2021 43rd Annual International Conference of the
IEEE Engineering in Medicine & Biology Society (EMBC)
Oct 31 - Nov 4, 2021. Virtual Conference

16-channel, Modular pTx Body Coil for 3 T MRI: A Proof of Concept

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***Abstract*— Parallel transmission (pTx) technology represents an effective technique to address radiofrequency (RF) heating issues for implanted patients submitted to Magnetic Resonance Imaging (MRI). In this abstract, a strategy to design a 16-channel pTx body coil is demonstrated on a 2-channel prototype.**

Results support the adopted solution as a promising strategy to realize the full pTx body coil.

***Clinical Relevance*— The results are a first and fundamental demonstration of a pTx design strategy pursued to realize a 16-channel pTx body coil aimed at improving MRI safety for patient carrying metallic implants.**

I. Introduction

Parallel Transmission (pTx) technology proved to be a valid solution in MRI to reduce RF heating with implanted patients while maintaining the overall quality of the diagnostic image [1].

In the present abstract, a possible solution to build a 16-channel, modular, elliptical, pTx body coil for 3 T applications, is shown. Modularity is pursued by a microstrip based design which allows avoiding any soldered connection between adjacent elements. The proposed strategy is demonstrated on a prototype consisting of 2 of the 16 elements that will compose the final pTx coil.

II. Methods

Electromagnetic (EM) simulations have been performed to optimize the elements geometry.

To obtain the power decoupling between the supply ports, two capacitors have been considered for each element connecting the microstrip line to its shield. The first capacitor ($C_{d,1}$) has been placed at 3/4 of the microstrip line length from the supply port and the second ($C_{d,2}$) at its end. The latter has also been used to shape the current distribution along the microstrip line in order to maximize the transmit sensitivity (B_1^+) in the central slice of the phantom. For each element, a variable capacitor (C_t) has been connected in series to the supply port for tuning purposes. Finally, a coaxial cable (cc) has been added in parallel to the $C_{d,2}$ capacitors to help obtaining the EM field decoupling among the two elements.

Optimum capacitor values and cc length ($C_{d,1}$ = 470 pF, $C_{d,2}$ = 10 pF, C_t = 5.1 pF, cc length = 20 cm) have been obtained through an EM/Circuit cosimulation procedure [2].

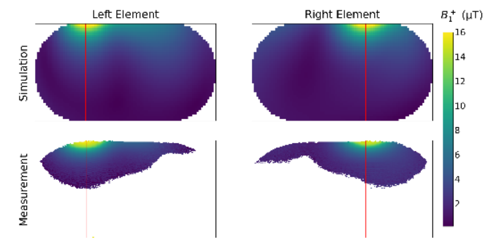

Figure 1. Comparison between expected (simulations) and measured B_1^+ distributions associated with a forward power equal to 1 kW. In the measured maps, the areas where noise was predominant are not shown.

III. Results

A two-port S-parameters measurement has been performed leaning the RF coil prototype above a foam support placed over a phantom (relative permittivity equal to 50, conductivity equal to 0.6 S/m). Two quarter-wave, 25 Ω transmission lines have been connected to the supply ports to improve matching. The following values have been measured at 123.2 MHz:
$S11 \approx S22 \approx$ -25 dB, $S12 \approx S21 \approx$ -13 dB.

In Figure 1 the simulated and measured B_1^+ distributions are compared. B_1^+ maps have been measured with a 3 T Siemens, Verio MRI scanner. The Root Mean Square Error, between simulated and measured B_1^+ along the red profiles, amounts to 1.4 µT for both elements.

IV. Discussion & Conclusion

The good power decoupling (only about 5 % of the power entering one port is reflected to the other) and B_1^+ decoupling, demonstrate the effectiveness of the proposed solution. Consequently, the results support the adopted solution as a promising strategy for the realization of the complete pTx RF body coil. The next step will be to involve in the analysis all the 16 elements of the RF coil, investigating the new values of the capacitors and coaxial lines length which optimize the RF coil performance.

Acknowledgment

This project (RMG: 17IND01-RMG1 MIMAS) has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.

References

[1] L. Winter, B. Silemek, J. Petzold, et al., “Parallel transmission medical implant safety testbed: Real-time mitigation of RF induced tip heating using time-domain E-field sensors”, in *Magn Reson Med*, 2020, vol 84, pp. 3468–3484.

[2] M. Kozlov, R. Turner, “Fast MRI coil analysis based on 3-D electromagnetic and RF circuit co-simulation” in *J Magn Reson*, 2009, vol. 200, no. 1, pp. 147–152.

*Research supported by EURAMET.

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