Application of RF Current Sources in Transmit SENSE

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INTRODUCTION: Transmit SENSE was introduced to reduce the RF pulse duration without sacrificing spatial definition by shortening the trajectory in k-space which a multi-dimensional RF pulse follows for spatial selective excitation [1,2]. A key requirement in order to implement Transmit SENSE is knowledge of coil patterns. However in the presence of other transmit array elements fed by conventional voltage sources, the impedance presented to the matching network becomes a function of the current amplitude and phase on each of those elements [3, 4]. Therefore, in order to be able to exercise accurate control over the amplitudes and phases of currents on each array element, it may be necessary to have an accurate knowledge of the mutual coupling, and take this into account in designing the RF pulse. This makes independent RF waveform transmission complicated. Alternatively, the use of RF current sources driving non-resonant coils [5] has been shown to mitigate the effect of mutual coupling. This is an effective method for achieving independent control of the current on each element so that the magnetic field can be accurately controlled for Transmit SENSE [6, 7]. In this paper we present Transmit SENSE experiments using RF current sources with spatial domain RF pulse design in parallel excitation method that is formulated as a quadratic optimization problem in the spatial domain, and allows the use of arbitrary k-space trajectories [8].

METHOD: A "Dual MOSFET current source" using two MOSFETs in parallel for larger current operations was used for Transmit SENSE experiments. Four surface coils were placed around the phantom (1g/L, $CuSO_4$) and each coil was driven by its own current source. Two independent RF waveforms, channel 1 and 2, were used for the 90 degree 2D spatially selective pulses. All imaging was done on a 4.7 T/ 33 cm Bruker Omega scanner, with the decoupler channel used for channel 2. Coil 1&3 were driven by channel 1 and coil 2&4 were driven by channel 2. A birdcage volume coil was driven by channel 1 in order to create the 180° refocusing pulse, with an RF switch directing power from channel 1 to the appropriate coils for the 90 and 180 pulses. The volume coil was also used for signal detection. A block diagram for the coil setup is shown in Fig.1. Sensitivity maps of coil 1&3 by channel 1 and coil 2&4 by channel 2 were obtained from three images - volume coil only, channel 1 only and channel 2 only. Based on the sensitivity maps, RF waveforms of channel 1 and 2 for square excitation (4cm by 4 cm) were generated as described in [8]. The k-space trajectory we used had an excitation FOV of 4.25 cm, and a resolution of 0.5 cm.

RESULTS: Preliminary results are shown in Figs 2-4. Fig. 2 and 3 show the measured sensitivity maps created by driving opposing coils simultaneously. The patterns indicate that current in the unexcited coils are well-suppressed, as expected from the current sources. Fig. 4 shows the initial Transmit SENSE image, ideally a square. This initial result is less than ideal, primarily due to mismatch between the two drive channels. Efforts are underway to calibrate the two channels for identical performance. Excitation outside of the ROI (region of interest) is in the 'don't care' region, where we don't care what pattern is excited – this allows a more accurate excitation to be achieved in the 'do care' region, by removing constraints.

CONCLUSIONS: Initial results for the Transmit SENSE experiment using the RF current sources have been demonstrated. Using current sources should provide a more straightforward approach to Transmit SENSE and method as the effects of mutual coupling are largely eliminated. Experimental results show that the current source can be used to drive loops as elements in a Transmit SENSE array. The proposed method allows for a surface phased array which can be placed on any load without retuning array elements.

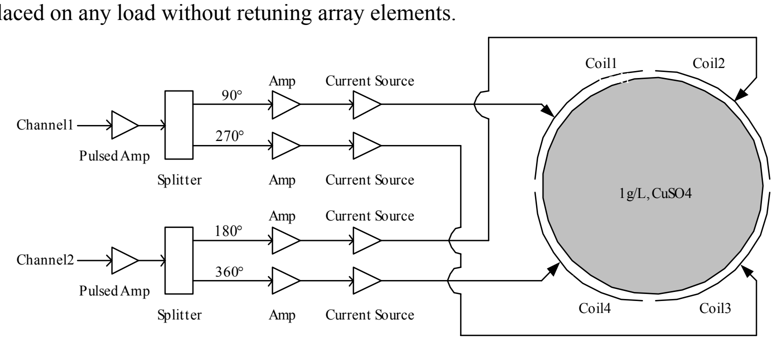

Figure 1. Block diagram of the coil setup with current sources

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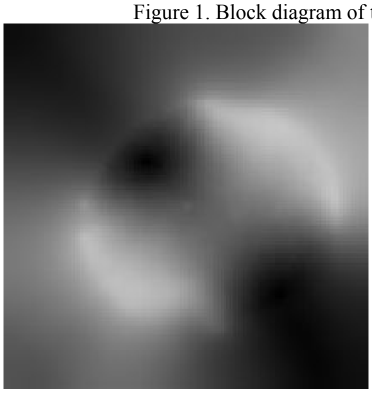

Figure. 2. Sensitivity map of coil 1&3 by channel 1

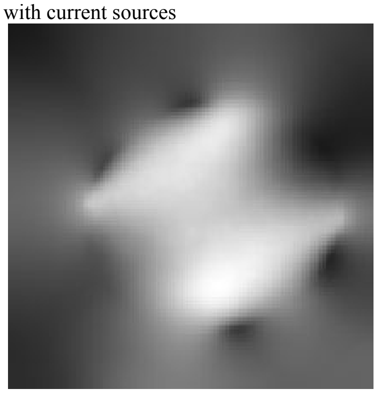

Figure. 3 Sensitivity map of coil 2&4 by channel 2

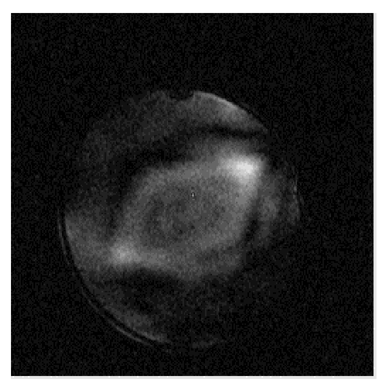

Figure. 4 Transmit SENSE image for square excitation

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