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Routing TEM pulses with interconnected transmission lines for computing applications with electromagnetic waves

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The development of semiconductor-based switching elements several decades ago can be considered the key that opened up the realm of computing as we currently know it. In fact, devices such as metal-oxide field-effect transistors (known as MOS-FETs) enabled the creation of logic gates as fundamental elements in digital electronics and computing circuits [1]. As computing processes becomes more and more complex, the number of such semiconductor-based elements increase. This can become a challenge both in terms of power and also spatial interconnection [2]. As these elements are based on transistors (switching elements) there is an intrinsic temporal delay produced by the charge-discharge process of parasitic capacitances appearing on their gates. Hence, when scaling up the number of elements, delays may become an aspect to overcome if one wish to accelerate computing processes. The research for alternative computing technologies started to take off at the end of the last century and different approaches have been proposed such as collision-based computing with solitons [3] and plasmonic networks [4]. In this context, computing with electromagnetic waves have been also proposed using metamaterials and metasurfaces as artificial man-made media. By enabling the arbitrary control of light-matter interactions both in space and time [5]–[9] they have demonstrated to be good candidates for computing applications such as solving mathematical operations [10].

In this work, to explore alternative ways of computing, we will discuss our recent and ongoing efforts in studying interconnected transmission lines (TLs) for future high-speed computing. We propose two types of interconnected TLs: series and parallel connections. We will discuss how the well-known TL theory can be exploited in configurations where multiple ports are excited by multiple ports using transverse electromagnetic (TEM) pulses [11]. The physics behind such interactions will be described in detail demonstrating how TL-based crossings have the potential for future high-speed computing operations using electromagnetic waves without the need of using charge-discharge based circuit elements being powered by electrical signals.

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