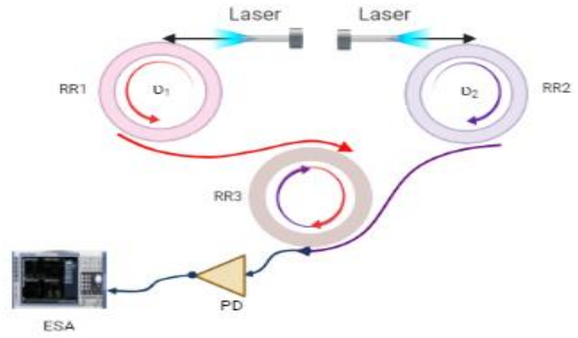
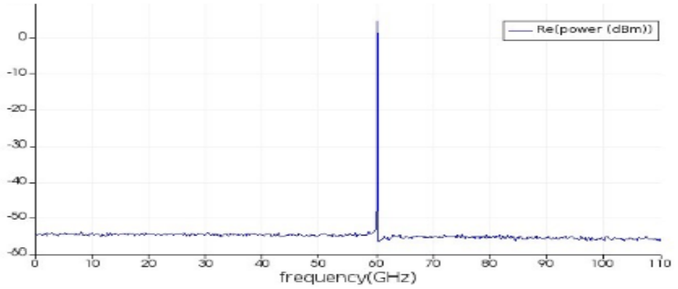


Fig. 2(b)



METHOD

Proposed two methods for the generation of RF signals are:

A) *Integrated OEO By Silicon Micro-ring Resonator*

In the optical section, design circuitry Fig. 1(a) involves; laser for providing an optical signal of 1.55 µm, a single drive MZM for external modulation followed by a silicon micro-ring resonator of length 10um for filtering. Further, the optical delay element is used for controlling the delay through the device by varying the distance light has to travel. The output oscillation Frequency corresponds to the difference of f0-fr i.e. the difference of optical signal and signal from micro-ring, at the input of the optical delay element. With no delay, the RF signal with phase noise of -99.4dBc/Hz at 1 MHz was obtained for 49.2 GHz Fig. 1(b). Whereas, when the delay of 5ps is applied the RF signal achieved at the output is at 32.9 GHz. This illustrates, depending on the delay applied a wider range of RF output signals are achieved using same circuitry.

B) *Integrated OEO Design Using Frequency Mixing*

Beat Frequency or Optical mixing is achieved by the interference of two monochromatic waves with different frequencies. So, an optical wave composed of two monochromatic waves of frequencies υ1, υ2 has a complex wave function at some point in time. The υ1 and υ2 used in the circuitry correspond to 192.69 THz and 192.76 THz in RR1 and RR2 respectively Fig. 2(a). In the RR3 interference between the two waves occur and RF generated can be analyzed by using the Electrical spectrum analyzers (ESA) at its output. The Phase noise of -90.71dBc/Hz at 10MHz was achieved for 60.1 GHz RF Signal Fig. 2(b) obtained in this design, which is comparable to the analog designs mentioned. Simulations were done on software's involving 3D-FDTD and Mode analysis. Dimensions of RR 1,2,3 taken are 50.4 µm, 50.47 µm, and 50.435 µm respectively.

Authors: Mariya Wani , Dr. Syed Azeemuddin

Research Center Name: Center Of VLSI and Embedded System Technologies(CVEST)