# Biomedical Applications of Sensitive Magnetic Measurements Based on SQUIDs: Brain Research and Cardiac Diagnosis

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## 1. Introduction

As the most sensitive magnetic sensors at low frequency, magnetometers based on SQUID (superconducting quantum interference devices) can be applied to measurements of magnetic signals from human body, for example, brain and heart, etc. By measuring these so called biomagnetic fields, functional understanding of brain and diagnosis of heart diseases can be done. In KRISS, we have developed several sensitive multichannel SQUID systems for brain research or cardiac diagnosis, and key technical feature and clinical applications are described in this paper.

## 2. SQUID systems for magnetocardiography and magnetoencephalography

To measure weak biomagnetic field signals, with amplitudes in the range of 100 fT (brain) ~ 10 pT (heart), sensitive SQUID systems are needed. We developed a second-generation SQUID systems based on new type of SQUID, double relation oscillation SQUID (DROS), which has high flux-to-voltage transfer coefficients and enables the use of simpler flux-locked loop circuits for SQUID operation. Among the SQUID systems we developed, 64-channel first-order axial gradiometer for magnetocardiography (MCG) measurements, and 160-channel helmet-type first-order gradiometer system for magnetoencephalography (MEG) measurements are in routine operation in the hospitals. Fig. 1 shows the MCG and MEG systems installed in the hospitals.

(a) (b)

Fig. 1. Multichannel SQUID systems installed in the hospitals. (a) MCG in Asklepios Klinik Hamburg Harburg, Hamburg, and (b) MEG system in Yonsei University Hospital, Seoul.