Asynchronous Ballistic Reversible Superconducting Computing

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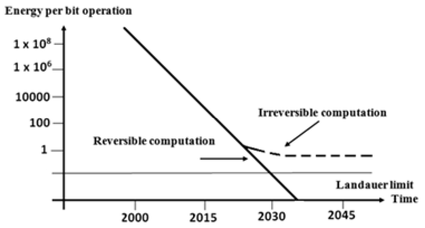
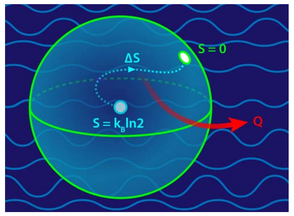
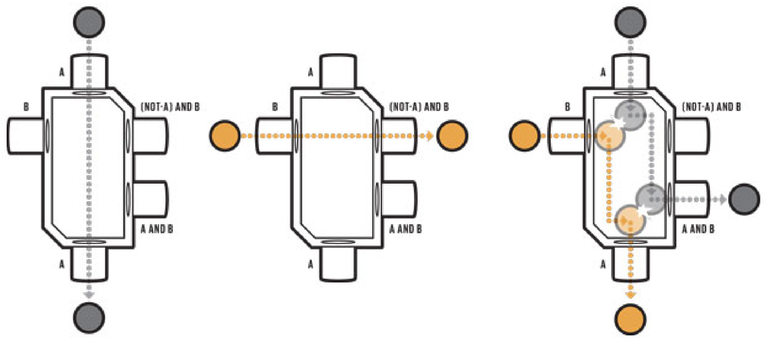
Introduction and Motivation

- Reversible Computing – Ability to recover inputs
  - Beyond CMOS
  - Landauer's limit – Minimum amount of energy required to transfer information
- Superconductivity – Current can be transmitted without any resistance
  - High power efficiency
  - Fast processing capabilities

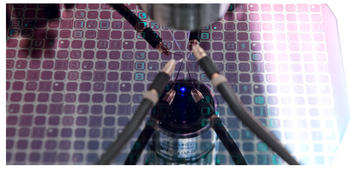






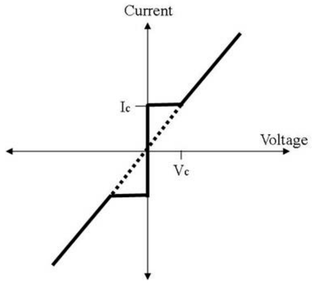
Applications

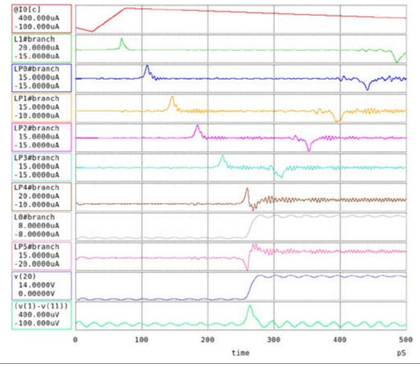
- Quantum Computing (Skywater)
  - DWAVE
  - Northrop Grumman
- Communications (HYPRES)
  - High bandwidth ADCs (Aerospace and Defense)



Project Background

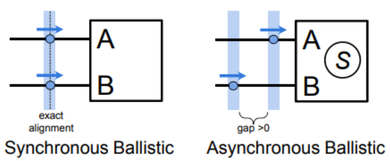
- WRSpice
  - Provides support for simulating superconducting circuitry using a SPICE foundation
  - Uses SPICE netlists files to be interpreted as a circuit
- Josephson junctions (JJ)
  - Can allow a current to pass through with zero voltage drop

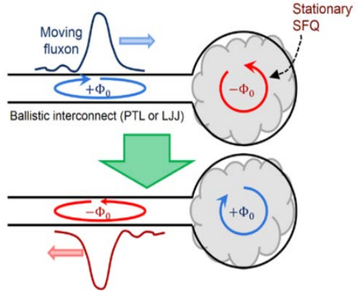


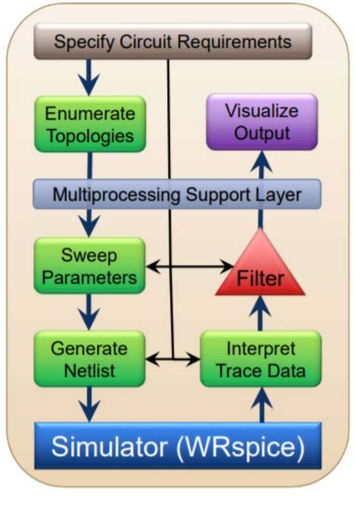


Objective

- Search and find asynchronous ballistic reversible superconducting (ABRS) circuits
  - Create a software tool to search for possible circuits
- Find design principles for ABRS circuits







Current Status

- Progress:
  - Generated all netlists for exclusively series and parallel circuits
    - Combinations of JJs, capacitors, and inductors
  - Developed simulation data output as CSV files which can be manipulated by MATLAB
  - Created python to WRSpice interface
- Challenges:
  - Understanding the theory in order to understand simulation outputs
  - Generalizing circuit building to not recreate previously simulated circuits
  - Finding an algorithm to optimize circuit search and identify working patterns

Future Work

- Spring Plan:
  - Add combinations of series and parallel circuits to netlist generation
  - Create a method of automating testing and filtering of results
  - Implement a search algorithm:
    - Random search
    - Systematic search
    - Genetic search
- Goals:
  - Find working circuits
  - Potentially: write a conference paper based on tool findings

References

- **Michael Frank** – PhD, SMTS at Sandia National Laboratories
  - Sponsor
- **Frank Allen** – Electrical Engineering student
  - Lead Engineer
- **James Hardy** – Electrical and Computer engineering student
  - Lead Programmer
- **Oscar Lopez** – Electrical Engineering student
  - Lead Researcher
- **Fadi Matloob** – Computer Engineering student
  - Project Manager