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# Sine Chaotification Model for Enhancing Chaos and Its Hardware Implementation

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**Abstract** When chaotic systems are used in different practical applications, such as nonlinear control and cryptography, their complex chaos dynamics are strongly required. However, many existing chaotic systems have simple complexity, and this brings negative ef <sup>11</sup> to chaos-based applications. To address this issue, this paper



introduces a sine chaotification model (SCM) as a general framework to enhance the chaos complexity of existing one-dimensional (1-D) chaotic maps. The SCM uses a sine function as a nonlinear chaotification transform and applies it to the output of a 1-D chaotic map. The resulting enhanced chaotic map of the SCM has better chaos complexity and a much larger chaotic range than the seed map. Theoretical analysis verifies the efficiency of the SCM. To show the performance of the SCM, we apply SCM to three existing chaotic maps and analyze the dynamics properties of the obtained enhanced chaotic maps. Performance evaluations prove that the three enhanced chaotic maps have more complicated dynamics behaviors than their seed chaotic maps. To show the implementation simplicity of the SCM, we implement the three enhanced chaotic maps using the field-programmable gate array. To investigate the SCM in practical application, we design pseudorandom number generators using the enhanced chaotic maps.

#### Keywords

**Author Keywords:** Chaotic system; chaotification; chaos-based application; cryptography; field-programmable gate array (FPGA) implementation; nonlinear control

**Keywords Plus:** SYSTEM; MAP; PERIOD

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