A FEW APPLICATIONS OF SUPERCONDUCTING DIGITAL ELECTRONICS

ASSOC. PROFESSOR, PASCAL FEBVRE, UNIVERSITY OF SAVOIE , FRANCE

Superconducting electronics has been used for a long time for niche applications in areas for which no other technology could meet the needs. This was needed to compensate the drawback of cryogenic cooling, often at liquid helium temperature at 4.2K, sometimes at less stringent temperatures like liquid nitrogen temperature at 77K since the discovery of high-Tc superconductivity in 1986. These specific areas include radio-astronomy and also optical astronomy, due to the requirements of receivers with ultimate sensitivity near the quantum limit. This is also the case in magnetometry where Superconducting Quantum Interference Devices (SQUIDs) are known to be the most sensitive magnetometers, used today in several fields including medicine, solid-state physics, particle physics, non-destructive evaluation or geological prospecting, as just a few examples.

Most of the devices developed were analog sensors or circuits. Nevertheless, during the last two decades, superconducting electronics has also been used to develop digital circuits by using Josephson junctions (the equivalent of the transistor in semiconductor electronics) in a specific mode for which the digital information is stored through quanta of magnetic flux and/or picosecond-duration voltage pulses. This type of digital electronics, called RSFQ for Rapid Single-Flux-Quantum [1], is a dynamic pulse logic which corresponds to a Return-to-Zero (RZ) mode of operation. RSFQ gates have the ability to operate potentially at very fast clock frequencies in the 10-1000 GHz range while consuming around one million times less than semiconductor gates. Some applications concern telecommunications and in particular Software-Defined Radio (SDR). Other ones are focused on the development of supercomputers or specific software processing tasks.

Dr. Pascal Febvre received his diploma of Physics and Chemistry from the 'Ecole Supérieure de Physique et Chimie Industrielles de la ville de Paris' (ESPCI) french 'Grandes Ecoles' in 1990. He received his Ph.D. diploma from the Université Pierre et Marie Curie - Paris VI in 1995. His Ph.D. work was performed at the laboratory of radioastronomy of the Observatory of Paris where he developed several superconducting receivers based on Superconductor-Insulator-Superconductor (SIS) mixers in the 380-750 GHz range for balloon-borne experiments.
In 1997, Dr. Febvre joined the LAHC laboratory, called now IMEP-LAHC (CNRS UMR5130) as a tenure-track associate-professor at University of Savoie where he built a research activity aimed at developing fast digital superconducting electronics based on the Rapid Si gle-Flux-Quantum (RSFQ) technique that processes magnetic flux quanta.

He teaches statistical physics, astrophysics and electromagnetism, and coached 6 PhD students and more than 50 undergraduate and graduate students. Dr. Febvre has an expertise in project management and superconducting electronics (sensors, digital, micro-nanotechnologies) in the microwave and THz frequency range, he owns more than 100 communications in International Journals and Conferences. He has been elected on the steering committee of the FLUXONICS European Society (2008-2010 and 2011-2013) and in the board of the European Society for Applied Superconductivity for the 2009-2013 period.