Ultrahigh Field Body Transmit Arrays Using Non-resonance Method: A Feasibility Study

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INTRODUCTION:

Due to the large size and thus increased inductance and parasitic capacitance, design of ultrahigh field body coil arrays or body transmitter arrays for parallel excitation faces technical challenges, such as difficulties to achieve the required high resonance frequency, increased phase variation along the coil conductors, daunting decoupling problems and degraded Q factors. In this work, we investigate a body transmit array design method using non-resonance method (NORM) for ultrahigh field MR signal excitation (and also reception if need) (1). The proposed method would provide a robust design technique for ultrahigh field body transmit arrays with multinuclear capability, improved decoupling among the elements, less phase variation along the coil elements and high frequency operation capability.

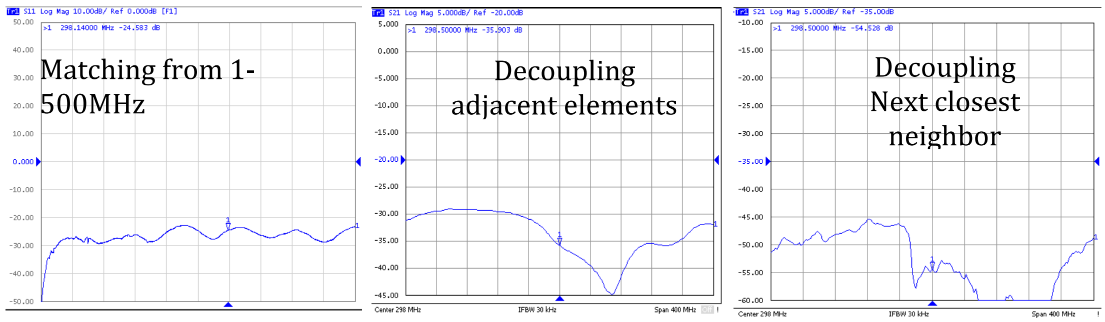

Fig 1 preliminary studies performed with 4 30-cm-long NORM elements placed in parallel. The NORM element was able to match to 50 Ohm within a broad range of 1-500 MHz (left insert). The decoupling measured between two adjacent elements (2cm apart) was ~-35 dB (middle insert) while the decoupling between the next closest neighbors was ~ -54dB (right insert). This performance would be well suitable for designing body transmit arrays.

METHOD:

The non-resonance method was implemented by using microstrip transmission lines. The preliminary studies on a 4 element planar NORM array demonstrated a robust decoupling performance shown in Fig 1. FDTD stimulations also showed that non-resonance lines have a much more uniform field distribution along the line than that of the resonant lines (Fig 2). These unique features of non-resonant microstrip are advantageous and essential to ultrahigh field body transmit array designs. An 8-channel body transmit array model was generated to evaluate the behaviors of its fields and decoupling performance using FDTD algorithm.

RESULTS and CONCLUSIONS: Fig 2 shows the FDTD simulation results on the B1 distribution along the non-resonant and resonant microstrips with different frequencies of 300MHz and 1GHz, demonstrating the non-resonant coil had a much flat B1 along the line over the resonant microstrip coil elements. In addition, the frequency independent property of non-resonant coils enables the multi-nuclear and multi-field strength capabilities of the non-resonant transmit array. In other words, a non-resonant body transmit array can be readily used for any nucleus at any field strength. In the 8-channel body array evaluation, FDTD results showed that the worst decoupling among the elements achieved at least -40dB, indicating an excellent decoupling performance. The combined B1+ of the individual fields from each element is fairly uniform in the imaging area at both 300MHz and 75MHz.. With the B1 control capability of the transmit array (combining the use of multi-channel transmitter), the B1 field can be manipulated based on specific application demands, e.g., B1 shimming, selective excitation and optimizing SAR. These promising features would make the non-resonance method a great choice of design methods for ultrahigh field body transmit arrays for parallel imaging.

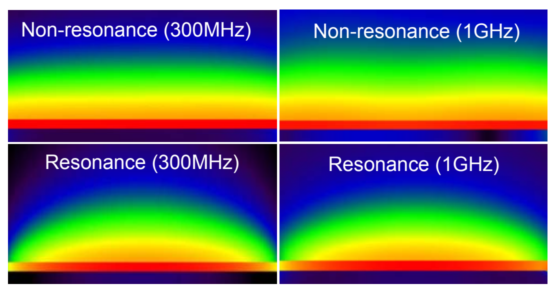

Fig 2 FDTD simulated results -- B1 maps along the non-resonant microstrip lines and resonant microstrips. The length of all the lines shown here was 18 cm. Non-resonant microstrip demonstrated a much flat B1 distribution (or less phase variation) along the line over the conventional resonant microstrips at frequencies up to 1GHz.

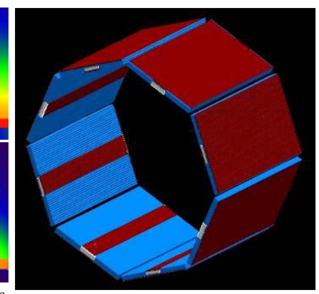

Fig 3 The 8 element body transmit array model. The size is 70cm dia by 48cm length which is adopted from one of the industry standards.

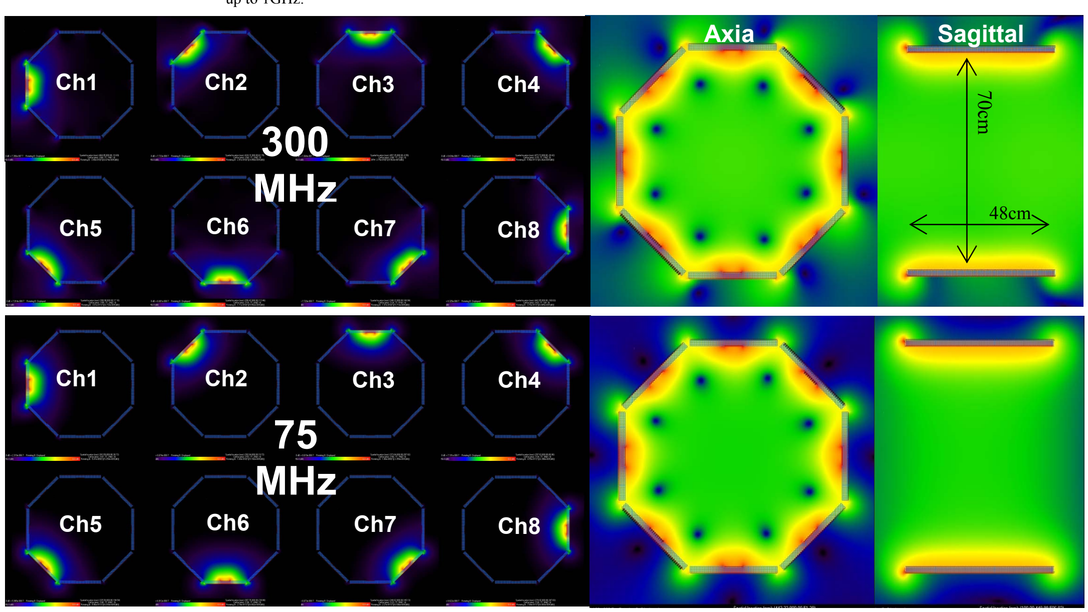

Fig 4. Without using any decoupling network, well-defined B1 profiles from each element have been obtained at 300MHz, indicating excellent decoupling among the NORM coil elements. It suggests a robust solution to ultrahigh transmit array design. The right is the combined B1+ from each element in axial and sagittal orientations of this 8-channel body transmit array which shows uniform distribution at 300MHz. The body transmit coil size is adapted from an industry standard (70cm Dia by 48cm length). If this body transmit array is fed by different frequency, e.g. 75MHz, the array showed similar behavior in terms of decoupling, impedance matching and field distribution.

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REFERENCES: (1) ISMRM 16, p435 (2008).