

Magnetic Logic Circuits for Extreme Environments

The goal of this research project is to demonstrate the feasibility of realizing digital logic gates from magnetoresistive (MR) devices. These devices are high-speed, radiation-tolerant and capable of reliable operation in extreme environments including low temperature (up to and below 77K) and wide temperature swing. Additionally, preliminary evidence indicates radiation tolerance up to 1 MRad. In contrast to semiconductor devices that are increasingly sensitive to single-event upsets (SEU) at smaller dimensions and operating voltages, MR devices promise scalability with better SEU immunity.

Although there has been previous work to implement magnetic logic with giant magnetoresistive (GMR) devices, practical usefulness has been limited primarily due to the lack of sufficient gain for realizing multi-stage or cascaded circuits. The gain is determined by the maximum change in the resistance of the device. Typically, GMR devices display a maximum change in resistance of about 40% which, despite being “giant” in comparison to previously observed magnetoresistive phenomenon, provides inadequate gain for the output of a magnetic logic element to drive the input of the next without an intervening semiconductor-based amplifier. Tunneling magnetoresistive (TMR) devices, where resistance change in excess of 300% has recently been demonstrated, offer to overcome this shortcoming making *all-magnetic* logic circuits possible.

The objective of this project is to develop, design, and test a 2-stage all-magnetic logic circuit using TMR devices.

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