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A 3-D Vector Measurement of Biomagnetic Fields Generating from the Human Body

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In the research of biomagnetic measurement, the magnetic field perpendicular to the body surface is usually used. However, there are problems of estimating multiple sources overlapping in time when many distinct areas of the cortex and/or cardiac tissues are active. In these cases, the magnetic field distribution obtained from the normal component filed is not helpful for estimating the location and number of sources, owing to the lack of a dipole pattern. In order to overcome this problem, we proposed a new 3-D vector measurement system of biomagnetic field.

We have developed a new 39-channel SQUID vector magnetometer system with 3-D second-order gradiometer for research use to measure the biomagnetic fields such magnetoencephalogram (MEG) and magnetocardiogram (MCG). This system can detect the magnetic fields perpendicular and tangential to the body surface simultaneously. Each magnetic flux detection coil is wound with Ni-Ti-Cu wire on a rectangular solid 3x3x6 cm. This is the total hardware system consisting of 39 dc-SQUID sensors with detecting coils, readout electronics, two liquid helium dewars for MEG and MCG, a gantry, and a magnetically shielded room. The noise fields of the normal component measured in MSR are about 15 fT/$\sqrt{Hz}$ at 10 Hz and less than 10 fT/$\sqrt{Hz}$ at white noise. The noise fields of tangential component are about 12 fT/$\sqrt{Hz}$ at 10 Hz and less than 10 fT/$\sqrt{Hz}$ at white noise. To assess discrimination and separation of multiple sources, we carried out both simulation study and 3-D vector measurement of the MEG mixed with an auditory evoked field and a somatosensory evoked field overlapping in time. We clearly estimated two sources in the brain by using constrained condition to calculate inverse problem obtained from the tangential filed components. It was also confirmed by comparison with magnetic resonance imaging of a subject's head superimposed source localization.

Key words : 3-D vector magnetometer, SQUID, 3-D vector measurement, MEG, MCG