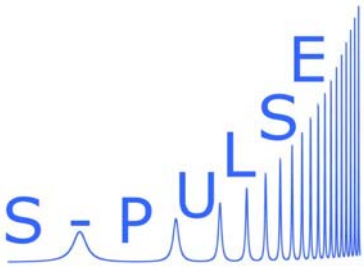

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Feasibility study for European centre of RSFQ technology

Deliverable 1.2.3

1. General need for a European Superconductive Electronics Centre

Superconductive electronics is an essential key technology, which can support a wide variety of fields, such as energy, electronics, transportation, medicine and environmental improvement. Superconductor technology enables the realization of equipment that was unachievable with conventional technology and bears great anticipation as a technology that will sustain society in the 21st century.

The unique physical properties of superconductive materials and the related electric and magnetic effects are applied in many different research domains. Europe already stated to launch intergovernmental organizations concerning special society needs and research demands [1, 2]. Today, Japan, the U.S.A and Europe are vigorously competing in the field of R&D for advanced superconductor technology. The U.S.A. and Japan are already operating national research centres for superconductive technology [3, 4, 5].

Building upon our research accomplishments within the FLUXONICS network and by the European cooperation between universities, research institutes and industries, we will further promote R&D that will lead to early applications of digital superconductor devices. In the field of low-integrated analog superconductor devices (e.g. magnetic field sensors) Europe keeps up with the competitors. However, the general tendency for analog and digital circuits is to increase the complexity considerably [6]. This change towards VLSI circuits needs adequate resources and has to be addressed in a focussed manner as is done in U.S.A. and Japan. A European Superconductive Electronics Centre (ESEC) can coordinate multidisciplinary programs for research, development, and technology transfer in the area of superconductive electronics. The focus will be the effective collaboration between national research institutes, universities and industry to establish a new electronics family based on quantum effects in superconductors. The Rapid Single Flux Quantum (RSFQ) electronics provides an ultra-low power consumption of only 1aJ (10.000 times less than a modern transistor) per logic operation and is therefore a promising future alternative to today's CMOS electronics. RSFQ is capable to operate at clock frequencies above 100 GHz. The further growing packaging density in conventional integrated CMOS circuits is already limited by their power density generating a massive thermal heating.

RSFQ electronics provides for several special applications an interesting perspective to ensure further progress beyond today's scaling limits. Comparable to the role CMOS is playing in semiconductor electronics, the RSFQ electronics is the key technology for increasing the complexity level of superconductive electronics.

2. Intended structure

A European Superconductive Electronics Centre (ESEC) of RSFQ technology will consist of a circuit department and system department, to ensure a proper fit between end-users' requirements and system architecture.
A general circuit design considers architecture issues, related to the increasing complexity, the need for fault tolerance and the information propagation time in ultra high-speed systems. In order to bridge the gap which hitherto prevented the conversion of superconductive electronics technology into products, special issues of system integration are to be addressed, too. Besides the system aspects, technical and economic aspects based on the experiences of FLUXONICS Foundry will be included in order to provide a comprehensive and valuable European platform with open access for interested users from education research and industry.

Based on comparative research, the European Centre ESEC can offer a variety of products and services:

- web-integrated tools for library access, foundry access and monitoring of fabrication status
- circuit design check, support and full featured design service
- integrated circuit fabrication based on thin film Niobium technology as continuation of today's FLUXONICS Foundry
- support of system design assembly for cryogenics systems
- conferences, expert meetings and annual Open Forum Meetings
- expert training, technical assistance and know-how transfer for superconductive electronics by means for summer-schools, workshops and seminars. Special emphasis will be put on further inspiring industrial interest.
- international exchange and networking with related institutions outside Europe
- overviews, reviews of evidence, quick scans and assessment of emerging technical solutions and development targets in the field of superconductive electronics
- evaluations, consultancy, knowledge-based recommendations for circuit design and system developments
- knowledge dissemination and contribution to the public discourse through the mass media
- books, reports, policy papers and other kinds of publications

The structure will include the following departments:

- a few distributed design centres (today: Ilmenau University of Technology / Germany, Chalmers University / Sweden, University of Savoie / France)
- one dedicated service and design entry point
- one fabrication facility for integrated circuits (a detailed assessment of the technical requirements is part of the "Report about technological requirements and for a general SE foundry", D1.2.2)
- one system support centre to assist cryo-packaging, cooling and interfacing of superconductive electronics
- many distributed theory groups located at European Universities

3. Requirements

To cope with the problems of short-term project funding in national and European projects, a long term stability of the technological basis for superconductive electronics is essential to keep track with the development in the U.S.A and Japan. Today the U.S.A. and Japan operate a foundry service [7, 8] for the fabrication of complex integrated superconductive electronics. The current European circuit fabrication is performed at Institute of Photonic Technology (IPHT), located in the federal state Thuringia in Germany.

Many experiments in basic physics utilize in-house design and fabrication of superconductive circuits. This low-complexity electronics is very often a research branch in numerous laboratories and not yet industrially applied. However, the recent installation of FLUXONICS Foundry [9] for the first time provides for a high-level and open-access technological basis for the production of integrated superconductive electronics. Since the quality and circuit yield is a function of foundry throughput, it is essential to focus the European demands in this emerging technology field. Making Europe competitive in this promising field requires a long-term stability for the support of the foundry service for the production of integrated superconductive electronics. The increasing of complexity to VLSI requires resources and has to be embedded into a long-term shrink-path strategy.

The long-term stability and the goals of the shrink-path strategy can be achieved by a European Superconductive Electronics Centre as proposed here. As a result of the cooperation within the FLUXONICS and the streamlining of the European research directions within the S-PULSE project, these days there are all preconditions in terms of expertise, structure, ways of communication, and cooperation given. Thus, the proposed ESEC appears to be feasible as far as the abovementioned expert-based preconditions are concerned.

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