Prostate imaging at 7T using four stripline elements and one amplifier

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Introduction

High field (7 Tesla) imaging offers great potential for diagnostic applications in oncology. However, the shorter wavelength of the RF signal at 7 Tesla causes interference of the RF waves and a reduced penetration depth inside the body. Prostate imaging at 7 T is therefore considered a complicated procedure, requiring advanced technology and experience. We demonstrate the contrary by developing a transceive RF coil and driver design that is able to cope with these challenges using one 4 kW amplifier and only two receive channels.

Materials and methods

The prostate coil array contains 4 stripline elements. Each element consists of a teflon substrate of 10 x 3.5 x 4.3 cm^3, with a 12 mm copper conductor and a ground plane extending over the lateral sides of the substrate up to 5 mm below the top (figure 1). To reduce capacitive coupling to the patient, a 5 mm teflon spacer was placed between the conductor and the patient.

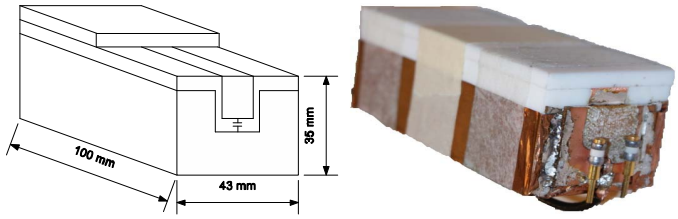

Figure 1: Schematic and picture of stripline element: Teflon substrate with copper conductor and ground plane extending over the lateral sides of the substrate.

Two elements were placed ventrally and two elements were positioned at the dorsal side. Decoupling circuitry was not necessary: The coupling between the two elements at the anterior side was –21 dB. The coupling at the posterior side was -23 dB.

The transmit signal from the amplifier is passed to a quadrature hybrid[1] via a self developed Tx/Rx switch. The two output signals from the quadrature hybrid are then connected to two of the stripline elements (either the two posterior or the two anterior elements). The receive signals from all four stripline elements are routed to the scanner via the same quadrature hybrids, the Tx/Rx switches and the preamps (figure 2).

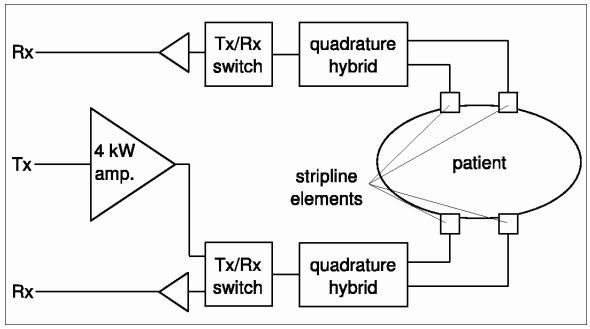

Figure 2: Schematic of circuitry between stripline elements and MR system

Results

In figure 3 a transverse gradient echo image is shown of the pelvic area and the prostate. The transmit signal is connected to the elements at the dorsal side. The image clearly shows the bend pattern near the transmitting elements. Although dark signal voids exist in the image, the prostate is clearly visible. Connecting the ventral elements to the transmit signal resulted in images of poorer quality (figure 4).

The simulations (figure 5) show that the B_1^+ field decays significantly upon penetration of the body. Furthermore, the SAR simulations indicate that the SAR peaks are located close to the coil elements. Therefore these SAR peaks will be the limiting factor to obtain sufficient B_1^+ in the prostate, stressing the importance of adding more elements to distribute the power.

Conclusion and discussion

For high field MR imaging, a four stripline element prostate coil with two of these elements connected to one amplifier, is able to visualize the prostate. In near future, a second amplifier will be used along with an already developed digital vector modulator, which allows us to use phase-amplitude shimming in order to improve the performance of the system.

[1]: Innovative Power Products, IPP-2066

[2]: A. Christ et al. "The Virtual Family – Development of anatomical CAD models of two adults and two children for dosimetric simulations" in preparation

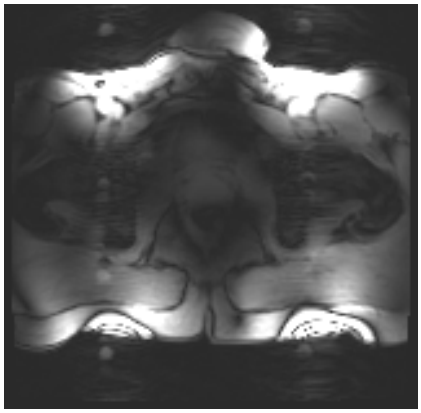

Figure 3: Transversal slice of prostate gradient echo scan at 7 T. Transmit signal to dorsal elements.

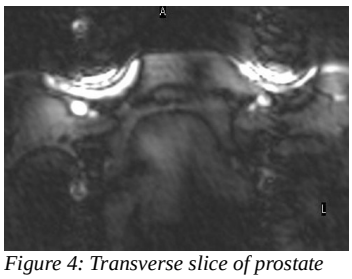

Figure 4: Transverse slice of prostate gradient echo scan at 7 T. Transmit signal to ventral elements.

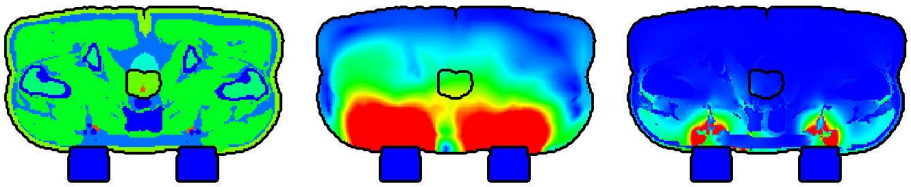

Figure 5: FDTD simulation results. From left to right: anatomy, B_1^+ distribution and SAR distribution