An 8-channel dual-tuned 1H/19F flexible 7 Tesla body coil with meanders

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Introduction

Ultra-high field strengths of 7 T and above promise a high SNR which is useful especially when trying to image nuclei with only a small incidence such as ^{19}F. A particular problem for high-resonance-frequency nuclei is introduced by the inhomogeneities due to the short wavelength which causes notable signal dropouts in body imaging. To cope with these problems, multi-channel methods such as RF shimming have been proposed. Since the resonance frequency of ^{19}F (ca. 280 MHz @ 7 T) is very close to the resonance frequency of ^{1}H (ca. 300 MHz @ 7 T), RF shimming or similar methods have to be applied for the detection of ^{19}F, introducing the need for a ^{19}F Tx array with multiple channels. A double-tuned array allows the use of the same B1 shim for both ^{1}H and ^{19}F, which should be sufficient due to the close proximity of the resonance frequencies. In this work we present a flexible 8ch Tx/Rx coil for human abdominal imaging of ^{1}H and ^{19}F at 7 T.

Material and Methods

The starting point of the development was an already successfully tested flexible 8-channel Tx/Rx micro strip line array with meanders [1]. To make the array double-tuned, the matching network was adapted. Figure 1 shows a schematic of the double-tuned element with meanders. The end capacitor C_e = 1.2 pF is used to adjust the current distribution on the micro strip line. The series capacitor C_s = 3.3 pF and the parallel capacitors C_p = 8 pF are the matching network for ^{1}H. The element was matched to the higher resonance frequency of ^{1}H with the capacitor C_p. To match the single element to a lower resonance frequency, the capacitance of the parallel capacitor C_p has to be increased; therefore, parallel to this capacitor, another capacitor C_f was introduced in line with a shorted line with a length of $\lambda_{1H}/4$. At the resonance frequency of ^{1}H, this has no effect. At the resonance frequency of ^{19}F the line has an inductance of ca. 212 nH. In line with a capacitor C_f = 1-1.2 pF, this leads to an effective capacitance C_{eff} = 3.4-8 pF, adding to C_p. The length of the λ/2 phasing line was chosen to be 180° at 290 MHz, right between the two resonance frequencies, so that only a small error is introduced at each frequency.

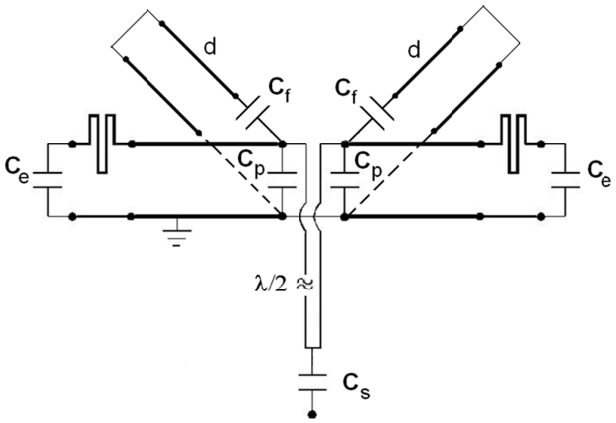

Figure 1: Schematic of a single element

The T/R-switches (Stark Contrast, Erlangen, Germany) with pre-amplifiers were located in a separate box at the head of the patient table. The imaging experiments were performed on a Siemens Magnetom 7 Tesla whole-body system (Siemens Healthcare Sector, Erlangen, Germany) equipped with a custom 8-channel RF shimming system [2]. First imaging experiments were performed in a horse's liver within a plastic box. The volume of this phantom was ca. 36 x 26 x 12 cm³. The liver contained a vial filled with 3 ml emulsion of 1% Perfluoro-15-Crownether. A vial with 10 ml emulsion of 10% Perfluoro-15-Crownether was put on top as a reference. For acquisition of the ^{1}H images a 3D VIBE sequence was used with an isotropic resolution of 0.6 mm acquired in 5:31 min. The 19F images were acquired with a 3D gradient echo sequence with an isotropic resolution of 4.8 mm. 48 averages were acquired at a total acquisition time of 5:12 min.

Results and Discussion

The vector modulators of the 8-channel shimming system were verified to modulate correctly within a frequency range of at least 100-500 MHz. The T/R-switches optimized for ^{1}H were successfully tested for their suitability for ^{19}F. Coupling between neighboring elements was below -20 dB for all channels at both frequencies. The reflection coefficient of all elements was around -10 dB and -7 dB for ^{19}F and ^{1}H, respectively, mainly due to tolerances in the length *d* (Fig. 1) and the compromise in choosing the value for C_s.

Figure 2a) shows ^{1}H VIBE images of the horse's liver within the plastic box acquired with an isotropic resolution of 0.6 mm overlaid with ^{19}F gradient echo images with an isotropic resolution of 4.8 mm using a hot metal color scale. Even though the pre-amplifiers are not optimized for ^{19}F, the 1% emulsion could still be detected. Fig. 2b) shows the relative B1 maps of the eight elements. RF shimming was possible with the 8ch array. Compared to the single-tuned coil variant, the SNR of the ^{1}H images was 55%. Since multi-tuned arrays always have a lower efficiency than single-tuned arrays, a dedicated receive array will be built in a future project, and the flexible body array will be used as a Tx/Rx array for ^{1}H and a Tx-only array for ^{19}F. This should enable the detection of even smaller concentrations of ^{19}F.

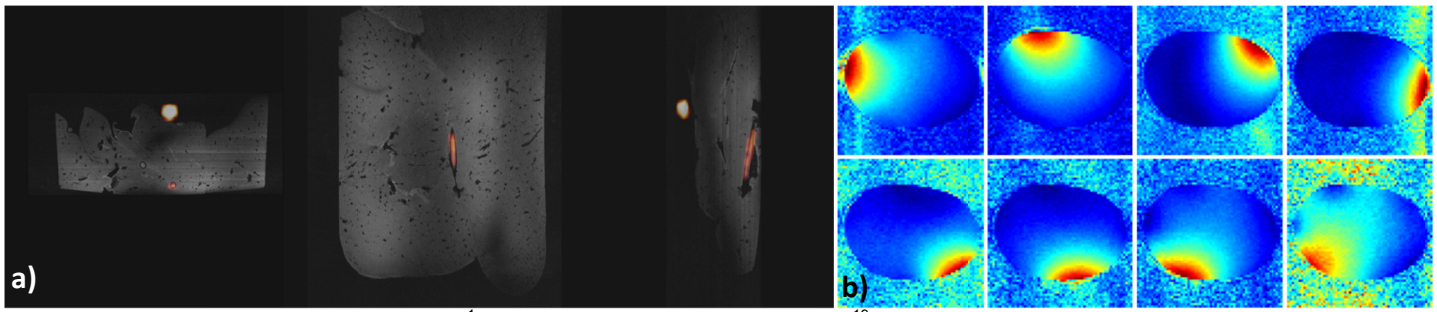

Figure 2: a) Axial, coronal and sagittal view of ^{1}H VIBE of a horse liver overlaid with ^{19}F 3D gradient echo images. The higher signal on the surface comes from a 10% solution of Perfluoro-15-Crownether, the smaller signal inside the liver from a 1% solution. b) Relative B1 maps of the eight elements in an elliptical oil phantom.

References: [1] Orzada et al., Proc Intl Soc MRM 2009, p. 2999. [2] Bitz et al., Proc Intl Soc MRM 2009, p. 4767.