Transmit Surface Coil Array using RF Current Sources

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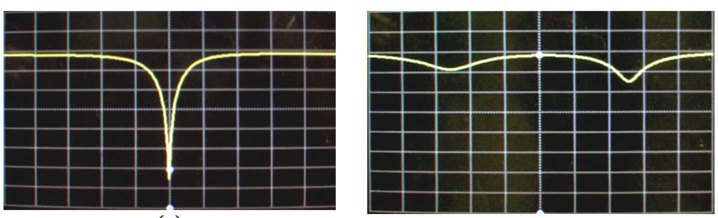
INTRODUCTION: The transmit SENSE technique can reduce imaging time by shortening the trajectory in k-space which a multi-dimensional RF pulse follows for spatial selective excitation [1, 2]. The use of multiple transmit coils, each with its own time-dependent waveform and spatial sensitivity compensate for the missing parts of the excitation k-space. To implement Transmit SENSE, independent transmit channels, each driven by a specific RF waveform, are required. However independent transmit channel operation is difficult to achieve in conventional arrays due to coupling between elements. S_{11} measurements of a 50 ohm tuned coil at 200.237 MHz without (Fig. 1-a) and with (Fig. 1-b) the other coil which is also tuned at 50 ohm are shown in Fig. 1. Note that the coil is detuned and there is a significant mode split demonstrating that the two coils are strongly coupled. This mode split makes it very difficult to control transmit channels independently when conventional 50 ohm coils are used in a transmit phased array. A novel approach to minimizing the effects of mutual inductance between coils elements is to use RF current sources driving non-resonant structures. This is an effective method for achieving independent control of the current on each element in a transmit array. Experiments show that a coil driven by the RF current sources is much less sensitive to loading and an inter-element coupling than a conventional 50 ohm matched coil fed by a standard voltage source mode amplifier. It makes independent current control on each array element of transmit phased array possible and gives the ability to create desired field patterns [3]. In this paper we demonstrate that the RF current source driving a non-resonant coil can be used for Transmit SENSE by showing the ability to produce the independent transmit field pattern in the presence of other coil.

METHOD: An RF power MOSFET (BLF245, Philips Semiconductors) was used for the current source. A drain bias voltage of 28V was applied to the drain terminal of the MOSFET. This set the MOSFET in the saturation region of its DC characteristic, necessary for it to behave as a current source [4]. Fig. 2 shows a block diagram of a surface coil driven by a RF current source. All DC bias connections are not drawn here. Previous works show that a MOSFET behaves as a true current source when output impedance from drain terminal, Z_{out}, is tuned at series resonance [5]. Two square coils of 8 cm length were used to obtain sagittal images. Two coils were placed next to each other on the phantom (1g/L $CuSO_4$). The dimension of the phantom is 16x9x2.5 cm (length, width and height). For testing purposes a volume coil was used for receive. We took two images with same setup- transmit coil 1 with coil 2 in place but not excited and vice versa. The setup is shown in Fig. 3 and Fig. 4-(a).

RESULTS: The sagittal images from the RF current source with a non-resonant square surface coil were obtained by the method described above. Fig. 4-(b) shows the volume coil image from transmit coil 1 and Fig. 4-(c) shows from transmit coil 2. Note that there is no signal from the area beneath the other coil, no significant changes and no distortions due to the induced currents. The images demonstrate that the coil driven by the current source operates independently of other, nearby coils, even when the two coils have a significant mutual inductance. These results indicate that RF current source technique should be useful in the implementation of phased array coils for Transmit SENSE.

CONCLUSIONS: Independent loop transmit coils using RF current sources have been demonstrated successfully. Experimental results show that the current source essentially eliminates coupling effects and indicate the feasibility of current source driven 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.



(a) (b)

Figure 1. S_{11} measurements of (a) conventional 50 ohm coil only, (b) conventional 50 ohm coil with another 50 ohm coil.

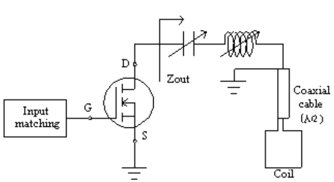


Figure 2. Block diagram of a current source with a square surface coil.

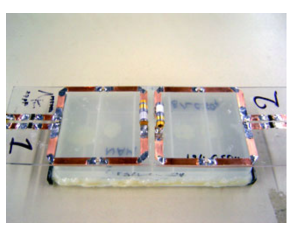
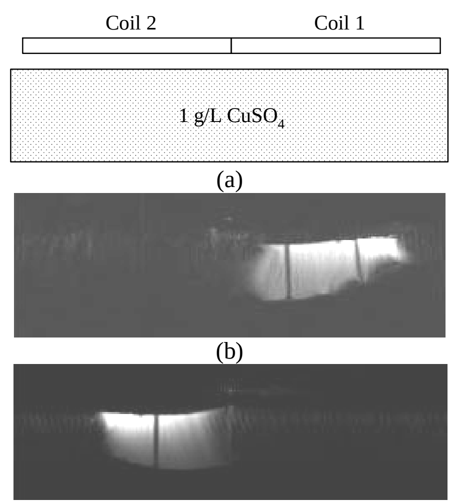


Figure 3 Image setup with a load (1g/L, $CuSO_4$).



(c)

Figure 4. – (a) Image setup, (b) Sagittal image when coil1 is used as a transmit coil and coil 2 is turned off (c) Sagittal image when coil 2 is used as a transmit coil and coil 1 is turned off.

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