Simulation and Measurement of Receive Surface Coil Detuning at 7T

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Introduction: The availability of volume transmit coils at 7T has introduced the need for detuning of receive-only surface coils at frequencies substantially higher than previously investigated. Disabling of receive coils during transmit is extremely important as inadequately isolated receive coils can focus transmit B1 fields and lead to high local tissue SAR. At lower frequencies, disabling of receive coils during volume transmit is typically done by the use of a resonant trap circuit which creates high blocking impedance in series with the coil (1). This abstract uses both FDTD field simulations and measured data to make preliminary studies of the requirements for multiple blocking networks on 7T receive-only coils.

Methods: We considered the situation of a single 5x16 cm rectangular surface coil element constructed of 0.5cm flat conductors. This size receive coil is similar to that required for typical close fitting eight-channel head array. The model receive coil was placed centrally within a 30cm ID high pass shielded volume coil of 20cm length. Each receive coil was detuned by one or more equally spaced infinite resistance gaps in the conductors to simulate high impedance blocking networks at these locations.

For simulation purposes, a commercially available FDTD software package (Xfdtd, Remcom, Inc, PA, USA) was used to simulate the time varying magnetic and electric fields of the volume coil and centrally located surface coil on a 5mm mesh. Three loops were simulated with distributed capacitance necessary to tune the intact receive coils to 298Mhz and with one, two, or four 0.5cm wide detuning gaps present. A fourth untuned receive loop of same geometry was simulated with a single 0.5cm detuning gap.

For measurement purposes, four receive loops of nearly identical geometry to the simulations were etched on G10 PC boards. As in the simulations, three of these loops were tuned to 298MHz with 8 distributed capacitors and 0.25cm breaks were placed at one, two, and four locations around the loops. A fourth untuned loop was tested which had a single 0.25cm gap at one end. These model detuned receive coils were then individually scanned inside a 7T detunable head coil in transmit/receive mode (NM-008A, Nova Medical, Inc, Wilmington MA) on a 7T GE whole body scanner. For simplicity, a standard GRE sequence was used for imaging on a silicon oil phantom. Consequently, the measured data showed combined effects of coupling both during transmit and receive.

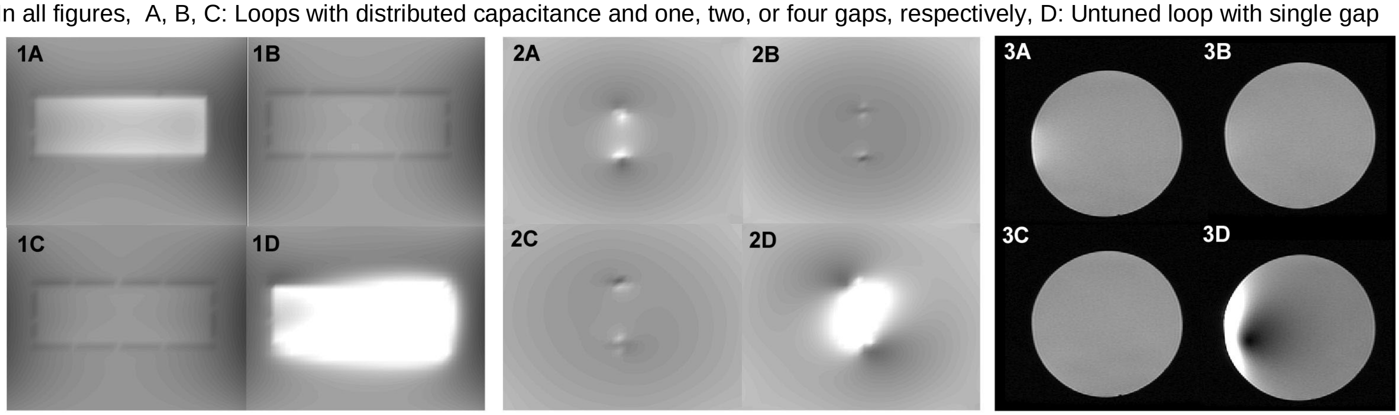
Results and Discussion: Figures 1 and 2 show the respective coronal and axial field profiles of the model detuned receive coils. Figure 3 shows the measured data in axial slices. Both simulations and measured data show significant B1 field distortion present on the receive-coil element containing a single high impedance block (figures 1-3A). Significant improvement was seen with two or four separate blocking locations though modest field distortions could still be detected even in the latter case directly adjacent to the conductors (figures 1-3B and 1-3C). The untuned loop with a single break had substantially more RF field interactions than the loops with distributed capacitance (figures 1-3D).

A rectangular receive coil loop with a single break appears as folded dipole. As the size of this structure approaches half-wavelength, it will increasingly interact with time varying electromagnetic transmit fields (2). The presence of distributed capacitance can reduce though not necessarily completely eliminate the dipole coupling to the transmit field.

The marked interaction of the untuned loop has important implications for array cable design where short lengths of conductors can have large induced RF common mode currents. As at lower frequencies, common mode baluns are required to minimize these currents though proportionally more are needed per unit length.

Conclusion: The simulations and measurements presented show the need for careful design of electrically large receive coils and arrays. Due to electric dipole effects, a single high impedance blocking network may not provide adequate isolation of high frequency receive coils. Simple untuned conductors will also interact with high frequency B1 fields and this has important implication for safe cable design and layout at 7T.

Figure1: Simulated coronal field profiles **Figure 2:** Simulated axial field profiles **Figure 3**: Measured axial image data on phantom
In all figures, A, B, C: Loops with distributed capacitance and one, two, or four gaps, respectively, D: Untuned loop with single gap



References:
1) Edelstein, et al, JMR 67, 156-161 (1986)
2) Kraus, JD, Antennas 2nd ed, McGraw-Hill, 1988, p151-3.