

Hybrid Hall Effect Devices -- a Novel Building Block for Reconfigurable Logic

Steve Ferrera, Nicholas P. Carter
University of Illinois at Urbana-Champaign

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Outline

- Motivation
- The HHE Device
- Reconfigurable Gates Using HHE Devices
- Simulation Results
- Conclusion

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Motivation

- SRAM-based lookup tables are the dominant implementation technology for reconfigurable logic
 - Fast
 - High Density
 - Volatile – lose state without power
 - Vulnerable to alpha particle strikes and other effects (importance of this depends on application)

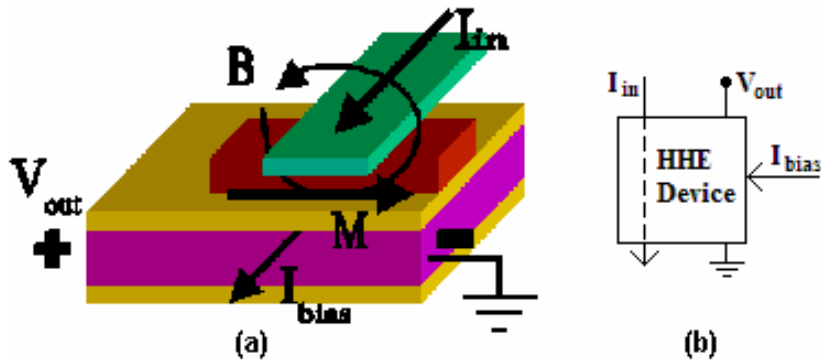
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Motivation 2

- Magnetoelectronic devices have the potential to overcome many of the limitations of SRAM
 - Non-volatile – retain state without power
 - Can integrate computation with storage
 - Radiation-tolerant, although affected by magnetic fields

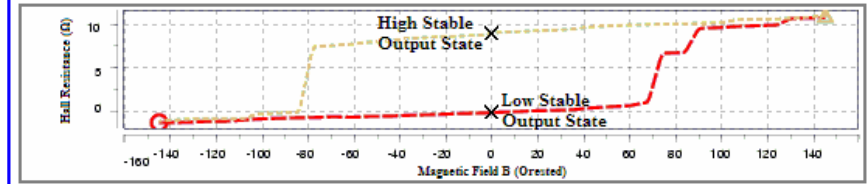
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Hybrid Hall Effect Device



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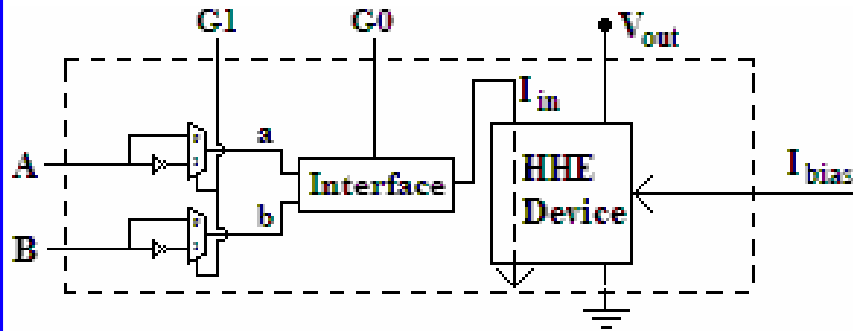
Hysteresis Loop



Once magnetized in a given direction, ferromagnetic element retains its state without requiring an external magnetic field

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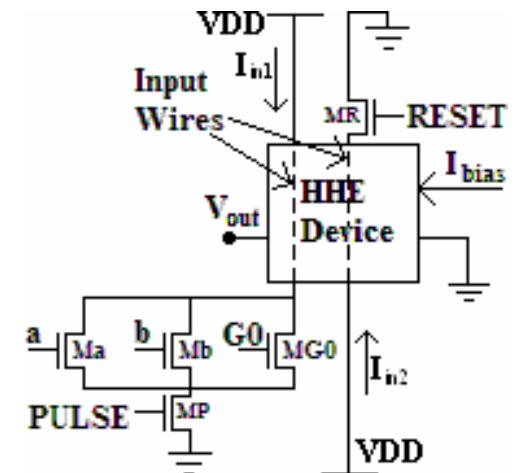
Reconfigurable HHE Gate



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Reset-Based Gate

- Two-wire HHE gate to simplify circuitry
- Reset pulse sets gate to logical 0
- Evaluation pulse conditionally sets gate to logical 1



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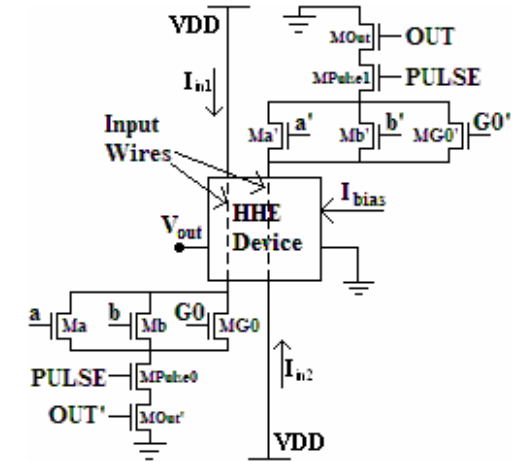
Limitations of Reset-Based Design

- High power consumption
 - RESET pulse draws enough current to set magnetization state of the HHE device on every cycle, even if gate output remains constant
- Multi-phase clocking

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Reconfigurable Gate With Output Feedback

- Use output voltage to prevent current flow through input wire corresponding to current state of the gate
- Single PULSE signal triggers evaluation of gate



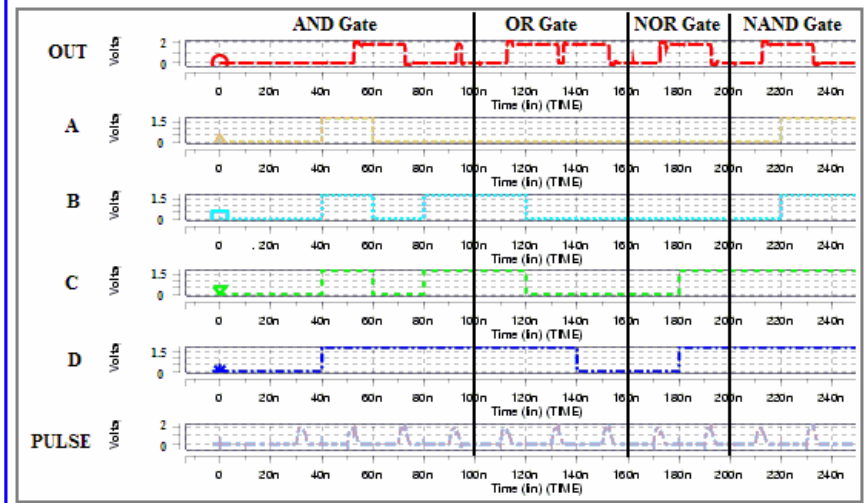
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Simulation

- Implemented HSPICE model of HHE device
 - Very accurate model of magnetization curve
 - Timing much more approximate

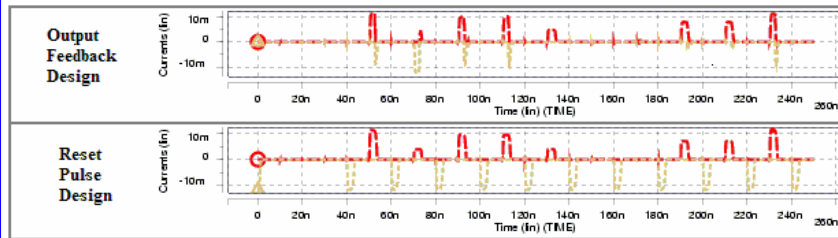
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4-Input Reconfigurable Gate



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Reset Pulse Vs. Output Feedback



- Output feedback design consumes 2.4x less power than reset pulse design, though this will vary depending on input pattern

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Future Plans

- Working with researchers at the NRL to fabricate the circuits described here
- Exploring PLA designs based on HHE devices
- Threshold logic circuits
 - Issue: fabrication variance
- Longer term: Trade off device usage vs wiring complexity in HHE-based FPGAs

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Conclusion

- HHE devices are a promising alternative to pure-CMOS reconfigurable logic in applications where non-volatility is important
- Have demonstrated a number of circuits that integrate HHE devices with more-conventional CMOS to implement reconfigurable gates

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