8-Channel Parallel Transmit and Receive System for 3 Tesla

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Introduction

Imaging at 3 Tesla shows inhomogenities in the RF transmit field due to the dielectric properties of tissue. Techniques to counter these effects were proposed in redesign of a whole body array [1]. Due to the distance to the patient, coil losses are dominant and therefore more RF power is needed to create the desired B_1 field in the center. For these requirements high power amplifiers are needed which are expensive. To reduce the power requirements, facilitate B_1 shimming, accelerate parallel excitation [2], and lower associated costs, one solution is to bring the transmit coil in close proximity to the body. With the close proximity the use of an extra receive array becomes cumbersome. Combining transmit and receive (T/R) is desired. To achieve parallel transmit and parallel imaging, a system implementation for an 8-channel transceiver array is presented.

Materials and Methods

The transceiver head coil consisted of 8 overlapped coils. The 8 elements were fixed on an acrylic former with an inner diameter of 267 mm. All elements were tuned to 50 Ohms on a cylindrical shaped phantom with 215 mm diameter and 250 mm length. The phantom for tuning was filled with a copper sulfate and saline solution. 1 g/l cooper sulfate plus 2.2 g/l sodium chloride were dissolved in de-ionized water.

Each channel of the transceiver coil is connected to a modified GE product head T/R-switch, displayed in Figure 1. To support a linear coil the ports, which are usually connected to the Input and Isolation port of the head quadrature hybrid, were shorted. An L-C matching circuit with an additional matching length (ML) was added. Due to adding a short between the input and isolation port, an L-C circuit was needed to improve matching. The matching length (ML) allowed easy opening and closing of the T/R-switch case with the L-C circuit in the line.

Eight of these individual modified T/R-switches were used to implement the setup shown in Figure 2. The setup consisted of 8 bias tees, 8 modified T/R-switches, one 8-channel GE HDx receive cable with an A-connector, and 8 DC blocks.

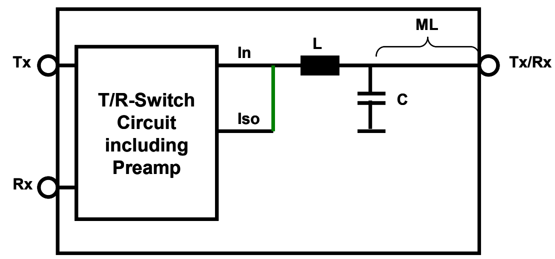

Figure 1: Block diagram of T/R-switch modifications

To switch between transmit and receive state, bias is added to the transmit line over a high power bias tee. The bias is taken from the system head and body bias. Three modified T/R-switches were supported through the head bias and five through the body bias, because of the current limitation of each output. Each T/R-switch is supported with preamp bias on an additional feed, supplied by a Rhode & Schwarz NGMO2 power supply. Therefore, the bias supplied on the RF receive line is not needed and blocked with a standard DC block.

The RF signal is routed from the amplifier through the bias tee. In the bias tee, DC is added to the RF line. Both signals DC and RF are routed into the T/R-switch. One transmit channel of the 8-channel head coil is feed by one T/R-switch. The receive signal is amplified in the T/R-switch and fed trough DC block in a standard GE HDx A-connector into the LPCA of the system.

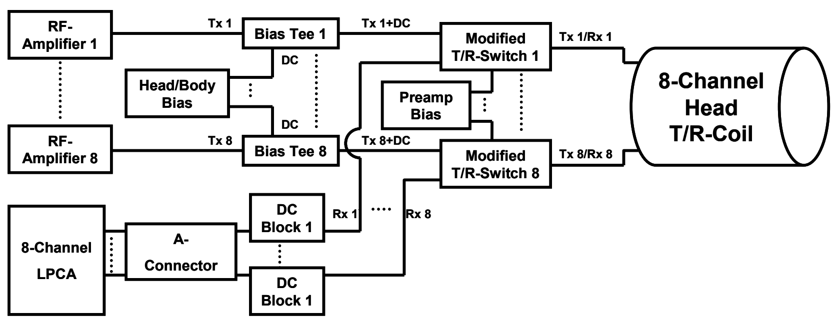

Figure 2: Block diagram of system implementation of the T/R setup

Results and Discussion

A very good matching of the coil was achieved, with a matching for each channel better than -30 dB, on the phantom. Next neighbor coupling for all coils was better than -9 dB. The T/R-switches had a matching of better than -18 dB on each port. For all bias tees, a matching better than -25 dB could be achieved.

Images were acquired on modified GE HDx system running on 14x. Coil magnitude and phase B_1 maps of each of the eight channels are shown in Figure 3. Smaller profiles were acquired for channel 7 and 8. The coil was not retuned to the volunteer's head. A 5 spokes pulse design was used to acquire in-vivo images with a 30 degree flip angle (TR: 200ms, TE: 8ms). An axial slice of the head is displayed in Figure 4. To assure volunteer safety due to potential SAR issues, power levels were limited to 200 Watts per channel.

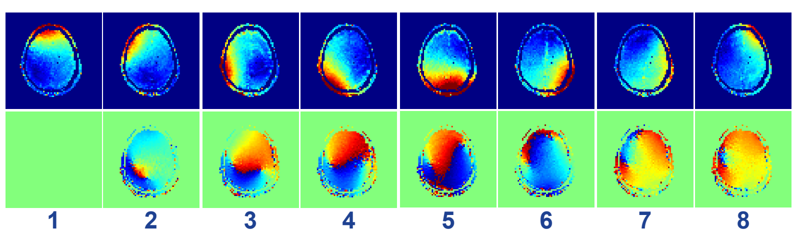

Figure 3: 8-channel head coil magnitude and phase B_1 maps

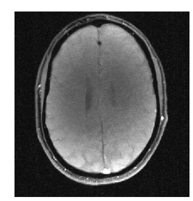

Figure 4: In-vivo image

The results show that a modified T/R-switch system was successfully implemented and used for parallel transmit applications.

References

[1] Boskamp E et al. ISMRM 16, 2008, 1094
[2] Zhu Y. et al. ISMRM 17 2009, 3003

Acknowledgements

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