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Development of a Ultra-Low Field Brain Magnetic Resonance System with Double Relaxation Oscillation SQUIDs

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We have been developing a novel brain functional imaging technique which directly detects neuronal currents in a brain. We named the technique Brain Magnetic Resonance (BMR) since it measures the nuclear magnetic resonance (NMR) signal of protons around the acting neurons. In order to make the NMR resonance with the neuronal oscillation frequency, micro-tesla-order static magnetic field is required. In this regime, a conventional inductive NMR pick-up coil is hard to show a sufficient signal to noise ratio, since the NMR signal drops inversely proportional to the square of the static magnetic field. Therefore, we utilize low-Tc SQUID sensors to detect the signal. In BMR, a high pre-polarization field (~0.1 T) and a ultra-low resonance measurement field (~μT) are separated and applied alternatively with pulse sequences. Thus, we need to protect the SQUID sensors from the transient fields as well as to realize a quick recovery of the flux-locked loop for signal measurements within a short relaxation time. Especially, double relaxation oscillation SQUIDs (DROS) are relatively vulnerable to such a transient field while they are feasible to make a multi-channel detection system, which is preferable to a BMR system. We circumvented the problem with a current limiter with a Josephson junction array. In this presentation, we will introduce the theoretical basis for the BMR technique and the design for our BMR system. The first experimental detection result of the ultra low-field proton NMR at ~2 μT with the protected external-feedback DROS will be presented, as well.

Keywords : brain magnetic resonance, BMR, SQUID, DROS, ultra-low field NMR