Silicon Photonic Neural Networks for Chaos-based Secure Communication

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***Abstract*—We propose a continuous time recurrent neural network of four neurons modeled on a silicon photonic platform to generate chaos. Two such chaotic systems can be synchronized with low-latency using master-slave synchronization for high-speed secure data communication.**

Keywords—chaos synchronization, cybersecurity, recurrent neural networks, silicon photonics

I. Introduction

The continued growth in Internet traffic and the rise in number of connected devices has necessitated the need for secure communications that support rapid authentication, key exchange, and encryption without occupying significant on-board resources [1] .Due to the current infrastructure of data transmission, latency is introduced when switching from the analog optical domain to the digital electronic domain, with secure signal processing functions largely done via software-based approaches. This latency can integrated all these devices monolithically on a silicon photonics platform [6]; i.e. tunable filter weight bank as silicon microring resonators (MRRs) based on a thermo-optic effect, BPD in germanium on silicon, and a MOD with a silicon MRR employing a carrier-depletion-mode effect in a reversed PN junction.

Chaos is generated by modelling the mathematical equation described by Eq.1. Two identical systems, the transmitter and receiver, will be simulated to provide chaos and coupled using master slave synchronization. Once coupled, a mask will be applied to data utilizing chaos. Masked data will be coupled in the chaos and then decrypted by the coupled transmitter. Due to the properties of chaos synchronization, any third-party system to the connection will alter the synchronized dynamics consequently reveling the existence of an intruder. This property is measured using so-called Lyapunov exponents, to achieve chaos one exponent must be positive [9]. The CT-RNN is modeled by a set of ordinary differential equations [11] which provides the system with nonlinear dynamic, given by:

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