Improving B1 Excitation in Head Apex by Combining Birdcage coil with Crossed Dipole Elements

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Introduction:

Circularly polarized (CP) Volume coils have been used for B1 excitation in Head imaging at 7.0 Tesla. The excitation pattern in the head shows a marked central brightening, with the apex of the head typically poorly excited .Previous work addressed this by combining a cylindrical array of dipole elements with three geometrically decoupled loops with their axis parallel to the magnet axis [1].

In this work we combined a Birdcage Coil with a Crossed Dipole antenna configuration by placing the crossed dipoles at the service end of the birdcage. The Crossed Dipole configuration generates a circularly polarized travelling Wave when used at a distance from the imaged object [3]. When placed in close proximity to the object this configuration produces a more localized excitation. The crossed dipole pair was placed close to the apex of the head and was used to modify the $B1^+$ pattern in the head, improving excitation at the apex.

Birdcage and Crossed Dipole Coils

Methods:

Figure 1 shows the experimental setup. An in house built eight rung hybrid birdcage coil was used. The Birdcage dimensions were O/D -30.4 cm and S/I Length -11.5 cm. The dipoles were fabricated from FR4 circuit board with 6 mm wide traces. To achieve maximum efficiency at 7.0 Tesla a simple dipole in free space needs to be around 50 cm long [4], which is not practical. The dipoles were shortened to 23.5 cm long with a tuning inductor placed in each of the dipole wires. The dipoles were matched to the load using a capacitor and a $\lambda/4$ lattice balun (Fig 2).

Figure 2. Match Circuit

The coils were connected to the scanner using an in house constructed 8 channel T/R interface boxes. A custom built head shaped phantom (Agarose Gel, 1% w/v of Nacl) was used for imaging. All data were acquired on a Siemens 7.0 Tesla whole body scanner (Siemens Medical Solutions, Erlangen, Germany) with an 8 channel parallel transmit system.

Two arrangements were tested namely the birdcage coil in a standalone configuration and the Birdcage coil combined with the crossed dipole configuration. The exact same phantom position and land mark were used in both the experiments. For the stand alone birdcage configuration the crossed dipole setup was physically removed. B1+ efficiency was determined by using a turbo-FLASH sequence with various preparations pulses to find the RF voltage required to produce a 90 degree flip angle in the center of the phantom. Actual flip angle maps were obtained using AFI sequence [5] with TR1/TR2 = 33.33/166.67 ms, 3mm isotropic resolution with 64x64x60 matrix.

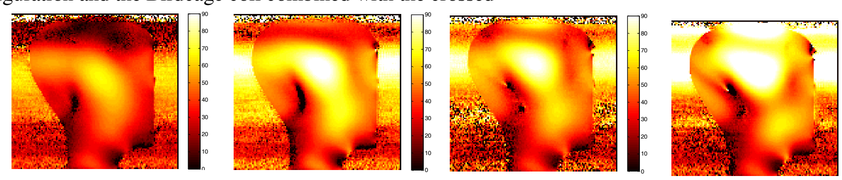

Figure 3.
turbo-Flash B1 maps: From L-R Birdcage, Birdcage Dipoles with Dipoles passive, Birdcage 81%, Dipoles 41% and Birdcage and Dipole Full power.

Results:

The coupling between the crossed dipole pair was –20 dB. The crossed dipole elements are sensitive to proximity to the sample, exhibiting strong frequency shifts. With the fixed coil to phantom relationship we were able to tune and match each element to better than -20 dB. The Birdcage ports were matched to -15 dB and the isolation between the birdcage ports was –18 dB. A 90 degree flip was obtained in the center of the phantom with 147V 500 µs hard pulse for the stand alone birdcage coil configuration. For the combined birdcage and crossed dipole case the transmit amplitude of the parallel transmit channels were adjusted to maintain the calibrated flip angle at the center of the phantom.

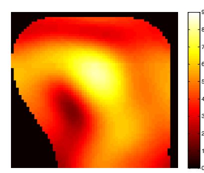

Figure 4
Birdcage Flip Angle Map

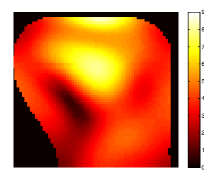

Figure 5
Birdcage and Crossed Dipoles Combined AFI Flip Angle Map

Sagittal turbo-Flash B1 maps for stand- alone birdcage, birdcage with dipoles present with dipoles not excited, birdcage at 81% with dipoles at 41% and Birdcage with dipoles at full power are shown in figure 3.The AFI B1 maps for the birdcage stand alone and birdcage and dipoles combination with birdcage at 81% of the power and dipoles at 41 % of power is shown in figure 4 and 5. The excitation produced by the birdcage coil in stand-alone configuration showed central brightening and poor excitation at the top of the head. The excitation pattern produced by the combined configuration showed improved excitation at the head apex at the expense of some reduction in excitation in more inferior regions of the phantom. The crossed dipoles produced an excitation even when they were left passive.

Discussion:

The proximity of the crossed dipole pair to the phantom produced a strong Excitation at the head apex. In addition the CP modes generated by Crossed dipole pair and the Birdcage coil interact with each other. This we believe is the reason for the change in B1 pattern observed in the center of the phantom compared to the B1 pattern produced by standalone Birdcage.

References:

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