Programmable photonic circuits

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Abstract. We highlight a recent trend in photonics where integrated photonic chips are designed and operated as programmable devices like in the case of integrated electronics. We discuss the potential application of these programmable photonic circuits in signal processing.

1. Introduction

The maturity of integrated photonic manufacturing has allowed implementation of advanced concepts in integrated optical circuits. Integrated photonic circuits nowadays can have very high number of component counts with each component can be tailored in terms of functionalities. An emerging concept recently embraced by integrated photonics is the concept of programmability [1-3]. In ways that mimic electronics, new generations of photonic circuits are presently composed of basic building blocks that are replicated and interconnected to make a larger circuit that can be programmed to carry out numerous functions.

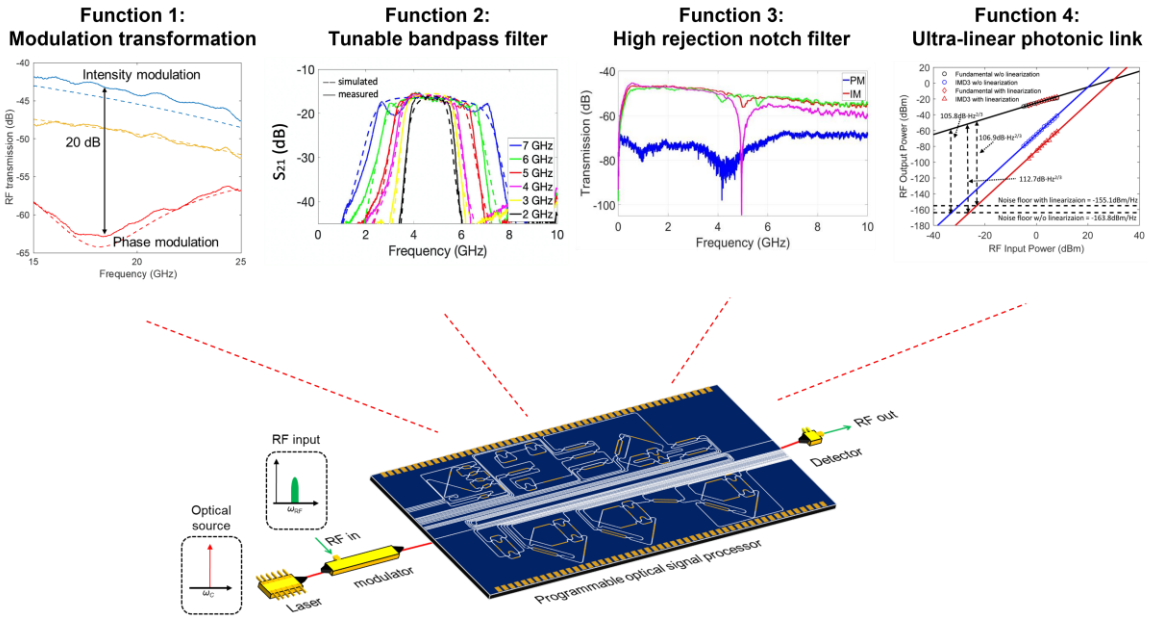

Figure 1. Illustration of a programmable photonic circuit implemented for microwave photonic signal processing.

2. Implementation

In terms of hardware implementation, there are a number of ways to construct a programmable photonic circuit. A more traditional way is to build the circuit based on a mix of dedicated building blocks, such as ring resonators, splitters, combiners, with each of these components capable of reconfiguration [4]. A recent departure from this concept proposed a circuit realized from a mesh of a single building block, which is a tunable beam splitter, that is arranged to allow feedback and feed-forward light propagation [5].

3. Applications

Programmable photonic can find applications in various fields including quantum photonics [1], computing [2], and microwave photonic (MWP) signal processing [3]. For MWP processing in particular, overall system performance including signal-to-noise ratio and linearity is an important factor that currently cannot be satisfied by the mesh-based programmable circuits. For this reason, a new approach in programmable MWP circuit has been proposed. This breakthrough approach relies on two new building blocks with unique programmability, namely an on-chip modulation transformer [6] and a double-injection ring resonator [7]. Using the interconnection of these building blocks an advanced MWP programmable circuit with all-optimized signal processing performance has recently been demonstrated [8].

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