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Superconductor Digital Electronics: – Current Status, Future Prospects

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Two major applications of superconductor electronics: communications and supercomputing will be presented. These areas hold a significant promise of a large impact on electronics state-of-the-art for the defense and commercial markets stemming from the fundamental advantages of superconductivity: simultaneous high speed and low power, lossless interconnect, natural quantization, and high sensitivity. The availability of relatively small cryocoolers lowered the foremost market barrier for cryogenically-cooled superconductor electronic systems. These fundamental advantages enabled a novel Digital-RF architecture - a disruptive technological approach changing wireless communications, radar, and surveillance system architectures dramatically. Practical results were achieved for Digital-RF systems in which wide-band, multi-band radio frequency signals are directly digitized and digital domain is expanded throughout the entire system. Digital-RF systems combine digital and mixed signal integrated circuits based on Rapid Single Flux Quantum (RSFQ) technology, superconductor analog filter circuits, and semiconductor post-processing circuits. The demonstrated cryocooled Digital-RF systems are the world's first and fastest directly digitizing receivers operating with live satellite signals, enabling multi-net data links, and performing signal acquisition from HF to L-band with 30 GHz clock frequencies. In supercomputing, superconductivity leads to the highest energy efficiencies per operation. Superconductor technology based on manipulation and ballistic transfer of magnetic flux quanta provides a superior low-power alternative to CMOS and other charge-transfer based device technologies. The fundamental energy consumption in SFQ circuits defined by flux quanta energy $2\text{x}10^{-19}$ J. Recently, a novel energy-efficient zero-static-power SFQ technology, eSFQ/ERSFQ was invented, which retains all advantages of standard RSFQ circuits: high-speed, dc power, internal memory. The voltage bias regulation, determined by SFQ clock, enables the *zero-power at zero-activity regimes*, indispensable for sensor and quantum bit readout.