Recent Research Developments of Adiabatic Quantum-flux-parametron Circuits Technology Toward Energy-efficient High-performance Computing

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***Abstract*— Adiabatic quantum-flux-parametron (AQFP) is an extremely energy-efficient logic, whose switching energy can be reduced to the level of the thermodynamic limit around k_BT due to the adiabatic switching of superconducting logic gates. We are developing fundamental technologies for high-performance computing based on AQFP logic circuits in order to overcome the explosive increase of the power consumption of high-performance computing systems such as supercomputers and servers in data centers. In this talk we will review our recent research developments of AQFP logic circuits toward energy-efficient computing. After introducing the operation mechanism of the AQFP logic circuits and the relationship between the switching energy, operating speed and bit-error rate (BER), we will show several newly developed technologies for realizing AQFP integrated circuits, which include AQFP cell libraries, new clocking schemes, design strategies and EDA tools. Based on these technologies, the logic operation of several AQFP integrated circuits, such as adders, multiplexers, decoders and register files have been demonstrated. It is also shown by the experiment that the BER of AQFP logic circuits is considerately small even at high frequencies. We also demonstrate high–density three-dimensional integration of AQFP logic circuits by using a double-gate-layer Josephson process. Finally we discuss the potentiality of AQFP circuits as an energy-efficient logic.**

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***Keywords (Index Terms)*– Adiabatic quantum-flux-parametron, AQFP, AQFP logic circuits, energy-efficient computing, bit-error rate, BER, double-gate-layer Josephson process.**

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