16-channel Tx/Rx body coil for RF shimming with selected Cp modes at 7T

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Introduction

Strip line elements with meanders have been shown to provide good decoupling and penetration characteristics in 7 Tesla body imaging [1]. A 16-channel array with these elements was built to apply "mode compression" [2] using a 16-channel planar Butler matrix [3] and a variable power combiner [4] to increase the capability for RF shimming with an available 8-channel transmit system.

Materials and Methods

To be able to distribute 16 strip line elements with meanders around the body, the width of the previously proposed elements [1] had to be reduced by 2 cm to a new width of 8 cm. The array consists of two parts (Fig. 1), a ventral semi-circular arrangement of 11 elements and a dorsal planar array containing 5 elements which is fit into the table. The semi-circular part has an inner radius of 28.2 cm. The outer dimensions were chosen to fit closely to the bore of the MR system. The 16 pre-amplifiers are situated in two multipurpose preamp boxes with T/R-switches at the head of the patient table. The cable length was chosen to achieve preamp decoupling. The 16-channel low-loss planar Butler matrix and variable power combiner were placed outside the bore at the head end.

All images were acquired on a Siemens 7T whole-body system (Magnetom 7T, Siemens Healthcare, Erlangen, Germany) equipped with a custom 8-channel RF shimming system and 8 x 1 kW peak RF power. For RF shimming, the eight modes with the highest signal in low-flip-angle Turbo Flash sequences were chosen. The corresponding ports of the 16-channel Butler matrix were connected to the outputs of the 8-channel variable power combiner. Using a vendor provided relative B_1^+ mapping sequence, relative B_1^+ maps were acquired for each input port of the variable power combiner. A shimming algorithm was applied to maximize the average B_1^+ amplitude within the entire axial slice by optimizing the phases of the 8 transmit channels.

Results and Discussion

Reducing the width of the ground plane and simultaneously reducing the distance between the strips of the elements increased the coupling in comparison to prior designs; the coupling to neighboring elements was better than -12 dB when the coil was not loaded and better than -14 dB when loaded with a volunteer (70 kg), which is 3 to 5 dB higher coupling than in prior designs [1] but still acceptable. The 16-channel rigid design shows greater load dependence than a previous 8-channel flexible design, where the ventral elements were placed directly on the subject.

Figure 2 A) and B) show the first and second-order clockwise circularly polarized modes (Cp^+, Cp^{2+}) of the array, whereby the entire RF power of the system was combined to the corresponding input of the 16-ch Butler matrix using the variable power combiner.

Figure 2 C) shows a coronal slice with a full field of view of 50 cm in head-feet direction; D) shows a cardiac image acquired with the first-order Cp^+ mode (22.5° phase increment).

Figure 3 A) shows the eight relative B_1^+ maps for each input of the variable power combiner connected to the selected inputs of the Butler matrix, B) shows a gradient echo image in a male volunteer using a shim which was calculated from the relative B_1^+ maps to achieve maximum combined B_1^+. The arrow indicates a cyst in the left kidney which is clearly visible and definable. Note the effective fat saturation over the entire axial slice.

The 16-channel body coil using elements with meanders has a large field of view, good image homogeneity, and provides the capability for RF shimming based on selected Cp^+ modes with the use of a variable power combiner to scale-up the drive capability of an 8-channel RF system.

Figure 1: The 16-channel coil on the patient table. The two multipurpose T/R-switch and preamp boxes are visible at the bore opening.

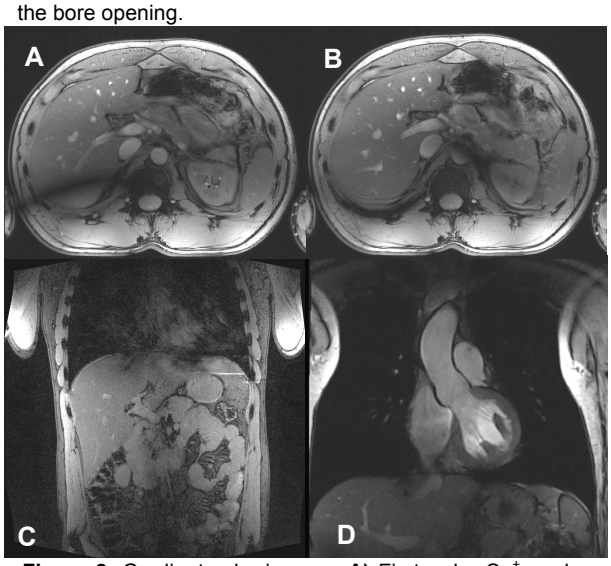

Figure 2: Gradient echo images. **A)** First order Cp^+ mode, **B)** second order Cp^{2+} mode, **C)** 50 cm FOV coronal image, **D)** example cardiac image.

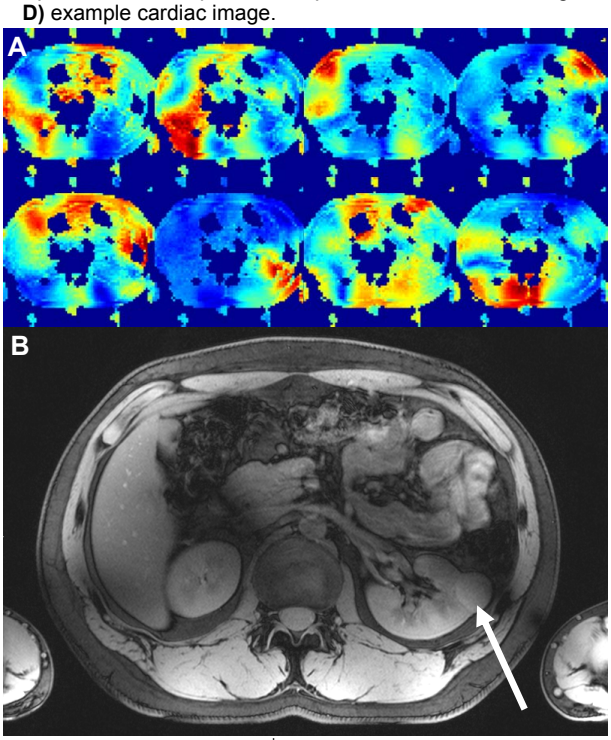

Figure 3: A) Relative B_1^+ maps for the 8 inputs of the variable power combiner. **B)** Gradient echo image with fat saturation, shimmed for maximum mean B_1^+ amplitude. The arrow indicates a cyst in the left kidney.

References

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