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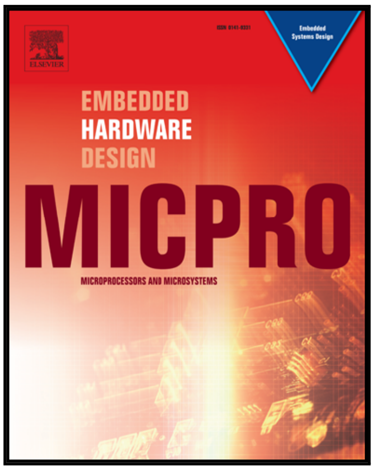

A Novel Configurable Flip Flop Design Using Inherent Capabilities of Quantum-dot Cellular Automata

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A Novel Configurable Flip Flop Design Using Inherent Capabilities of Quantum-dot Cellular Automata

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Abstract: One of the most attractive fields in quantum-dot cellular automata (QCA) is the implementation of configurable structures. In this paper, a novel QCA structure of a configurable flip-flop (CFF) element is introduced. In a bottom-up design approach, this paper firstly proposes well-organized QCA layouts for a positive/negative clock signal generator, a level/edge pulse converter, and a bit transport/toggle storage block. In the next step, these blocks are connected in a cascade construction to form a robust and efficient flip-flop element with a comprehensive configurable capability. The simulation results demonstrate the accuracy of proposed QCA-based structures. Design capability and flexibility of the proposed CFF element are further evaluated through the synthesis of high-level circuits including registers and counters. Consequently, this new element is the best building block to be used in the next generation of configurable systems such as QCA-based FPGAs.

Keywords: Quantum-dot cellular automata; nanoelectronics; configurable hardware; FPGA; flip-flops; registers; counters.

1. Introduction

QCA (Quantum-dot Cellular Automata) is an advanced electronic nanotechnology that supplies logic states not as voltage levels but rather based on the situation of electrons pair [1]. In QCA technology, the basic unit is a QCA cell with four quantum-dots where the electrons pair position establishes logic states [2]. QCA cells are used rather than transistors in the CMOS technology for realizing digital circuits. The QCA-based design style has received considerable attention in recent years because of its high speed and extremely low power dissipation at the Nanoscale [3-5].

The advent of configurable logic hardware in the form of FPGAs (Field-Programmable Gate Arrays) allows electronic designs to be quickly developed and prototyped. The general architecture of FPGA is suitable for a broad range of applications [6] such as IC prototyping, digital signal processing, real-time image processing, cryptography, device controlling, and a growing variety of other areas. With advances in QCA technology, the implementation of configurable hardware can be considered as an interesting topic of research as the work in this paper. There are several previous studies on QCA-based configurable structures related to FPGAs [7-16]. The PIs (Programmable Interconnects) and CLBs (Configurable Logic Blocks) are great circuits that are arranged in regular arrays to form the complete architecture of FPGAs. The QCA-based PI elements have been presented in [7-9] to allow the logic blocks to be interconnected. The QCA-based CLB is composed of LUT (Look-Up Table) and D-FF (D-type flip-flop) elements that are grouped in slices as shown in Fig. 1 in a similar manner to that used in typical CMOS FPGAs. In the QCA technology, LUT-based CLB structures have been proposed in [10–16] to implement the desired