

Reversible Computation, a Quantum-Inspired Low-Consumption Viable Technology?

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Abstract—Through the very last reversible CMOS circuit realizations, this tutorial will discuss the viability of the quantum-inspired low-consumption reversible pass-transistor CMOS technology.

Index Terms—quantum-inspired, reversible computation, adiabatic signal, delay, error correction, threshold voltage, design, implementation, ripple-carry adder, arithmetic logic unit, H.264/AVC, encoding decoding, Spectre simulation, quantum computing, pass-transistor.

OVERVIEW OF THE TUTORIAL

Quantum computing and circuits are of growing interest and so is reversible logic as it plays an important role in the synthesis of circuits dedicated to quantum computation.

Several prototypes and proofs of concept of reversible (quantum-inspired) digital circuits have been successfully designed and fabricated in recent years. These include a 4 bits reversible ripple-carry adder based on Cuccaro's design [1] (Fig.1), a reversible arithmetic logic unit (ALU) designed by Thomsen *et al.* [2] (Fig.2), and a 4-bit inputs to 6-bit outputs H.264/AVC encoder (Fig.3).

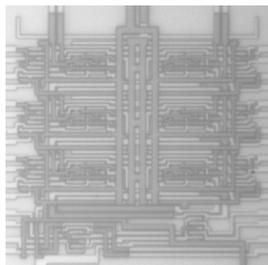


Fig. 1. Photograph of the 4 bits Cuccaro adder.

These physical implementations of quantum-inspired reversible circuits proved that digital reversible dual-line pass-transistor technology can be used for reversible computations. Therefore, reversible logic may provide an alternative to classical computing machines, that may overcome many of the power dissipation problems in the near future.

In order for this new technology to be used in commercial applications, several questions have to be answered first.

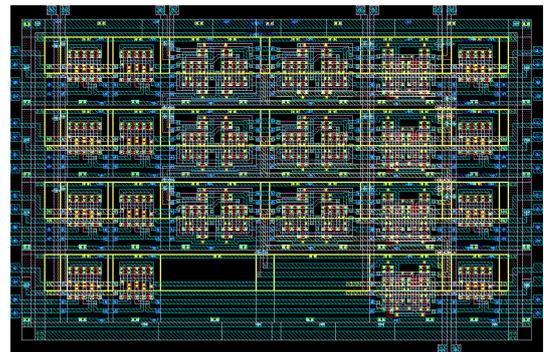


Fig. 2. Layout of the 4 bits reversible Arithmetic Logic Unit.

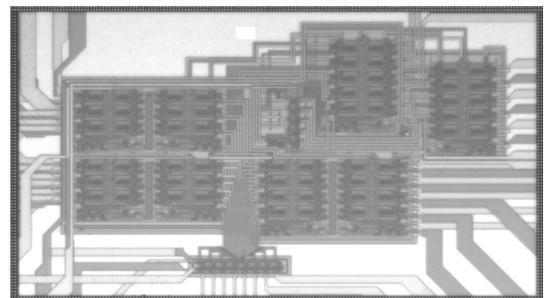


Fig. 3. Photograph of a 4 x (4 to 6 bits) H.264/AVC encoder.

Taking the example of these physical realizations, this tutorial will therefore:

- discuss the adiabatic addressing of signals [3] and show that:
 - adiabatic signals provide better results in term of performances and reliability than conventional rectangular pulses usually applied in conventional CMOS circuits,
 - adiabatic calculations performed on reversible CMOS circuits allow correcting most of the calculation errors caused by rectangular signal delays, thanks to the effective threshold voltage of the transmission gates,

- present simple interfacing of reversible CMOS circuits with classical CMOS restoring technology [4] showing by the way that:
 - CMOS reversible circuits can be embedded in larger systems in order to either replace or complete some functions usually done by conventional circuits and
 - reversible circuits may be designed such that they are fully compatible with conventional restoring CMOS technology.
- and then discuss the limits of the reversible CMOS technology and in particular:
 - the maximum acceptable delays and amplitude drops [5],
 - the number of gates possibly cascaded [5],
 - the maximum reachable frequencies [5],
 - the theoretical energy saving possible [6], [7],
 - the main actual breaks for reversible computation technique expansion.

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