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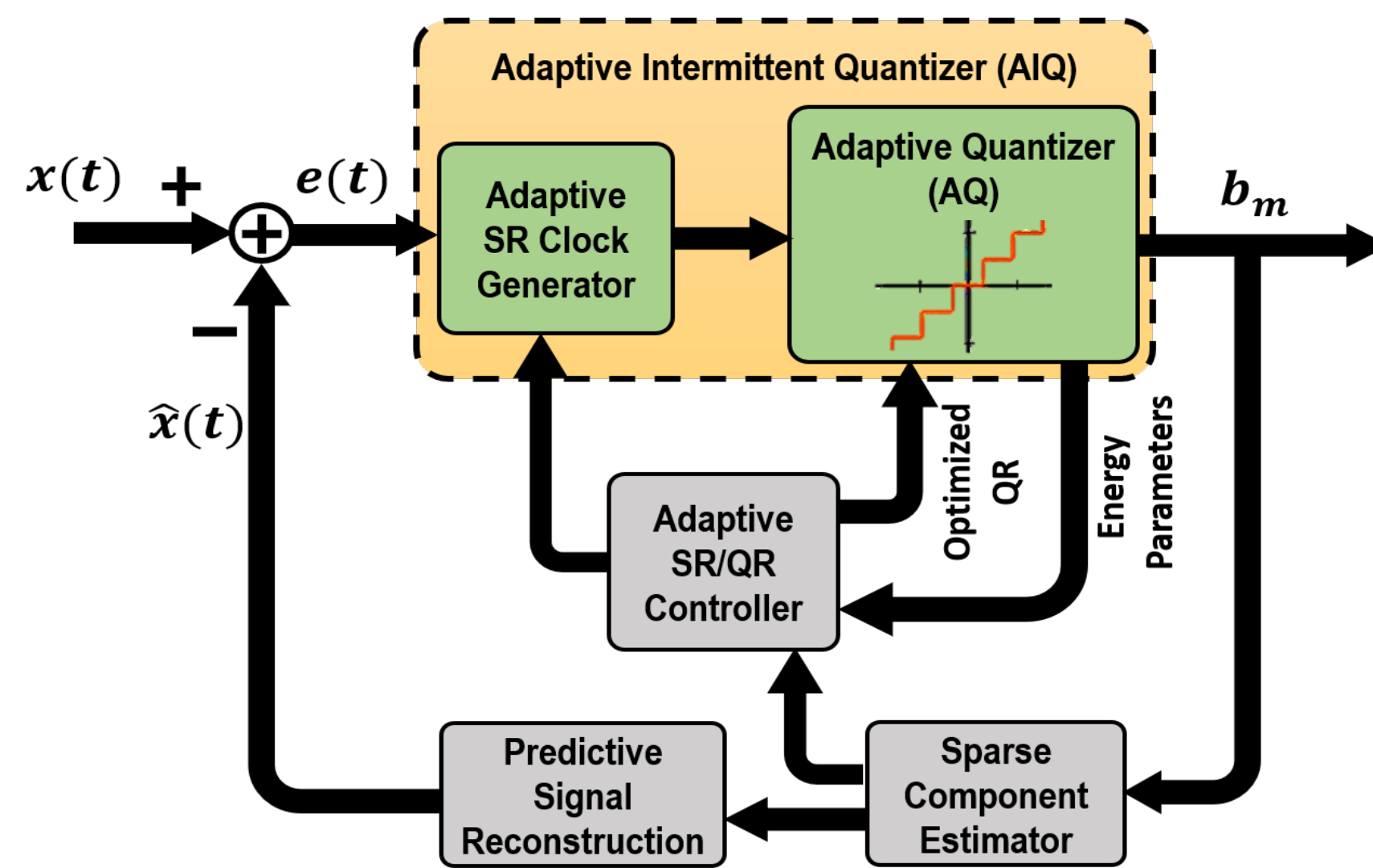
A Spin-based Analog to Digital Converter Interactive Simulation Framework

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Energy-Aware Adaptive Rate and Resolution Sampling

- Beyond-CMOS device / algorithms research
- NSF Communications, Circuits and Sensing Systems (CCSS) multidisciplinary effort
- Innovative **circuit designs utilizing emerging spin-based devices for Compressive Sensing [1][2][3]**
- Foci of CCSS include **development of a novel framework for intelligent sensing and associated educational tools.**



Educational Outreach Goals

Project Website:

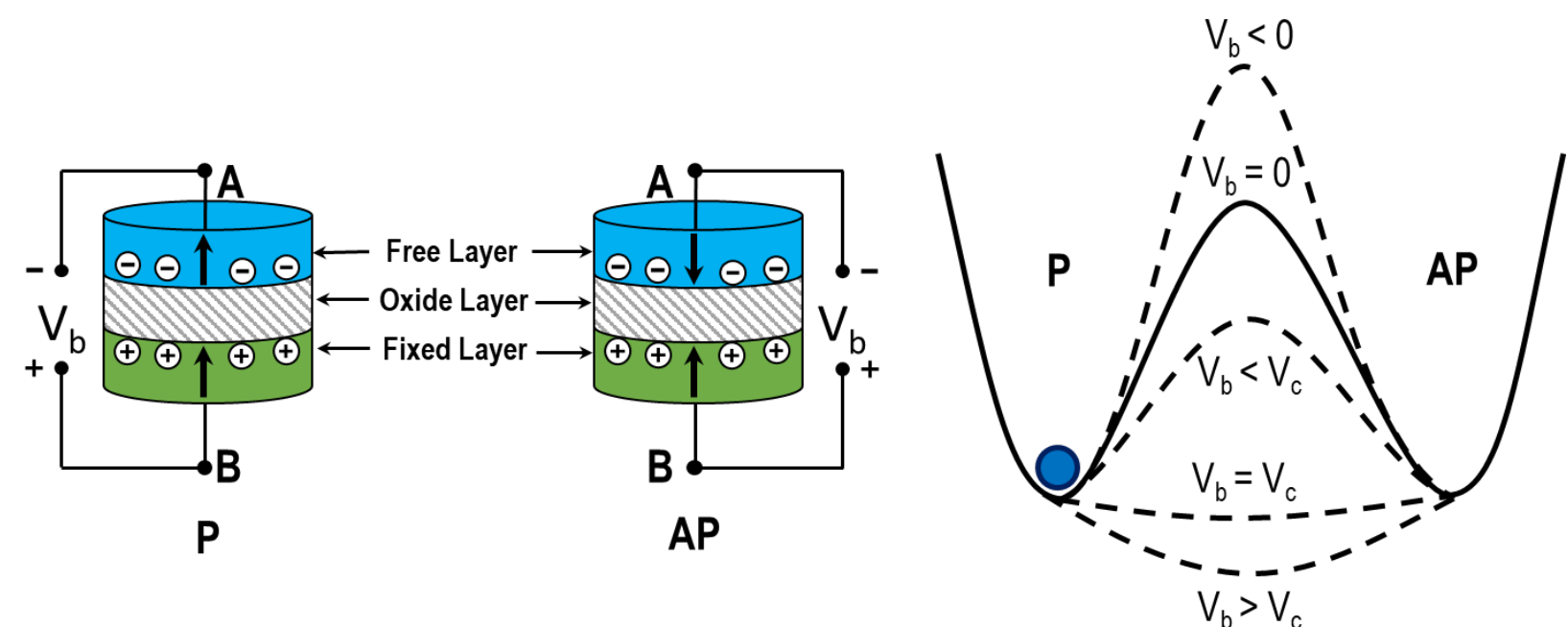
(<http://cal.ucf.edu/ccss>):

includes project overview, recent research publications and awards, team members, and educational resources.



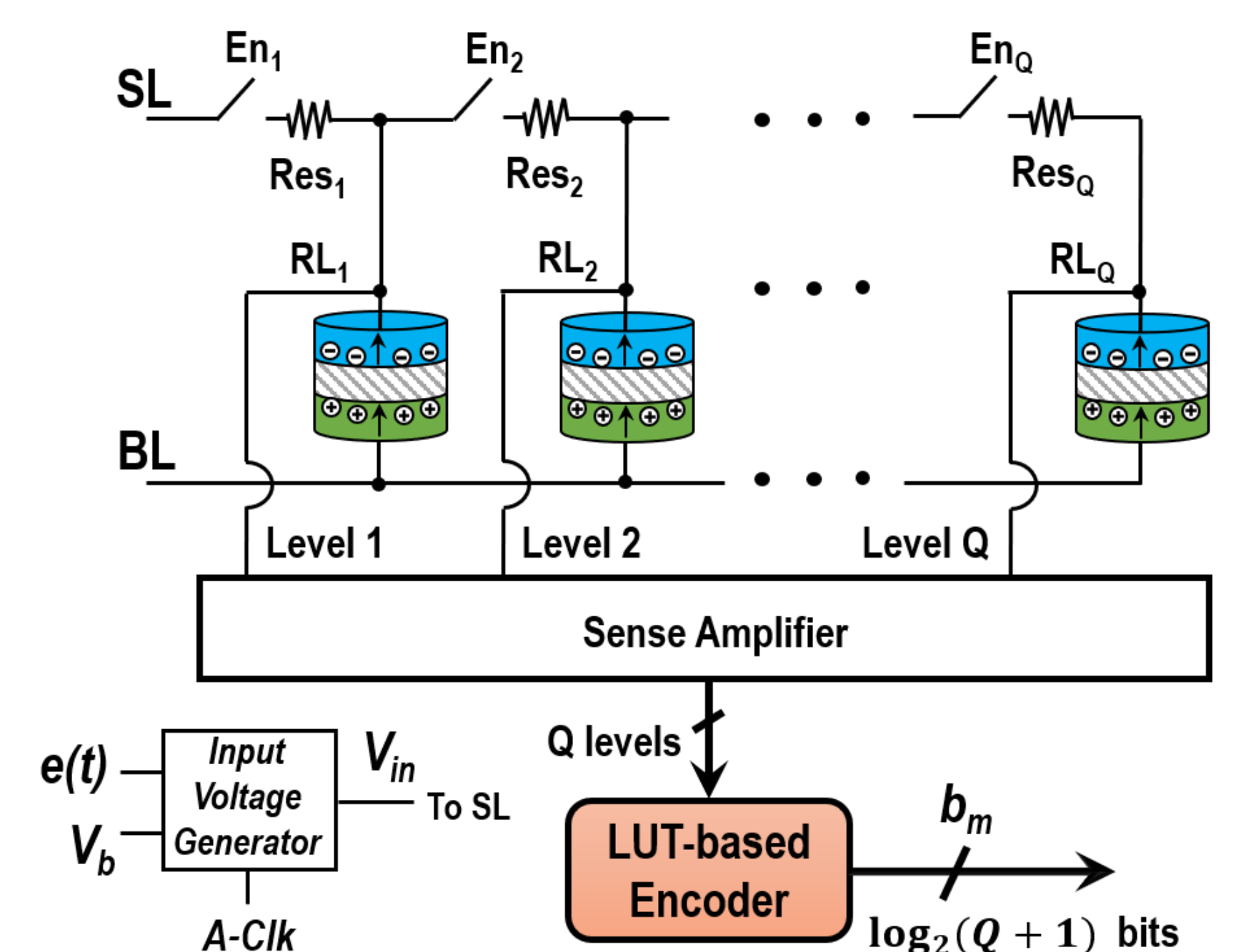
VCMA-MTJ Device

A spintronic device that offers non-volatility, near zero stand-by power dissipation, area efficiency, fast energy-efficient read and write operations by further reducing the dynamic power dissipation using the Voltage Controlled Magnetic Anisotropy (VCMA) effect [1].



Spin-based ADC Leveraging VCMA-MTJ Devices

- **Adaptive Spintronic-based ADC:** faster and more energy-efficient signal sampling and quantization. Additionally, the utilization of spin-based devices offer various quantization levels via VCMA effect [1].
- **Three Modes of Operation:**
 - **Reset Step:** All VCMA-MTJ Devices will be reset to zero representing the Parallel State.
 - **Sampling Step:** Utilizes a bias voltage to modify the energy barrier and applies an analog input to write into the active VCMA-MTJ devices.
 - **Sensing Step:** Senses the data stored in each active device using a sense amplifier.

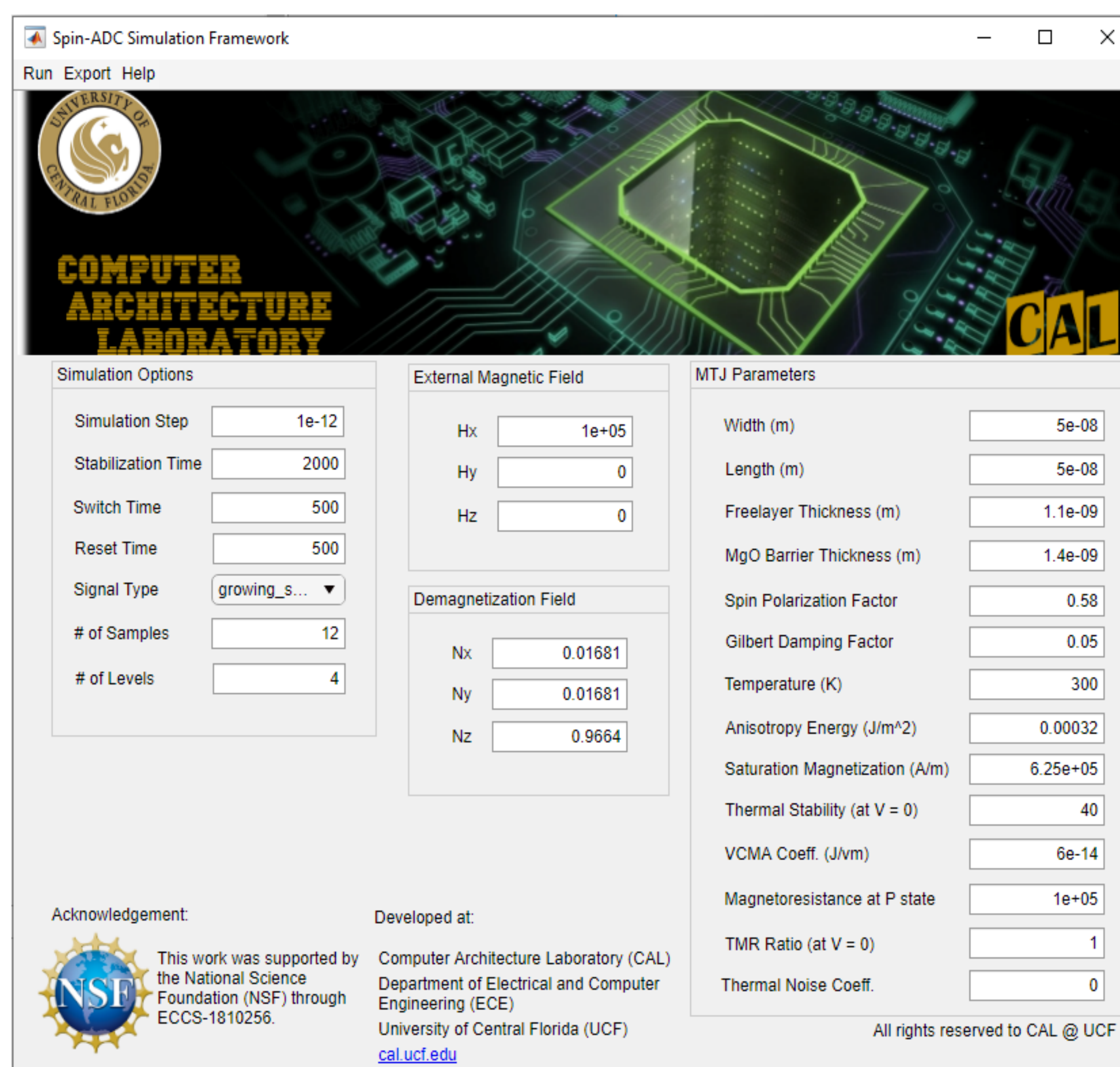


Interactive Tool Flow

Functionalities

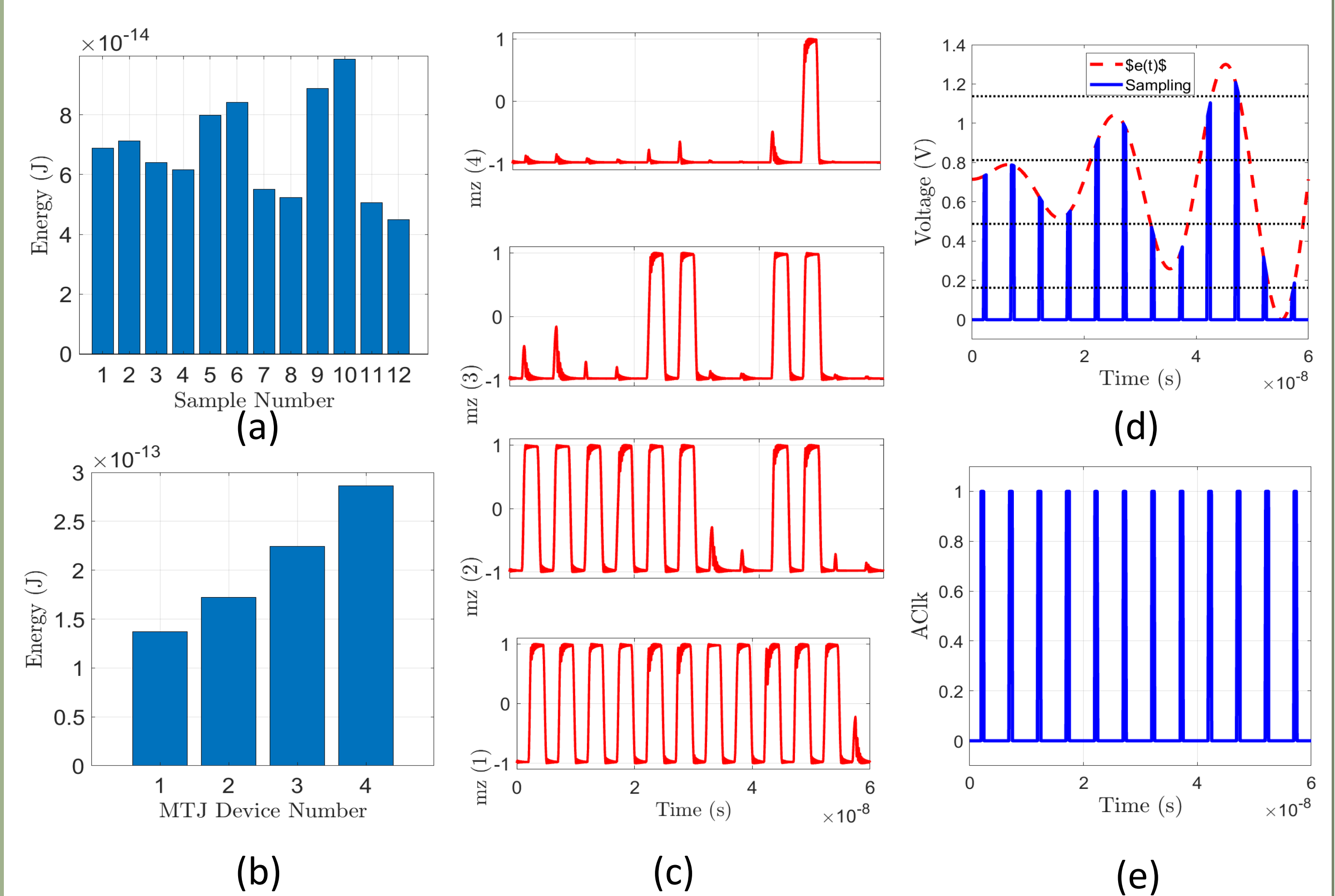
- Spin-ADC Interactive Simulator provides a **Graphical User Interface (GUI)** that allows for the modification and insertion of values for Spin-ADC simulations.
- **Default parameter values** reflect simulation cases used in [1].
- **Vary device parameters** for running different simulations with different scenarios.
- **Run option** that compiles all parameters and simulation options to display simulation results.
- **Simulation results** are displayed in a different GUI window displaying different characteristics.
- **Help option** that redirects to various educational resources website for more information.

GUI



Web-based interface of simulation framework

Output Waveforms



Sample output of proposed simulation framework: (a) depicts energy consumed for each sample, (b) illustrates energy consumed by each MTJ, (c) shows magnetization orientation of each MTJ, (d) demonstrates analog input waveform, and (e) visualizes sampling rate.

Outreach Objectives

- Utilize research findings in undergraduate & graduate coursework.
- Develop an interactive tool based on research findings.
- Utilize the proposed tool to engage and attract high school students into STEM-related fields.
- Use educational resources website for explanation and distribution of the proposed interactive tool.

Current Work

- Spin-ADC Interactive Simulator: Simulation Runs with 2-Terminal MTJs
- Spin-ADC Interactive Simulator: MTJ Parameters Walkthrough
- Finalize the export option to save the acquired data from simulations in a spreadsheet document.

Acknowledgements

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References

- [1] S. Salehi, M. B. Mashhadi, A. Zaeemzadeh, N. Rahnavard and R. F. DeMara, "Energy-Aware Adaptive Rate and Resolution Sampling of Spectrally Sparse Signals Leveraging VCMA-MTJ Devices," in *IEEE Journal on Emerging and Selected Topics in Circuits and Systems*, vol. 8, no. 4, pp. 679-692, Dec. 2018.
- [2] S. Salehi, A. Zaeemzadeh, A. Tatulian, N. Rahnavard, and R. F. DeMara, "MRAM-based Stochastic Oscillators for Adaptive Non-Uniform Sampling of Sparse Signals in IoT Applications," in *Proceedings of IEEE Computer Society Annual Symposium on VLSI (ISVLSI'19)*, Miami, FL, USA, July 15-17, 2019.
- [3] S. Salehi, R. Zand, A. Zaeemzadeh, N. Rahnavard, and R. F. DeMara, "AQuRate: MRAM-based Stochastic Oscillator for Adaptive Quantization Rate Sampling of Sparse Signals," in *Proceedings of ACM Great Lake Symposium on VLSI (GLSVLSI'19)*, Tysons Corner, VA, USA, May 9-11, 2019.

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