SIMPLIFYING PARALLEL TRANSMIT COILS BY SELECTIVELY PAIRING THE CHANNELS

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Abstract

Parallel transmit (pTx) systems provide benefits for the transmit field, such as possibility to homogenize and spatially tailor it. For this and many other features, it is a useful technology for Magnetic Resonance Imaging (MRI) scanners and especially at UHF. In this paper a simplification method of the pTx system by pairing the channel with predefined algorithm is proposed. This makes the system usage more handy and yet flexible enough to maintain the performance.

1. INTRODUCTION

Parallel transmit (pTx) system in Magnetic Resonance Imaging (MRI) is one of the major technologies. pTx compared to the conventional coils have increased degrees of freedom. They provide possibility to homogenize the transmit $B1^+$ field [1], control SAR [2], provide spatially tailored transmit field [3] etc. pTx coils was introduced in 2006 by Katscher [4], and its importance has increased by expanding the ultra-high field (UHF) MRI scanners on the market. The main reason for this is that, besides the benefits, UHF delivers uniformity of the $B1^+$ field, initiated by the interference of the shorter radiofrequency (RF) wavelength [5].

Handling the pTx system requires solving the hardware and computational challenges, such as decoupling the transmit channels, cable decoupling, B1+ mapping, generating pulse design etc. Having said that, pTx systems are cumbersome to implement in the research centers and more over for the clinical examinations. Simplifying the pTx systems is a way that helps increasing its availability. Proposed method to simplify the pTx coils is to pair the transmit channels by the predefined algorithm that proposes the best pairs that can be offered. Proposed method offers technique to control the degrees of freedom in the pTx systems by pairing the channels and when the transmit channels are paired, it requires less requirements and variables to be controlled.

2. METHODS

To perform the experiment, 6 channel, single row pTx coil were chosen (Figure 1). It was built in the CST Studio Suite and inside the coil cylinder shape water phantom was placed. Coil frequency was set at 300MHz, that corresponds to the 7T MRI scanner.

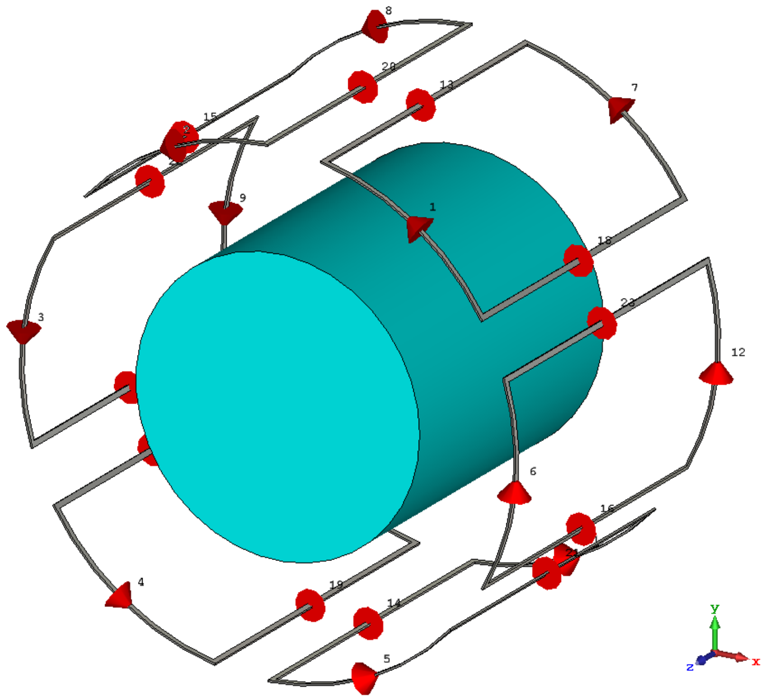

Figure 1. 6-channel, single-row pTx coil.

During the experiment, two slices were used: slice A, which is in the geometrical center on the XOY plane and another slice B – 75 mm from the geometrical center to the Z' direction on the same plane.

Firstly, the B1$^+$ maps were built for each coil and each slice in the simulation software (Figure 2, Figure 4) and then the correlation to each channel was displayed by calculating the MSE (Figure 3, Figure 5) with equation 1:

$$MSE_{k,l} = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} \left[b_k(i,j) - b_l(i,j)\right]^2 \quad (1)$$

Where k and l are the numbers of the channels; m and n are the dimensions of the B_1+ maps; and b_k and b_l are the B_1^+ maps for k and l channels, respectively.

After mapping the MSE for each channel combination, Kuhn-Munkres algorithm [6] was applied to choose the best possible pairs.

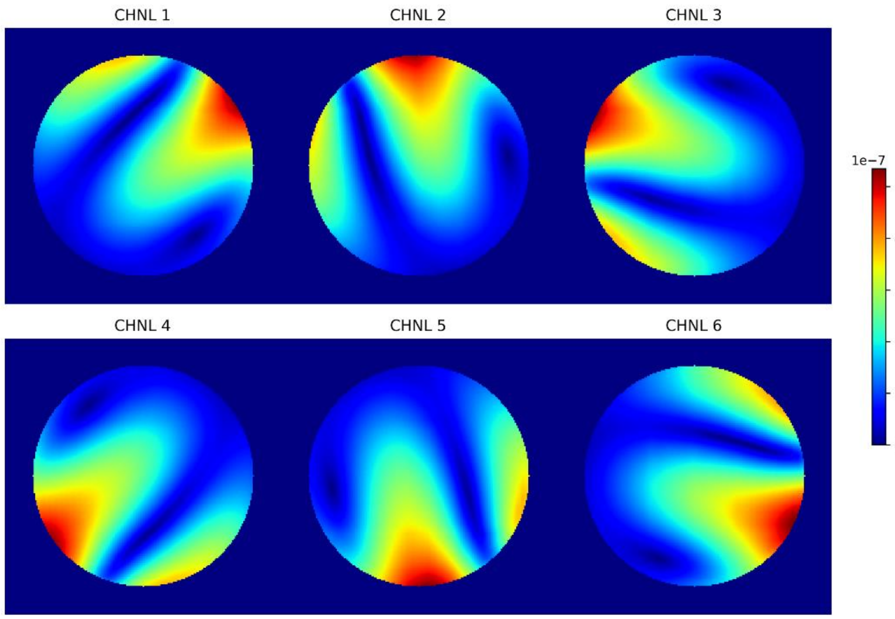

Figure 2. B_1^+ maps for each channel (CHNL) for slice A.

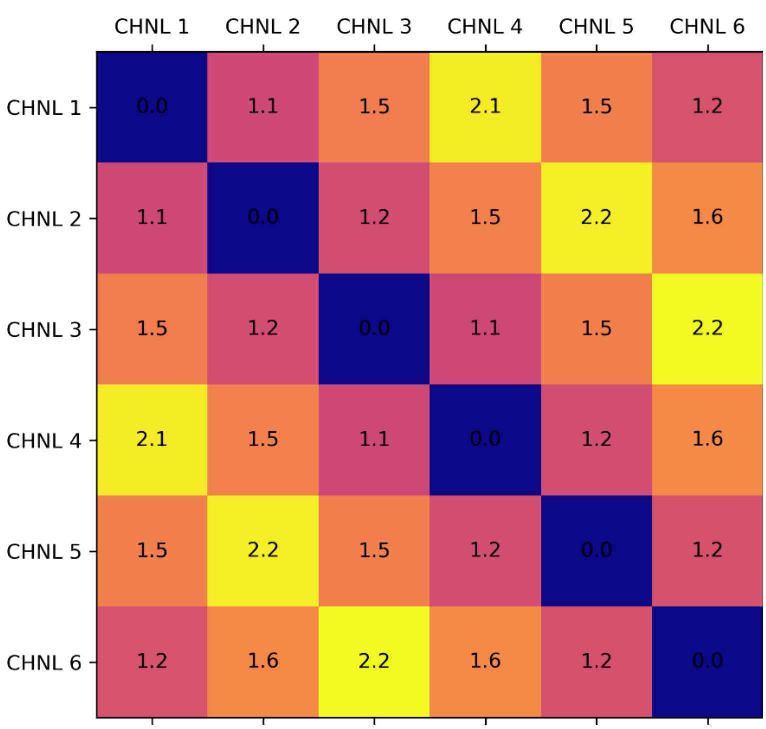

Figure 3. MSE $\times 10^{14}$ values between each channel for slice A.

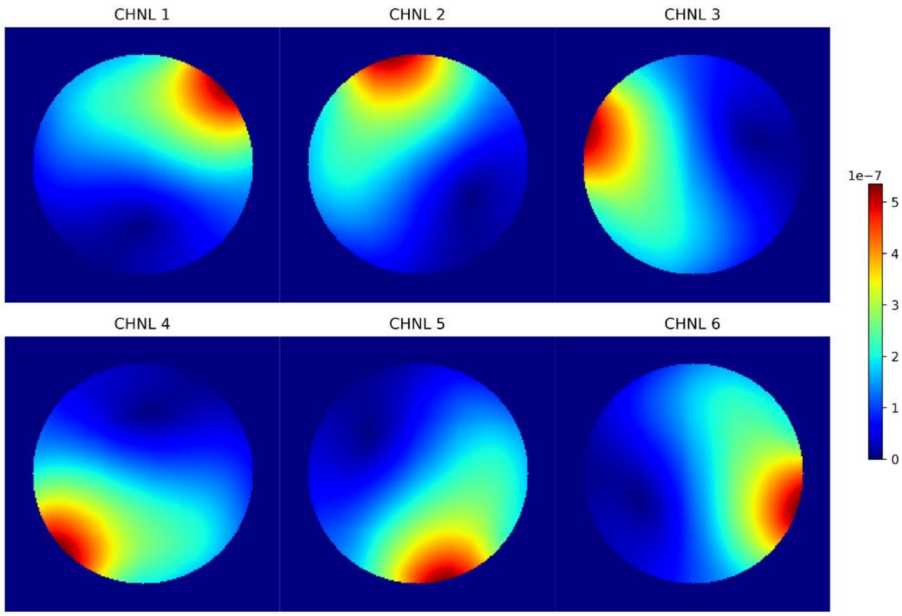

Figure 4. B_1^+ maps for each channel for slice B.

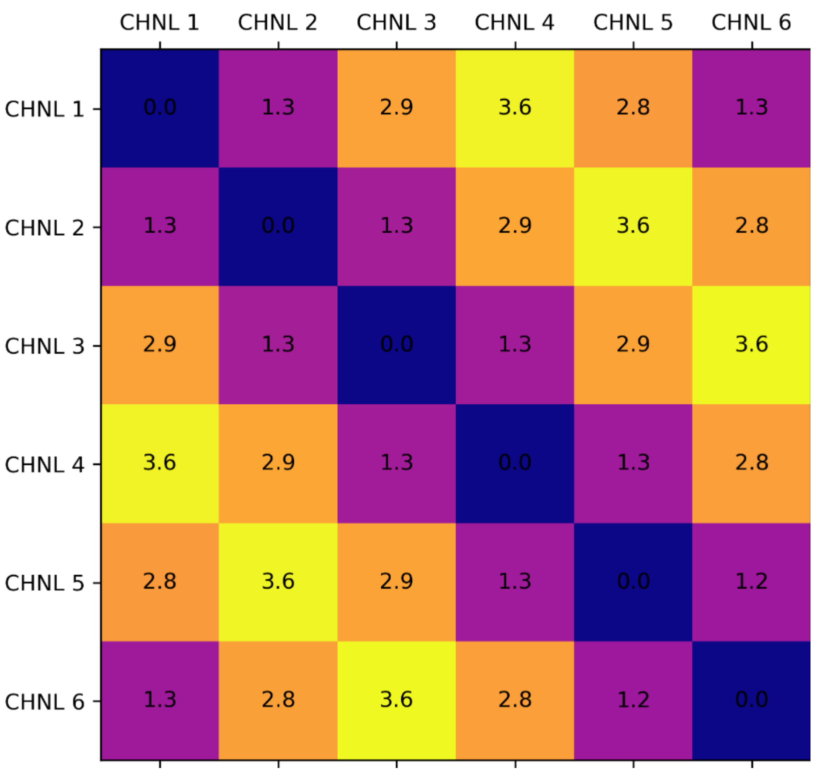

Figure 5. MSE $\times 10^{14}$ values between each channel for slice B.

Based on the results from the Kuhn-Munkres algorithm, best pairs combinations were also demonstrated in the simulation software. These pairs for the above mentioned coil are channel 1 and channel 4; channel 2 and channel 5, channel 3 and channel 6. B_1^+ maps for these combinations for the slice A and B are shown on Figure 6 and Figure 7, respectively.

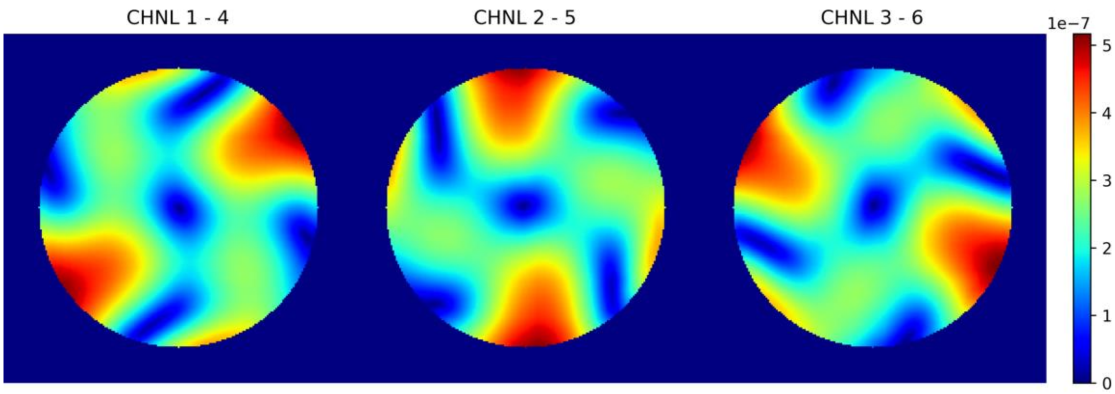

Figure 6. B_1^+ maps for chosen pairs for slice A.

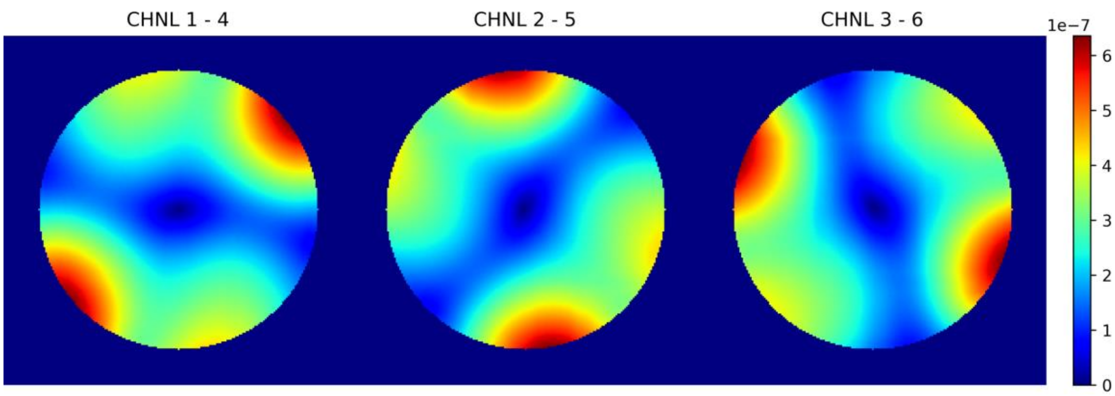

Figure 7. B_1^+ maps for chosen pairs for slice B.

4. CONCLUSION

The proposed method can be used as a guideline that demonstrates how the pTx channel can be simplified. Pairing the transmit channels decreases the requirements on the technical and for the computational side as well. This method also does not restrict using the full capability of the receive channels, even if the coil is transceiver (transmit and receive), which is important to maintain the signal-to-noise ratio (SNR).

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