Phase correction for eight-channel head coil in MR Spectroscopy

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Synopsis

An eight-element head coil is used in MR imaging to increase Signal-to-Noise ratio (SNR). For MR imaging it works because only magnitudes are necessary for adding up the eight signals, and hence phase shifts among the channels are no longer an issue[1]. However, problems arise when it is used for MRS as phase shifts become important in the summation. In this abstract, we propose a method for phase correction, and investigate the impact of using this head coil on MRS in terms of SNR.

Introduction

An eight-channel head coil (Fig. 1) has recently been introduced to increase SNR, and therefore image quality in MR imaging. For MRS, however, phase shifts between one channel and another (Fig. 2) will lower the SNR and spectral resolution when the spectra are simply added up. The phase shifts depend on the chemical shift imaging (CSI)-voxel positions, an analytical derivation of which will be reported separately. In this abstract, we do present an example of the phase shifts of one position as shown in the highlighted (blue) box in Fig. 3.

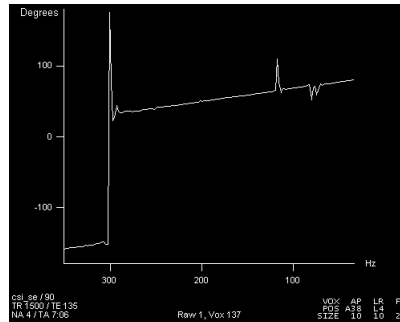**Fig. 1** *Eight-channel head coil used for both MRI and MRS[2]*

Fig. 2 *An example of phase shifts between channel 1 and 7 resulting in an offset of ±90 degrees.*
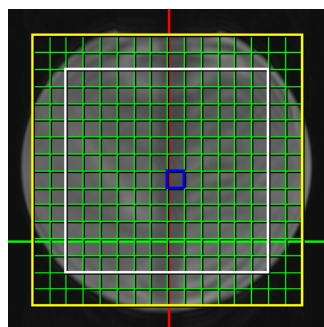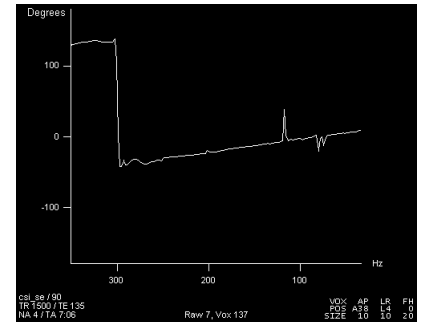

Fig. 3 *Phase shifts depend on voxel position (blue box)*

Methods and materials

We propose a phase correction of each CSI-voxel that compensates the offsets as seen in Fig. 2. This is done in four steps: **a.** choose a channel as a reference channel; **b.** unwrap and calculate a mean slope of the phase of step **a**; **c.** repeat steps **a, b** for every other channels; **d.** estimate a new phase for every channel with respect to step **b** such that the mean square difference is minimized. After the phase correction is completed, we sum up all the spectra now with the corresponding estimated phase. Finally, the SNR is calculated and compared with that of the single head coil.

In vitro localized MRS experiments were performed on a 1.5T whole body system (Magnetom Sonata, Siemens, Germany). A sphere containing an acetate and lactate solution was scanned using the eight-channel head coil, with and without phase correction.

Results

After phase correction in which all phase are aligned (Fig. 4), we sum up all the spectra with a corrected phase resulting a total spectrum shown in Fig. 5. The SNR is then calculated before and after the phase correction in which a gain of 4 dB is achieved at the position shown in Fig. 3.
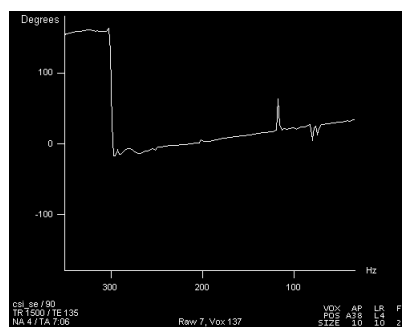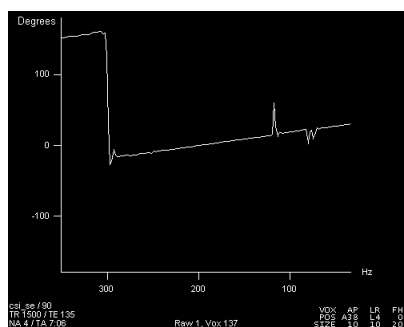

Fig. 4 *Phase of channel 1 and 7 after phase correction, they are neatly aligned. In this case channel 7 was used a reference channel.*
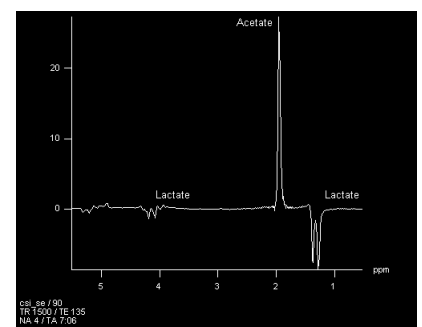

Fig. 5 *A total spectrum of water suppressed at the position shown in* **Fig. 3**.

Conclusion

We have shown that a gain of maximum 4 dB in SNR can be achieved in MRS using an eight-channel head coil provided that phase correction is applied and it is measured in the vicinity of the midpoint of the head coil. This agrees with the theory that the total signal would add arithmetically (8 times), and the noise would add geometrically ($2\sqrt{2}$).

References

1. de Zwart, J.A. *et al*., "Design of a SENSE-optimized High Sensitivity MRI Receive coil for brain imging", Magn Reson Med. 47:1218-1227 (2002)
2. MAGNETOM Sonata, *User manual*, Siemens Medical Systems, Erlangen.