# Quadrature Strip-Line Surface Coil For Ultra-High Field Imaging (7T)

**A. Jones[1], A. W. Magill[1], and P. Glover[1]**

[1]Sir Peter Mansfield Magnetic Resonance Centre, University of Nottingham, Nottingham, United Kingdom

**Introduction**

Surface coils are useful for imaging peripheral regions of the brain with MRI. While volume coils have greater homogeneity across the entire brain, surface coils offer higher SNR over a smaller field of view. This is especially true at high fields where the short wavelength of the $B_1$ signal causes interference effects. This causes loss of signal in some regions when using a volume coil [1], whilst a surface coil can be positioned directly over the ROI ensuring good sensitivity.

We have developed a quadrature transmit-receive strip-line surface probe for use at 7T. At short wavelength a strip-line can produce a more homogenous $B_1$ field than a loop, as loops suffer from signal cancellation due to the opposing current flowing in opposite sides of the loop [2]. The use of orthogonal strip-lines means that quadrature drive is possible without complicated decoupling networks; placing the strips orthogonally is enough to prevent coupling. Quadrature reception improves the SNR by $\sqrt{2}$ while quadrature transmission reduces the SAR by a factor of 2. A reduction in SAR is highly advantageous as images of the cortex with both higher temporal and spatial resolution may be obtained.

**Methods**

A probe was constructed from two independent orthogonal strips (fig. 1). Both ends of each strip are connected to a ground plane at via a 3pF capacitor in series with a 50pF variable capacitor. The strips are 120mm long and 10mm wide, positioned 20mm and 22mm above the ground plane. The probe is driven by inductive coupling using two axially-orthogonal loops, each placed under a strip line. Both drives are grounded at the same point, so a balun is not required. The strips are tuned by varying the capacitance on either end of each strip, and matched by adjusting the position of the driving loops. Although there is a virtual earth at the centre of each strip, they should not be directly connected as this results in coupling of the two modes.

**Experiment and Results**

Each strip-line was tuned in-turn using a network analyser (4396B Hewlett-Packard, CA), with a 50Ω load connected across the terminal of the other strip. The isolation between strips was measured to be -20dB, so additional decoupling was not necessary (fig. 2). The loaded and unloaded Q-factors of the probe were 29 and 56 respectively. Images were acquired of a 160mm-diameter spherical phantom filled with 50mMol saline solution using a Philips 7T Achieva system (Fig 3 & 4). When driven in quadrature mode the images show a $\sqrt{2}$ improvement in SNR over the linear mode images.

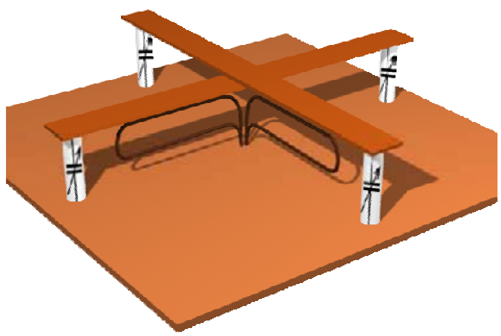

Figure 1. Graphical representation of the quadrature probe with inductive driving loops.

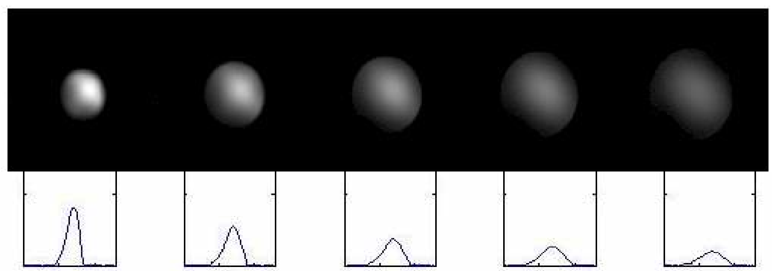

Figure 3a) Five transverse slices starting next to the probe on the left towards the central slice of the phantom on the right b) Signal intensity along the centre of the image

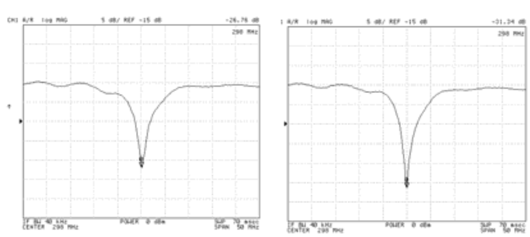

Figure 2. S11-parameters for each strip. The orthogonal positioning ensures minimal cross talk between the degenerate strips, therefore no coupling occurs.

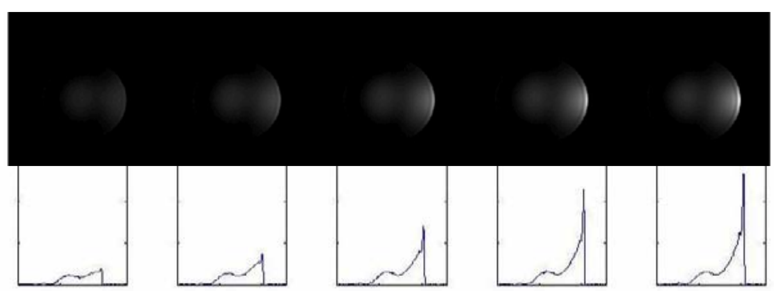

Figure 4a) Five coronal slices with probe located on the right hand side. b) Signal intensity along probe axis.

**Discussion and Conclusion**

A strip-line quadrature surface coil has been introduced and demonstrated. It is simple to tune and match, and the geometry ensures that complicated decoupling circuits are not necessary. As a quadrature probe it is ideal for transmission and reception, with proximity to the sample ensuring a good filling factor and SNR. The probe will have immediate application to fMRI of cortical regions.

**References**

[1] Vaughan JT, et al. *magnetic resonance in medicine*, 46:24-30, 2001, [2] Lee RF, et al. *magnetic resonance in medicine*, 45:673-683, 2001

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