Single-Flux-Quantum-Based Information Processing for Low-Power Microelectronics – Principles and Current State-of-the-Art

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One of the options for realizing microelectronics with very low power consumption is given by the Rapid Single Flux Quantum (RSFQ) technique [1,2]. Although the energy consumption per logical switching is very low – typically in the range of 10^{-19} J and thus lower than the "ultimate CMOS" projections at the limits of scaling [3] – the operation speed can be quite high, allowing circuits to be operated at tens of GHz clock speed. The realization of RSFQ integrated circuits and systems based on this principle is reported by various sites.

After a brief introduction in the operation of RSFQ electronics, the current state of engineering such circuits in Europe / Germany is described. In particular, capabilities of modeling, simulation, and implementation will be addressed. Examples of realizations and practical use cases illustrating the current state-of-the-art will be given. Furthermore, the current understanding and possibilities of systematic design of such circuits from single gates / cells towards systems as well as the connection to fabrication processes will be discussed. Following some remarks on the existing European collaboration network, an assessment on already known and potential limits, resulting research topics to overcome them and – based on this – the prospective level of integration, i.e. the suitability of RSFQ as a scalable hardware platform for neuromorphic circuits as well as quantum information systems will be given.

References

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