

Transmit/receive array for prostate imaging with fully flexible dipole antennas

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Introduction: The use of dipole antennas for ultra-high field imaging is developing rapidly, particularly for body applications [1-4]. Many design variations have been presented among which the so-called ‘fractionated dipole antenna’ [5] where the dipole antenna legs were split into segments, interconnected by inductors (meanders). In this way, SAR levels could be alleviated. However, the elements still need to be in close contact with the imaging subject for optimal matching of the antennas to the tissue. With straight, rigid antennas this is not always possible; parts of the antenna will be at distance from the body. In these cases, the energy flux has to pass through a narrower contact surface, resulting in higher SAR levels and suboptimal B1 levels. To avoid such incomplete abutment of the elements to the body, we have developed a flexible version of this array, so the array can adapt to the curvature of the imaging subject. This should increase efficiency and reduce SAR levels. In addition, the flexible array provides a more comfortable setting for the imaging subject. The challenge for this array is that a flexible setup can potentially cause larger variability in the loading of individual elements which may result in large amounts of reflected power. Therefore, the variability in matching and coupling between 3 subjects has been investigated to test whether such an approach is feasible with a fixed-tuned matching network.

Methods: The antenna elements are made from flexible PCB board (0.5 mm FR4). The antennas are 30 cm long and are split by four meanders (figure 1a). In the center of each antenna, a symmetrical matching network (figure 1c) is mounted on the PCB. An extra plastic strip is mounted underneath the center of each element to prevent fractures. Each matching network and cable attachment was protected by a plastic housing. Eight antennas are mounted on two slabs of foam with a thickness of 30 mm to ensure approximately 20 mm spacing towards the body (figure 1d). All antennas are tied loosely to the foam slab to allow the pieces to slide over each other when bending the array.

Results: a flexible 8-element transmit-receive array was built for body imaging at 7 Tesla. Matching and coupling was determined for three male subjects (figure 2). These results show that a flexible setup is feasible using fixed-tuned fractionated dipole antennas as array elements. Also note that the coupling between elements is very small (<-15 dB).

The array was evaluated on a Philips Achieva 7 Tesla system (Philips Healthcare Best) by a prostate imaging experiment. An AFI B1 map was obtained to determine the efficiency and a T2w TSE image was acquired to obtain a qualitative measure of the performance. The B₁⁺ level inside the prostate (using 8x350 W net input power) was 7 uT.

Conclusion: Flexible radiative antennas can be used as practical RF arrays for 7T body imaging since matching as well as coupling remains good between subjects without readjusting matching conditions.

References: [1] Raaijmakers et al. MRM 2011 [2] Winter et al. PloS One 2013 [3] Eryaman et al. ISMRM 2013 [4] Wiggins et al. ISMRM 2013 [5] Raaijmakers et al. ISMRM 2013

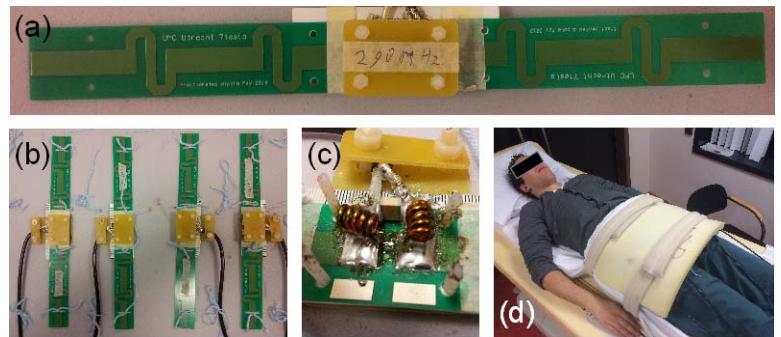


Figure 1: Flexible array of fractionated dipole antennas a)One single antenna b) Four antennas mounted on a slab of foam b) Matching network c)Array setup for prostate imaging

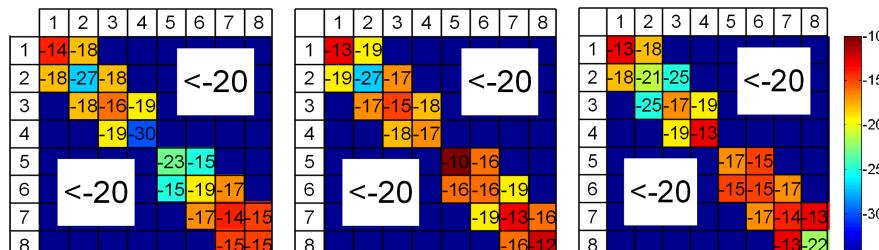


Figure 2: Coupling matrix for three male subjects
 1) 1.84 m, 80 kg; 2) 1.90 m, 88 kg; 3) 1.80 m, 74 kg.

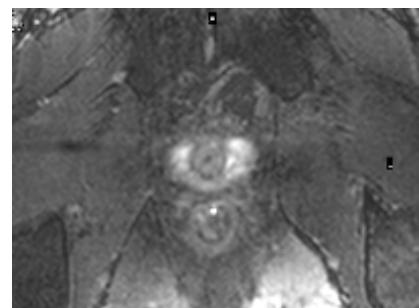


Figure 3: a) TSE imaging result
 TR/TE =6000/70 ms, 1x1x12 mm³