

# 一个新的超大范围超混沌系统分析与 FPGA 实现

周 围, 吴周青

(重庆邮电大学 光电工程学院/国际半导体学院, 重庆 400065)

**摘 要:** 超混沌系统与混沌系统相比动力学特性更加复杂, 但是目前大多数超混沌系统参数范围较小, 提供的密钥空间较小, 而且在系统参数发生改变时系统容易跳出混沌状态. 针对这个问题, 本文提出了一个新的超大范围超混沌系统. 该系统在参数  $c$  属于  $[1, 10^7]$  时都表现为超混沌状态. 理论分析了新系统的基本动力学行为, 包括系统相图、平衡点、Lyapunov 指数谱和分岔图. 本文进一步用 FPGA 实现了该混沌系统, 给出了系统参数  $c$  分别为 5、100、1000 和  $10^5$  时, 在示波器上捕捉到的  $x$ - $z$  相轨迹图, 验证了该超大范围超混沌系统的 FPGA 可实现性.

**关键词:** 超混沌; 超大范围; 动力学分析; 现场可编程门阵列 (FPGA)

## Analysis and FPGA implementation of a novel super-wide

### range hyperchaotic system

ZHOU Wei, WU Zhou-qing

(College of Electronics Engineering / International Semiconductor College, Chongqing University of

Posts and Telecommunications, Chongqing 400065, China)

**Abstract:** The hyperchaotic system has more complex dynamic characteristics than the chaotic system. However, most hyperchaotic systems currently have a small parameter range and provide a small key space, and the system easily jumps out of the chaotic state when the system parameters change. Aiming at this problem, a novel super-wide range hyperchaotic system is proposed in this paper. The system is hyperchaotic when the parameter  $c$  is  $[1, 10^7]$ . The basic dynamics behaviors of the novel system are analyzed theoretically, including system phase diagrams, equilibrium points, Lyapunov exponent spectrums and bifurcation diagrams. In this paper, the chaotic system is implemented by FPGA, and the  $x$ - $z$  phase trajectories captured on the oscilloscope are given when the system parameters  $c$  are 5, 100, 1000 and  $10^5$  respectively, verified the FPGA achievability of the super-wide range hyperchaotic system.

**Key words:** hyperchaotic; super-wide range; dynamic analysis; field programmable gate array (FPGA)

**作者简介:**

周 围 男, (1971-), 博士, 教授. 研究方向为电路与系统、通信系统及信号处理等.

吴周青 (通讯作者) 男, (1991-), 硕士研究生. 研究方向为混沌理论及其应用研究. E-mail: cejin@foxmail.com