On the Effects of Environmental Factors on the Functionality of Modern Dynamic Random Access Memory Modules

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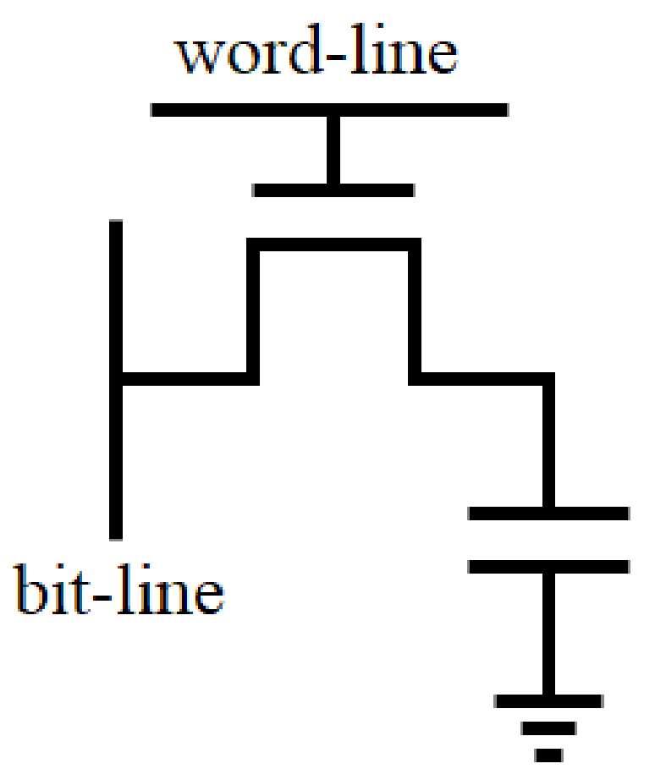
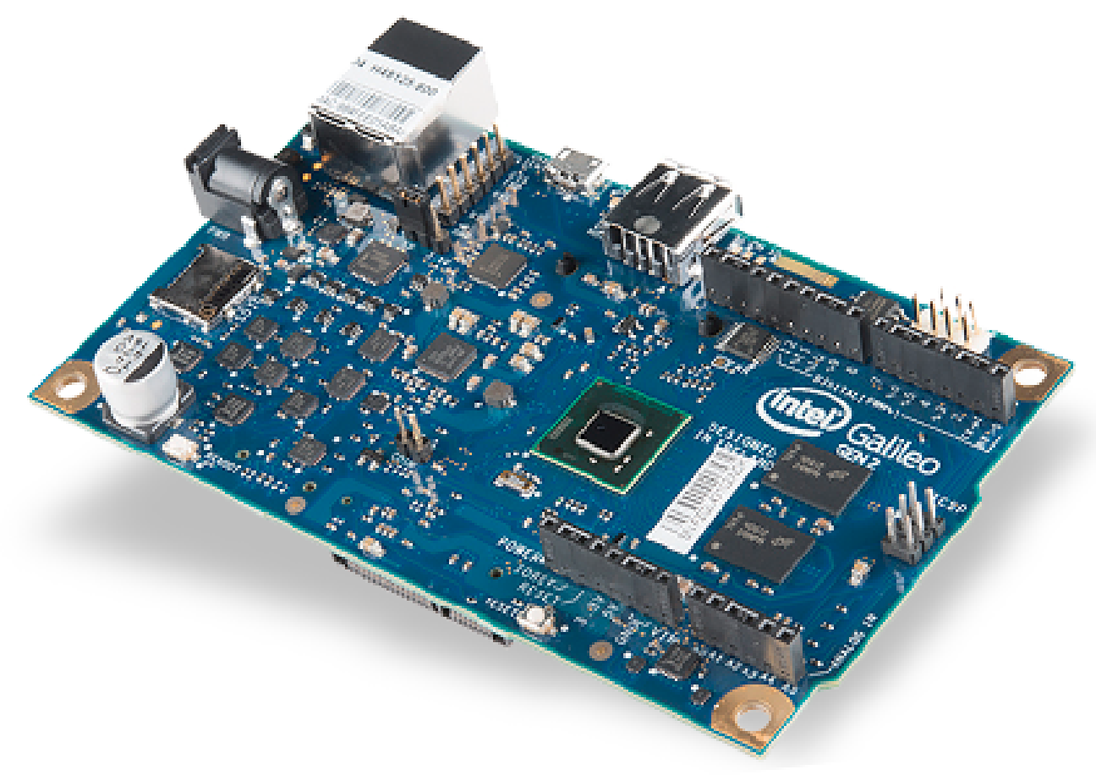
Introduction and Motivation

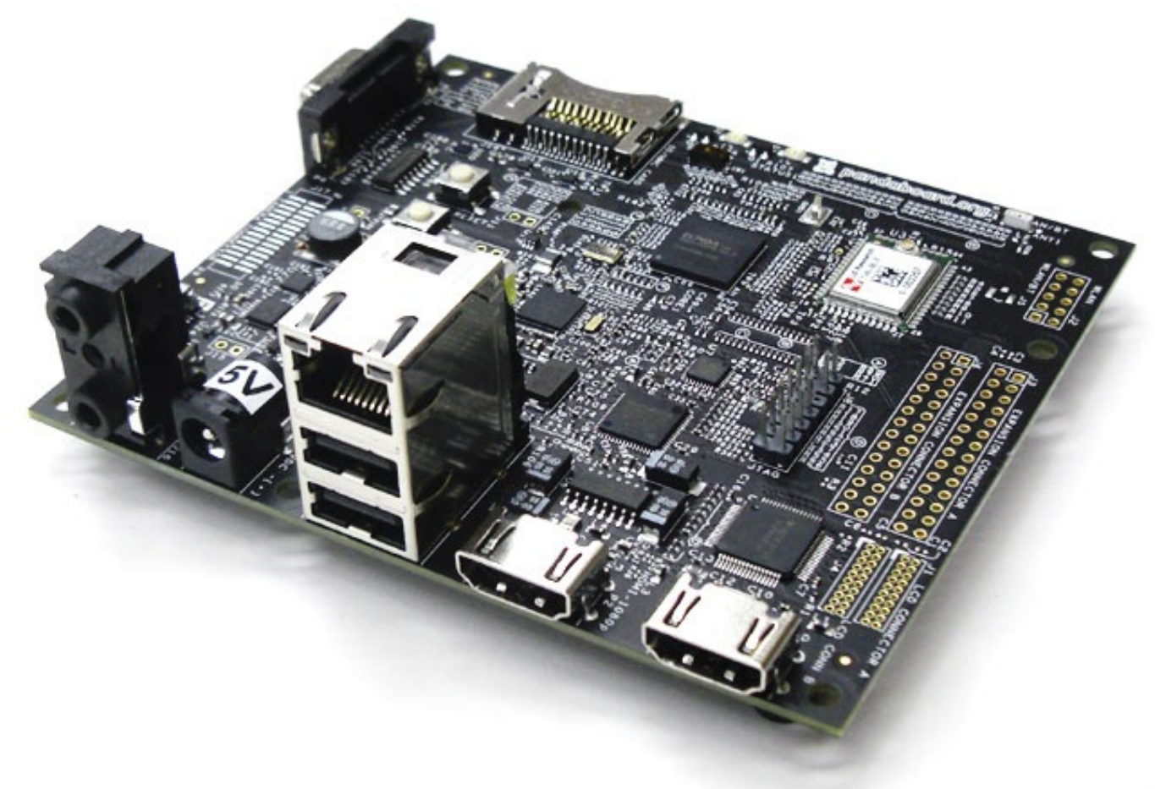


- Modern DRAMs are produced using a very large scale of integration; their manufacturing process is at nanometer scale.
- DRAM cells consist of a gatekeeper transistor and a storage capacitor, whose state indicates the logical value of each cell.
- However, due to the DRAM cells becoming smaller and smaller, such memory modules may be significantly affected by adverse environmental conditions.
- DRAM Physical Unclonable Functions (PUFs) are security primitives, whose operation is based on DRAM characteristics.
- To check the robustness of DRAM modules under adverse conditions, we investigate the effects of ambient temperature, voltage and radiation on DRAM PUFs.

Experimental Setup



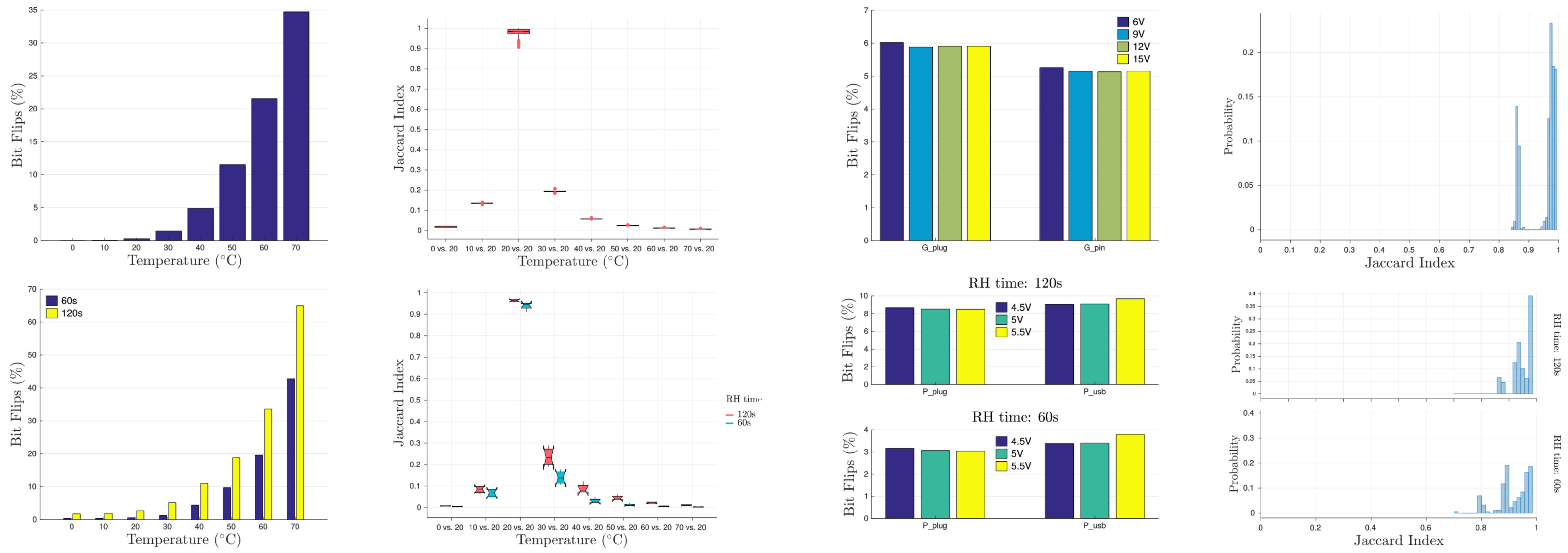
- Intel Galileo Gen. 2
- 256MB DDR3 SDRAM
- Power input of 12V through power jack socket



- PandaBoard ES
- 1 GB LPDDR2 SDRAM
- Power input of 5V through power jack socket

- Intel Galileo Gen. 2 tested at 6V, 9V, 12V or 15V provided through its power jack socket or a pair of power pins
- PandaBoard tested at 4.5V, 5V or 5.5V provided through its power jack socket or its USB socket
- Both platforms are tested at different temperatures: 0°C, 10°C, 20°C, 30°C, 40°C, 50°C, 60°C, 70°C.

Results



- Experimental results for Intel Galileo (top 4 figures) and PandaBoard (bottom 4 figures) at different temperature (left 4 figures) or voltage (right 4 figures) conditions. All experiments were conducted with the refresh operation disabled.
- The robustness of DRAM is highly affected by ambient temperature; temperature variations reduce the reliability of DRAM.
- External power supply voltage variations do not have a significant influence on DRAM.
- Based on “Analysis of Radiation Effects on Individual DRAM Cells” by Scheick et al., we expect that radiation may reduce the reliability of DRAM.

Publications

[1] W. Xiong, A. Schaller, N. A. Anagnostopoulos, M. U. Saleem, S. Gabmeyer, S. Katzenbeisser & J. Szefer, "Run-Time Accessible DRAM PUFs in Commodity Devices", Proceedings of the 18th International Conference on Cryptographic Hardware and Embedded Systems (CHES 2016), vol. 9813 of "Lecture Notes in Computer Science (LNCS)", pp. 432-453, Springer, 2016.

[2] A. Schaller, W. Xiong, N. A. Anagnostopoulos, M. U. Saleem, S. Gabmeyer, S. Katzenbeisser & J. Szefer, "Intrinsic Rowhammer PUFs: Leveraging the Rowhammer Effect for Improved Security", Proceedings of the 2017 IEEE International Symposium on Hardware Oriented Security and Trust (HOST), IEEE, 2017.

[3] A. Schaller, W. Xiong, N. A. Anagnostopoulos, M. U. Saleem, S. Gabmeyer, B. Škorić, S. Katzenbeisser & J. Szefer, "Decay-Based DRAM PUFs in Commodity Devices", IEEE Transactions on Dependable and Secure Computing (TDSC), IEEE, 2018.

[4] N. A. Anagnostopoulos, S. Katzenbeisser, J. Chandy & F. Tehranipoor, "An Overview of DRAM-Based Security Primitives", Cryptography, vol. 2, iss. 2, MDPI, 2018.

[5] N. A. Anagnostopoulos, T. Arul, Y. Fan, C. Hatzfeld, A. Schaller, W. Xiong, M. Jain, M. U. Saleem, J. Lotichius, S. Gabmeyer, J. Szefer, S. Katzenbeisser, "Intrinsic Run-Time Row Hammer PUFs: Leveraging the Row Hammer Effect for Run-Time Cryptography and Improved Security", Cryptography, vol.2, iss. 3, MDPI, 2018.

[6] N. A. Anagnostopoulos, T. Arul, Y. Fan, J. Lotichius, C. Hatzfeld, F. Fernandes, R. Sharma, F. Tehranipoor & S. Katzenbeisser, "Securing IoT Devices Using Robust DRAM PUFs", 2018 Global Information Infrastructure and Networking Symposium (GIIS'18), 23-25 October 2018, Thessaloniki, Greece.

[7] N. A. Anagnostopoulos, T. Arul, Y. Fan, R. Sarangdhar, R. Sharma, M. Rosenstihl, C. Hatzfeld, F. Tehranipoor & S. Katzenbeisser, "On the Effects of Environmental Factors on the Functionality of Modern Dynamic Random Access Memory Modules", 7th International Conference "Micro&Nano 2018", 5-7 November 2018, Thessaloniki, Greece.

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