Planar surface gradient coil for vertical B_0-field

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Introduction

Surface Gradient Coils (SGCs) can be used to reduce eddy current effects and increase gradient efficiency[1]. We have designed and built an SGC set for an open access MRI system, based on a planar 3-coil resistive magnet with a B_0 of 10 mT[2].

Subjects and Methods

The winding for the longitudinal gradient was designed using matrix inversion and consists of four concentric circular loops, wound from 0.9 mm-diameter enamelled copper wire. The transverse gradient windings are made from enamelled copper wire of 0.7 mm diameter. They were designed iteratively and are based on two loops, with the inner windings split into four separate paths. The SGC designs are shown in figure 1. The SGC was optimised to produce a linear gradient over a sphere of approximately 35 mm diameter, with its center displaced by 28 mm from the SGC plane. The loops are held in place between two Perspex discs and the SGC has an overall thickness of 16 mm and a diameter of 245 mm. A home-made pulse programmer generates gradient-waveforms which are then fed into three power amplifiers (Crown M-600) to drive the SGC.

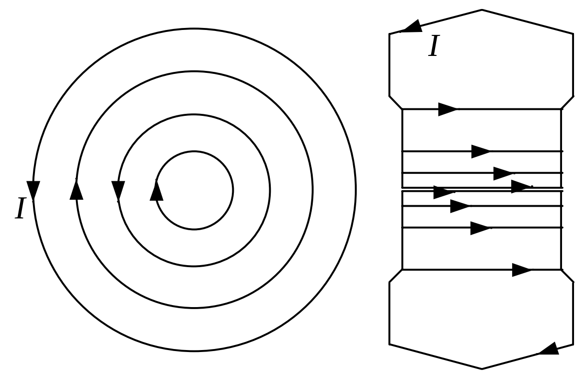

Figure 1: Longitudinal (left) and transverse (right) SGC design.

Results

The electrical parameters of the SGC are shown in the table. We used the SGC to acquire the Spin-Echo image shown in figure 2. A solenoidal RF coil was used to receive the signal and the phantom comprised test tubes with an external diameter of 10 mm filled with copper sulphate solution (T_1=153 ms, T_2=144 ms, measured at 0.36 T).

	Transverse	Longitudinal
Resistance [Ω]	1.7	2.3
Inductance [mH]	0.38	1.35
Efficiency [mT/m/A]	1.3	1.0

Discussion

There is geometric distortion towards the edges of the image, because the phantom size exceeds the linear gradient region. This is in agreement with simulations, which show the gradient fields to be linear within ±5 % over a sphere of approximately 32 mm (longitudinal) and 35 mm (transverse) diameter. A relatively wide slice (25 mm) was used to improve the SNR, but this emphasises gradient non-linearity perpendicular to the imaging plane and causes blurring at the edges of the image. However the seven test tubes at the center of the sample are imaged without distortion. The SGC improves on the efficiency and accessibility of the MR system's existing volume gradient coils and we hope to combine it with a planar RF coil for imaging small surface regions of the human body.

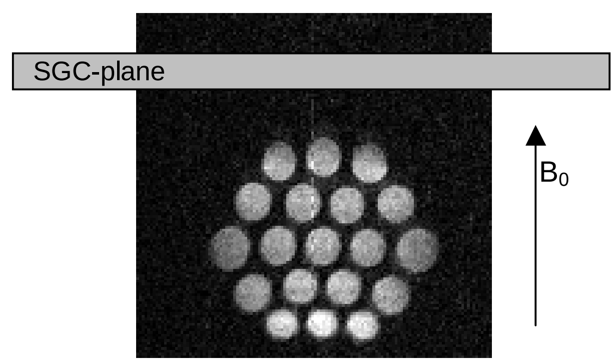

Figure 2:Transaxial SE image (TR=300 ms; TE=30 ms; 25 mm slice thickness; 128^2 pixels; 8 averages).

References

1. Cho ZH et. al., Concepts in Magnetic Resonance, 7:95-114, 1995
2. Seton HC et. al., 17th ESMRMB-Meeting, Paris, France, 112, 2000