Miniaturized Patch Antenna for Traveling-wave Excitation: Pilot Study at 7 T MRI

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Introduction: Traveling-wave excitation in high field MRI has been introduced in an effort to increase field of view (FOV) and improve RF transmit (Tx) field homogeneity [1]. There are many different options to design and drive a patch antenna efficiently, since antenna shape, substrate material, and feeding position can all affect its efficiency [2]. Recently, an interesting patch antenna was developed (not for MRI purpose), which is 80 % smaller size than conventional patch antenna at 300 MHz without notable loss of antenna efficiency [3]. Circular polarization (CP) with single feeding point is also possible. Here, we report our investigations how we used the miniaturized patch antenna at a 7T MR system.

Methods: Images were acquired with a miniaturized patch antenna designed for another application [3] using a 7T MRI system (Siemens, Erlangen, Germany). Dimensions of the front plate and substrate (acrylic plate, ε_r 2.62) are 159×159 mm^2, 182×182×12 mm^3, respectively. Thirty-six plugs (K85 ceramic material [3], ε_r 70-80) were placed strategically in the substrate, to produce a small sized antenna and to accomplish CP with a single feed (Figure 1). More detailed information about the design and miniaturized patch antenna are given in [3]. Since the patch antenna produces a CP field with only a single feed, the proper direction of propagation had to be determined by transmitting to the phantom from both the patient and service ends of the bore. (Direction of spin rotation by patch antenna excitation should match with the direction of spin rotation by the system magnetic field (B_0), for effective excitation). As shown in Figure 2, we placed a spherical oil phantom (diameter 17.2 cm) at the center of the magnet and tested the patch antenna at two different locations, at -50 cm and at +50 cm from the center of the MR system along z, with the antenna facing the oil phantom in each case (Figure 2a). A U-shaped 6-channel Rx array placed under the oil phantom (Figure 2b) was used for reception in both cases. In each case, an axial gradient-echo (GRE) image was acquired with TR/TE=300/3 ms, FA=60 deg, slice thickness=10 mm, FOV=220×220 mm^2, Matrix 256×256, and 4 averages. Flip-angle maps (using rectangular pre-saturation pulse) were also acquired at the same location of GRE images with TR/TE=5000/2.04 ms, slice thickness=10 mm, FOV=220× 220 mm^2, matrix size=128×128, 4 averages, duration of saturation RF pulse=2 ms [4]. The same reference voltage (150 V) was applied to the RF power amplifier for each case.

Results and Discussion: GRE images at the antenna location of +50 cm and -50 cm are shown in Figure 3a and 3b, respectively. Much higher signal intensity was observed with the antenna at the -50 cm location, which means that the direction of field rotation matched that of nuclear precession with the antenna at that location, and also demonstrates that the patch antenna produces a primarily CP field with only a single feed. The bottom area of the GRE image has higher signal intensity because of the Rx array position. Figure 3c shows FA map with the antenna located at -50 cm. Due to the need to tune by modification of the geometry, transmit efficiency may be further improved with this antenna. Future work will include a fine tuning this antenna and comparing the resulting transmit efficiency to a conventional patch antenna design. Due to its small size, this patch antenna may have less interference with other hardware components (magnet bore, other RF coils, etc.) and also allow for placement of multiple patch antennas in the bore for configuration of a patch antenna array for parallel imaging [5].

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References:

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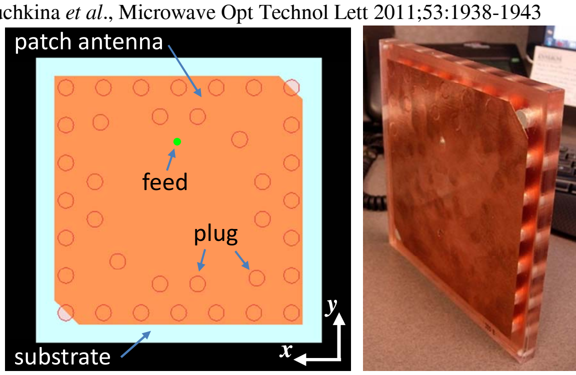

Figure 1. Miniaturized patch antenna with one feed point for circular polarization.

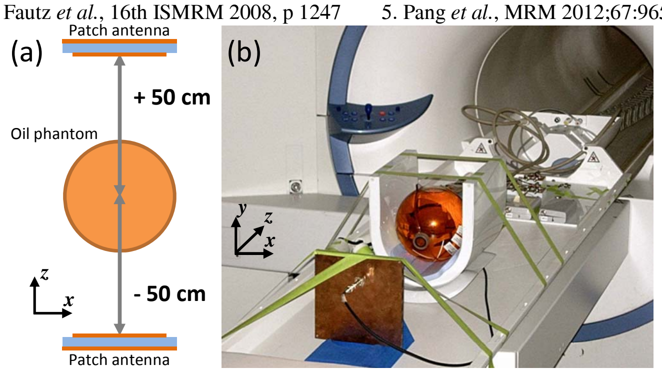

Figure 2. (a) 7T experiment set-up to find patch antenna position for CP mode. (b) Patch antenna is placed at -50 cm position from the oil phantom center.

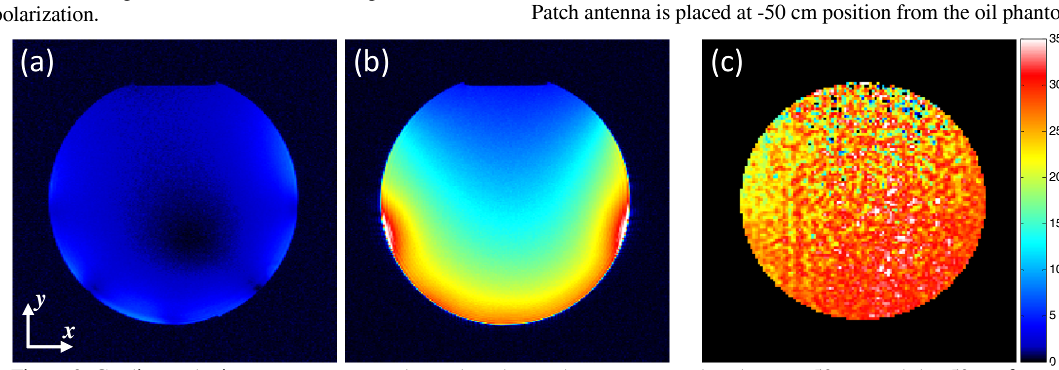

Figure 3. Gradient-echo image at transverse-plane when the patch antenna was placed at (a) +50 cm, and (b) -50 cm from the oil phantom center. (same scale) (c) Flip-angle map corresponding with (b) in degrees.