B_1 homogenisation using a multichannel transmit array

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Introduction:

The increasing use of high field systems in routine applications reveals the strong interaction between the patient's body and the RF field [4]. Variation of the B_1 field distribution causes variation of the flip angles inside the patient's body which leads to shading in the acquired images. Previous investigations, restricted mainly to simulations [1], have shown that B_1 homogeneity can be improved with an optimisation of the currents in a 16 rung transmit array. The present investigation should now prove the results in a practical setup.

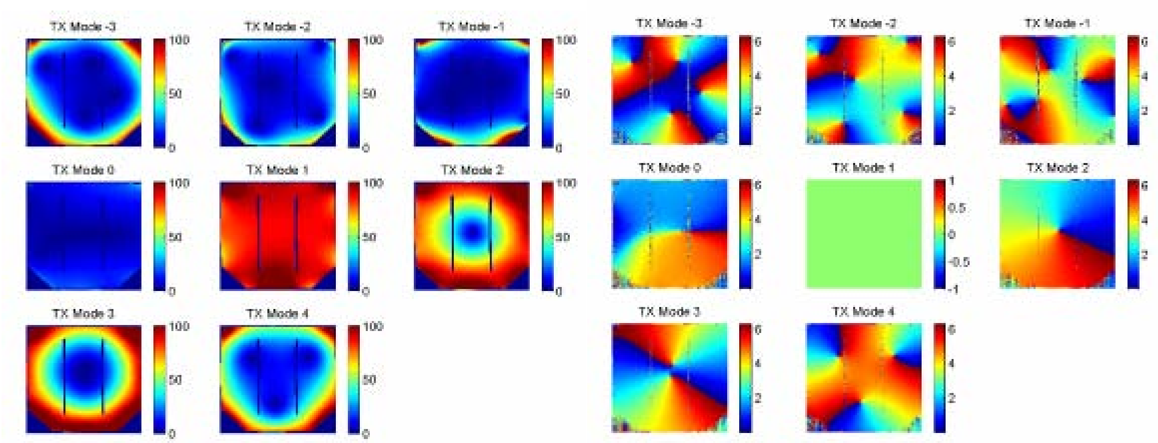
Method:

We designed a Transmit-Array setup, which was integrated into a modified 3 T Siemens Magnetom TRIO. The system was able to use 4 transmit channels simultaneously, which could be controlled individually for its amplitude and phase relations. These 4 channels were connected to the CP transmit modes (modes 1 ..4) of an 8 element whole body transmit antenna using a degenerate bandpass birdcage with the resonant modes at the same frequency. The elements of the antenna were combined by a Butler matrix [5], acting as an analogue Fourier transformer which drive the required current distributions in the antenna. So it was possible to excite the different resonant modes of the antenna separately, and thus create different B_1 distributions in a phantom or patient (see Figure 1). The limited number of TX channels was justified by previous FDTD simulations, which showed that the main improvement in B_1 homogeneity results only from a limited set of modes (e.g. modes number 1, 2, and 3), while the contribution of counter rotating modes or the common mode excitation is negligible.

We measured the B_1 or flip angle distributions for all modes with different phantoms. An oil phantom [3] was used to show the B_1 field distributions of the different modes in the unloaded antenna (Fig. 1). These ideal B_1-distributions are modified by phantoms or patient loading. We measured B_1 maps on volunteers exciting the different modes separately. The results were then used to numerically optimize the homogeneity in selected areas. The calculations delivered the amplitude and phase settings for the TX channels. By that we were able to obtain images with improved homogeneity. The measured B_1 distribution agreed well with the calculated data. When the area for homogenisation is limited (e.g. on the liver), it works there very effectively, but in other areas the B_1 homogeneity decreases (Fig. 2).

Result:

The test showed that it is possible to improve the B_1 homogeneity in vivo using a multi channel TX-Array. The required number of channels can be halved if Fourier modes are used instead of single antenna elements. Besides static B_1 homogenisation this setup can also be used for application techniques like TX-sense [2].



[**Fig. 1:** flip angle distribution in a square phantom (40 cm x 40 cm, filled with oil) for all TX modes, received with mode -1.
Left: flip angle or B1 magnitude
Right: phase of B1 field relative to mode 1

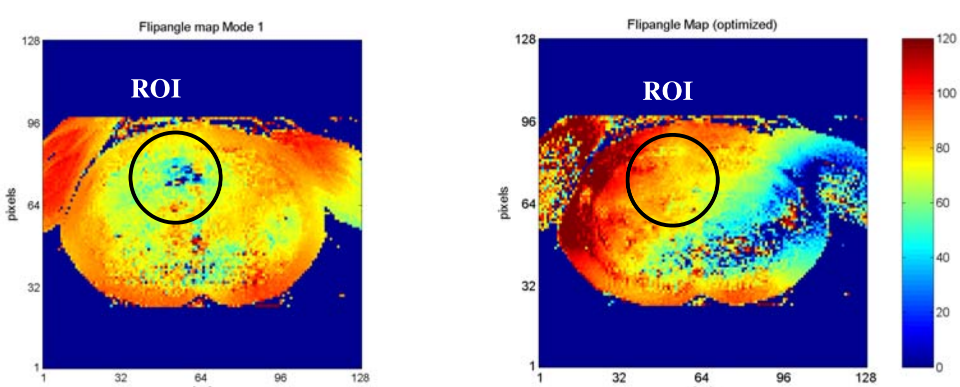


Fig 2: measured flip angle distribution in a male volunteer. – left: TX only with mode 1; right: using more TX modes to increase homogeneity in the selected ROI (liver)

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