

## Fabrication of 62-channel DROS Planar Gradiometer System for Magnetocardiogram Measurements

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We fabricated a magnetocardiogram (MCG) measurement system based on integrated double relaxation oscillation SQUID (DROS) planar gradiometers. Using DROS, the flux-to-voltage transfer coefficient could be made large enough, typically  $1 \text{ mV}/\Phi_0$ , that readout electronics for SQUID operation were compact and simple, compared with the conventional DC SQUIDS. The pickup coil is a first-order planar gradiometer which has higher intrinsic balancing than the wire-wound axial gradiometers. Typical noise of the planar gradiometer is about  $1.3 \text{ fT}/\text{cm}/\sqrt{\text{Hz}}$  or  $5 \text{ fT}/\sqrt{\text{Hz}}$  at 100 Hz, operated inside a moderately shielded room. By arranging the planar gradiometers to measure MCG fields tangential to the chest surface, we could measure MCG signals effectively with smaller sensor coverage than the conventional vertical measurements. The covering area of the 62 channel system is  $162 \text{ mm} \times 162 \text{ mm}$ , which was proved to be large enough to measure the essential MCG field distribution in a single measurement. The Helium dewar has a capacity of 40 L and has an average boil-off rate of 3.7 L/d with the 62-channel insert. The patient bed has a nonmagnetic cycle for stress-MCG measurements. The MCG system was installed in a heart center of a hospital for diagnostic study of coronary artery diseases, and MCG data were analyzed using the home-made analysis software.

keywords : SQUID gradiometer, magnetocardiogram measurement, SQUID electronics