Active Decoupling for Prostate MR Imaging and Spectroscopy with Extended Field of View at 7T

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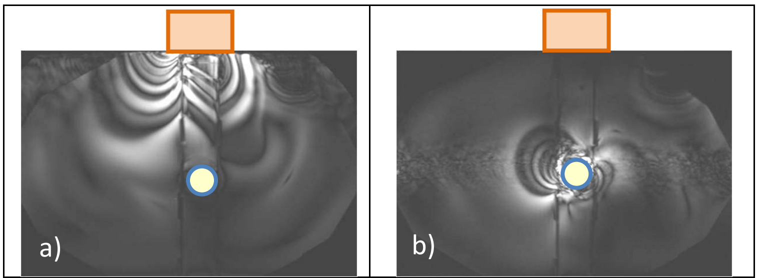
Introduction: Prostate imaging at higher magnetic fields like 7 Tesla can be challenging. B_1 shimming can be applied using external coils, but the strength in B_1 at the prostate location remains low. An endorectal coil (ERC) is generally used to obtain increased receive sensitivity at the prostate location, but when used for transmit it can substantially increase the B_1. While conventional imaging benefits form a uniform B_1, MR spectroscopy requires strong B_1. Therefore, the combination of these properties would be preferable. In contrast to receive-only (Rx) coils that need PIN diodes to be decoupled from the transmitters, the ERC transceiver remains tuned when combined with external coils. Such combination expands the B_1 field of the ERC, particularly for large prostates. However, RF coupling between the elements needs to be considered to avoid coil efficiency to be compromised and RF hot spots to be generated. Therefore, we propose the use of active decoupling as an alternative to PIN diode decoupling by transmitting with the ERC with an optimized amplitude and phase to counteract the coupling caused by the field of the external elements.

Methods: A 7 Tesla system (Philips Healthcare, Cleveland, OH, USA) was used for all the experiments. One radiative antenna and a loop coil in an ERC both tuned and matched to 298.2MHz were used for the phantom experiments. Each element was driven with 1kW power. A water phantom emulating a body torso was used to investigate the coupling between each element. The radiative antenna was positioned on top of the phantom and the ERC was inserted in a PVC tube inside the phantom in the mid-axial plane of it. To achieve a stronger coupling between these elements to investigate the active decoupling in more detail, a double compartment water phantom was used. In this case, both coils were positioned close to each other and the ERC was tilted to find the maximum coupling situation between both elements using S_{12} measurements. In-vivo measurements were performed with a double element ERC[1] (2x1 kW) and two radiative antennas (2x4 kW) above the pelvis of the volunteer. All phantom images were obtained as a 2D FFE slice with 102 TFE factor, TE/TR=7/200 ms, 600° flip angle, 400x400 mm^2 FOV, 408x204 matrix and 10 mm slice thickness while transmitting with all elements. In-vivo images were obtained with 2D FFE, TE/TR=2/42 ms, 45° flip angle, 500x500 mm^2 FOV, 3 mm thickness, 252x250 matrix . From the images B_1 was estimated from the transition black-white zones that correspond to spin excitation or inversion caused by the strong nominal flip angle (600 degrees). The measurements were obtained transmitting only with the ERC or the radiative antenna while receiving with all elements. The B_1 amplitude of the ERC was then scaled to the value obtained with the external antenna in the area close to the ERC. The phase was manually adjusted to obtain negligible field disturbance in the area of the ERC while transmitting with all elements.

Results and discussion: Measurements on the torso phantom and in-vivo showed no coupling between the elements (Figure 1 a-c), as expected from the strong tissue load dominance. Therefore, active decoupling was not needed. In-vivo results show the enlarged FOV when combining the ERC with the antennas, not only in reception, but also during transmission.
Measurements on the high coupling situation show that after transmitting with both elements and optimizing the transmission phase and amplitude of the ERC it is possible to actively decouple the antenna from the loop coil (Figure 2 a, b) in 1-2 minutes.

Conclusions: we have shown that active decoupling can be as effective as PIN diode decoupling. Using a minimum adjustment time to match the amplitude and phase of the fields, any inductive coupling can be counteracted. With this approach we minimize the components of the ERC (by avoiding a PIN diode inclusion), optimize the sensitivity in prostate MRI, enable combined use of uniform MRI with efficient MRS and even extended the B_1 field of the ERC for the large prostates cases. This approach is practical for MRI and MRS of the prostate at high field. However, this can be extended to other field strengths and techniques like UTE where switching times between Tx and Rx could be reduced by avoiding the use of PIN diodes.



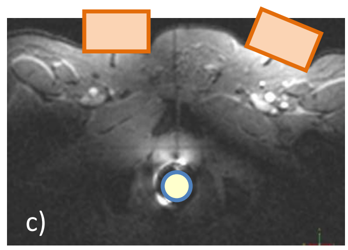


***Figure 1:** Measurements on body phantom showing Tx fields reflected by the black-white transition zones due to high nominal flip angle (600 degrees). The yellow circle shows de position of the ERC. The orange blocks represent the radiative antennas. a) TxRx with radiative antenna showing no coupling on the loop coil. b) TxRx with loop coil, showing no coupling on the radiative antenna. In-vivo imaging in c) with a 2-elements ERC and 2 radiative antennas showing no coupling between elements.*

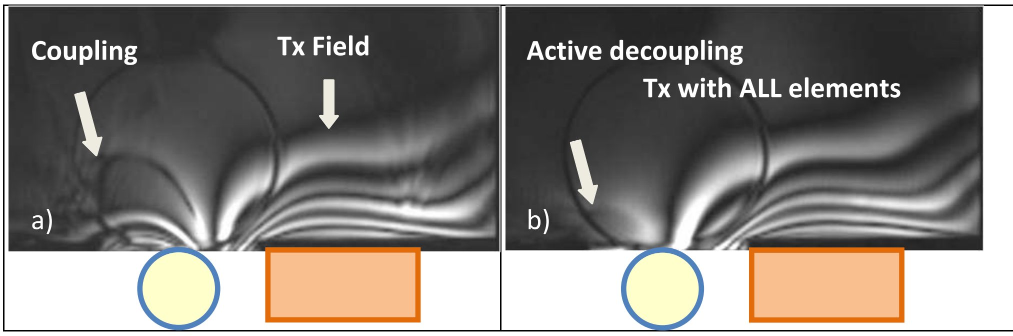


***Figure 2:** Measurements in a double compartment phantom with maximum coupling scenario (a) when TxRx with the radiative antenna only. The active decoupling on b) is achieved when Tx with both elements. The amplitude and phase of the ERC is chosen to counteract the effect of the antenna.*

[1]Proc. Intl. Soc. Mag. Reson. Med.2009, Honolulu, Hawaii. 4744