On-chip Frequency Discriminator for Microwave Photonics Signal Processing

D. Marpaung and C. G. H. Roeloffzen

Telecommunication Engineering group, University of Twente, Enschede, The Netherlands

Abstract— Microwave photonics (MWP) techniques for the generation, distribution and processing of radio frequency (RF) signals have enjoyed a surge of interest in the last few years. The workhorse behind these MWP functionalities is a high performance MWP link. Such a link needs to fulfill several criteria namely high link gain, low noise figure and high spurious-free dynamic range (SFDR). High SFDR dictates high linearity and low noise in the links. In a conventional intensity modulated direct detection (IMDD) link the SFDR is mainly limited by the laser relative intensity noise (RIN) and the third order intermodulation distortion (IMD) either from the directly modulated laser or the electro-optic modulator. To break way from these limitations, one might look towards alternative modulation schemes where phase or frequency modulations are used. A type of MWP link that gains significant interest recently is the phase (or frequency)-modulated direct detection link. In such a link, a phase modulated signal is converted to intensity modulation (PM-IM conversion) using an optical frequency discriminator, thereby allowing a simple direct detection scheme instead of the complicated coherent detection. The interest in such a scheme stems from two reasons; first, a phase modulator can provide high linearity and its operation does not require biasing. The second reason is that there is an additional degree of freedom in tailoring the characteristic of the optical filter discriminator to enhance the link performance, i.e., for noise and distortion suppressions.

In this work the we report a high performance phase modulation direct detection microwave photonic link employing a photonic chip as a frequency discriminator. The photonic chip consists of five optical ring resonators (ORRs) which are fully programmable using thermo-optical tuning. In this discriminator a drop-port response of an ORR is cascaded with a through response of another ORR to yield a linear phase modulation (PM) to intensity modulation (IM) conversion. The balanced photonic link employing the PM-IM conversion exhibits high second-order and third-order input intercept points (IIP2 and IIP3) of +46 dBm and +36 dBm, respectively, which are simultaneously achieved at one bias point.

Using the same photonic chip frequency discriminator, we extend the concept of PM-IM conversion to demonstrate the generation of impulse radio ultrawideband (UWB) pulses. We show that the discriminator chip in combination with a phase modulator forms a temporal differentiator. By means of tailoring the discriminator response using either the individual or the cascade of drop and through responses of the ORRs, first-order or second-order temporal differentiations are obtained. Using this principle, the generation of UWB monocycle, doublet and modified doublet pulses are demonstrated. The use of this CMOS-compatible discriminator is promising for the realization of a compact and low cost UWB transmitter.

Author information

Author 1:
Title: Dr.
Name: David Marpaung
Affiliation: University of Twente
Address: PO Box 217
City: Enschede
Postal code: 7500 AE
Country: The Netherlands
Phone: +31 53 489 5342
Email: d.a.i.marpaung@utwente.nl

Author 2 (presenting author)
Title: Dr.
Name: Chris Roeloffzen
Affiliation: University of Twente
Address: PO Box 217
City: Enschede
Postal code: 7500 AE
Country: The Netherlands
Phone: +31 53 489 2804
Email: c.g.h.roeloffzen@utwente.nl