Ph.D. in Information Technology
Thesis Defense

April 10th, 2024
at 2:00 p.m.
Room BIO 1, Building 21

Michele CASTRIOTTA – XXXVI Cycle

FULLY INTEGRATED CRYOGENIC ELECTRONIC READOUT FOR SPIN-BASED QUBITS

Supervisor: Prof. Giorgio Ferrari

Abstract:

Developing fault-tolerant quantum computers operating at deep cryogenic temperatures necessitates auxiliary cryogenic electronics to control and readout qubits. Indeed, the proximity between classical and quantum hardware reduces wiring complexity to room temperature instruments, minimizes heat load, and mitigates parasitic capacitances.

Currently, classical electronics operate at room temperature, occupying entire rooms. The future of this solid-state quantum computer technology hinges on developing cryogenic electronics platforms, offering benefits like enhanced qubit integration and improved reading speed and resolution. To address the limited cooling capacity of refrigerators, we have designed a power-efficient, fully integrated CMOS readout system tailored explicitly for semiconductor spin qubits. This readout system employs direct spin-to-digital conversion, integrating spin-dependent currents from single-electron transistors and precise comparators to provide 1-bit digital outputs corresponding to the qubit states. The cryogenic comparator uses floating-gate transistors, ensuring low power consumption, compactness,

and self-calibration. Remarkably, this readout system can resolve minute variations in sensing currents down to 250 pA with sub-microsecond temporal precision and a fidelity of 99.86%. Moreover, it operates within a tiny footprint (less than 0.04 mm2) and consumes 1.2 mW of power. Compared to conventional RFreflectometry readout techniques, it eliminates the need for offchip components and microwave signal handling, offering a more compact and reliable readout solution.

PhD Committee

Marco Sampietro, **Politecnico di Milano**
Fabio Sebastiano, **TU Delft**
Jörg Hendrik Bluhm, **RWTH Aachen**