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RRAM-Enhanced Differential Threshold Logic Gates That Are Robust For Low Voltage Operation

All digital circuits use sequences of logic gates that implement Boolean functions to store and transmit binary information. Threshold logic gates receive multiple input signals and produce a single output if the number of signals is below a hardwired threshold value, and can therefore process any Boolean function that might otherwise require multiple ordinary logic gates. As a result, digital circuits made from threshold logic gates are smaller, faster, and more power efficient. Differential threshold logic gates (DTG's) withstand electromagnetic interference by comparing the difference between two clocked complementary signals. However, current DTG's suffer a disproportionally large clock load for a higher number of input signals, allow variable loading that can cause clock timing issues, and for all DTG architectures, circuit failures begin to occur at low supply voltages (under 1.08V) and thus require greater resistance from the input networks.

Researchers at ASU have developed DTG's enhanced by a network of resistors that are robust for low voltage operations (down to 0.6V for 65nm technology). The CMOS-compatible nanoscale resistors are made from oxide-based resistive random access memory (RRAM). The RRAM resistors are read-only and need to be programmed only once after fabrication, and are designed so that their programming does not affect normal high voltage operation. The DTG's are equipped with complementary signal assignment that ensures the number of incoming complementary signals are never equal, resulting in a constant load on the clock regardless of the number of input signals that saves power. The RRAM-enhanced DTG's achieve a remarkable balance between functionality, versatility, and dependability, such that circuit size and power consumption are significantly reduced without any performance degradation.

Potential Applications

- Digital Circuits
- DSP Cores
- Microelectronics
- Microprocessors

Benefits and Advantages

- Efficient – Decreases circuit area and power consumption without penalizing performance
- Inexpensive – Smaller circuits mean lower semiconductor material costs.
- Innovative – Utilizes RRAM resistor network for supply voltages under 1.08V.
- Practical – Implements simple, single-input, as well as complex, multi-input Boolean functions.

- Versatile – Supports both high and low voltage operations.

For more information about the inventor(s) and their research, please see

Dr. Sarma Vrudhula's directory webpage