Skysong Innovations
Advancing the Arizona State University Knowledge Enterprise

1475 N. Scottsdale Road, Suite 200
Scottsdale, AZ 85287-3538
Phone: 480 884 1996 Fax: 480 884 1984

Case ID:M12-193P
Published: 10/3/2012

# Spintronic Threshold Logic Gate and Spintronic Threshold Logic Array

## Inventors

Sarma Vrudhula
Nishant Nukala
Niranjan Kulkarni

## Contact

Shen Yan
shen.yan@skysonginnovations.com

Within the field of digital logic circuits, there are special gates called threshold gates (TG), which operate differently from conventional CMOS logic gates. The study of threshold functions date back to the 1960s and an extensive body of literature exists on the subject covering their properties, methods for identifying them, function decomposition and network synthesis. The advent of nanotechnology has renewed interest in threshold logic because several nano-devices such as resonant tunneling diodes (RTDs) and quantum cellular automata (QCAs) are inherently threshold gates. Threshold functions are a subset of Boolean functions that can be expressed as a predicate involving a linear (integer) weighted sum of the input variable and dome integer threshold. Given that a single threshold gate can implement an otherwise complex logic function, with the availability of an efficient design of a threshold gate, a network of threshold gates can potentially lead to significant reduction in area, dynamic and leakage power, and increase in performance when compared to an equivalent logic network consisting of conventional logic primitives.

Researchers at Arizona State University have taken an entirely different approach to realizing a threshold gate. They have developed a first of its kind architecture for a threshold logic gate based on the integration of conventional MOSFETs and a Spin Torque Transfer-Magnetic Tunneling Junction (STT-MTJ) device. The resulting cell, called Spintronic Threshold Logic (STL), is extremely compact, and can be programmed to realize a large number of threshold functions, many of which would require a multilevel network of conventional CMOS logic gates. These researchers invented a novel array architecture consisting of STL cells onto which complex logic networks can be mapped. The resulting array is called a Spintronic Threshold Logic Array (STLA) and has several advantages not available with conventional logic.

Potential Applications

- Any company invested in Field Programmable Gate Arrays (FPGA)

Benefits and Advantages

- Non-volatile logic circuit - Will retain the partial results of a computation even when the power is disconnected
- Compact - It resembles the structure and operation of a DRAM, and is very compact
- Fully observable and controllable - The inputs of every STL cell are fully controllable, and its outputs are fully observable, without having to include any scan capability
- Efficient - Zero standby power consumption.

- Reduced Size - Substantial reduction in area, up to 12X fewer transistors than corresponding FPGA