Impact of different meander sizes on the RF transmit performance and decoupling of micro strip line elements at 7T

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Target audience: RF coil developers working at ultra high field MR imaging systems.

Introduction: Micro strip line (MSL) elements[1,2] and dipole antennas[3] have successfully been incorporated as radiofrequency (RF) transmit elements in MRI at 7T. Some inherent features of both types are combined in meander elements (ME)[4] (**Figure 1A**). This work investigates the impact of changing meander size on RF transmit performance and on the decoupling between ME.

Material and Methods: Modelling of the ME is done in CST Microwave Studio (CST AG, Darmstadt, Germany). All modeled elements have a length of 250 mm in z-direction, a width of 100 mm in y-direction and a distance of 20 mm between the ground plane and the meander structure (**Figure 1B**), both on a 0.8 mm Rogers 4003C carrier substrate. Central feeding is used and simulated in a co-simulation using a λ/2 balun and a matching network [2] which allows for a reflection factor of $S11 =< -20.00$ dB at a center frequency of 297 MHz. A rectangular phantom ($\varepsilon = 45.3$, $\Omega = 0.87$ S/m) is placed 30 mm above the ME. Close to the meander structure the meshing is refined to 0.5 mm. Starting with a simple MSL (meander size = 0) the meander size is increased in steps of 2.5 mm until at 50 mm the whole size in y-direction (100 mm) is covered (green in **Figure 1B**). By variation of the capacitors at the end (C_{end}), a maximum H-field is achieved by repeated evaluation of a central line plot along the z-direction 30 mm inside the phantom. After optimizing each single ME, for evaluation of the decoupling between elements an identical ME is placed next to the first one in y-direction, so that a distance of 10 mm between the elements simulates the setup of a real transmit array.

Results and Discussion: With increasing meander size (increasing electrical length), smaller values for C_{end} have to be used for maximizing the field strength as can be expected and the model approaches the case of a dipole antenna. In **Figure 2** line plots of the H-field along the y-direction 30 mm inside the phantom are depicted, demonstrating maximum field strength for medium meander sizes inside the object of examination compared to larger and smaller meander sizes. **Figure 3** illustrates the decoupling S12 between adjacent ME with equal meander size. Starting from a MSL, increasing the meander size improves the decoupling between the elements until an optimum at 27.5 mm is reached. Further increasing the meander size subsequently leads to increased coupling. This is explained by the distribution of both H- and E-fields. Their magnitudes are shown exemplified for a single element MSL and the ME with sizes of 27.5 and 50 mm, respectively, in **Figure 4**. The ME with 27.5 mm meanders has minimum field propagation in y-direction, causing less power transfer to an identical adjacent ME. This is systematic for all simulated sizes.

Conclusion: ME with medium meander size allow for maximum central H-field strength. Additionally, the intrinsic mutual decoupling to identical adjacent elements is optimal compared to ME with enlarged meander size, which approximates a dipole antenna, and to ME with reduced size, which converges to the case of a MSL. This points out the advantages of ME compared to MSL and dipole antennas. Consequently, RF transmit-arrays consisting of ME should be based on elements with medium meander size. Further studies in this field should prove the simulation results in a real implementation.

References:

1. D.O. Brunner et al. Proc. Intl. Soc. MRM 15, #448 (2007)
2. G. J. Metzger et al. MRM 59: 396-409 (2008);
3. A. J. Raaijmakers et al. MRM 66:1488-97 (2011);
4. S. Orzada et al. Proc. Intl. Soc. MRM 16, #2979 (2008)

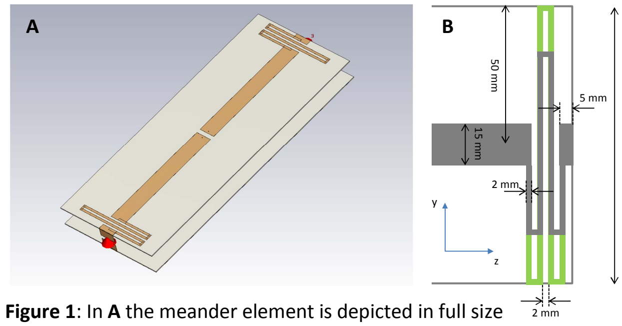

Figure 1: In **A** the meander element is depicted in full size while **B** shows the dimensions and orientation in the simulations.

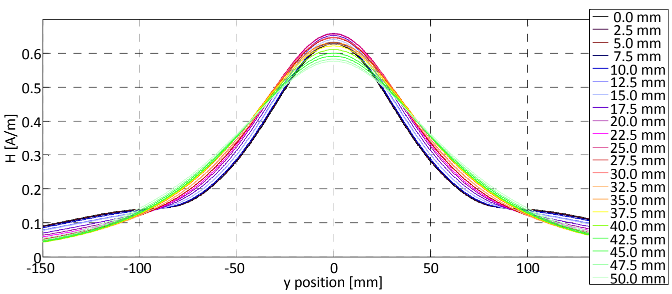

Figure 2: Central line plots of the H-field along the y-direction 30 mm inside the phantom.

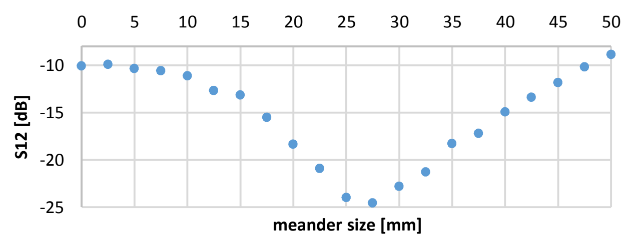

Figure 3: Coupling between adjacent meander elements of equal size. Note that a meander size of 27.5 mm leads to maximum decoupling of -25 dB.

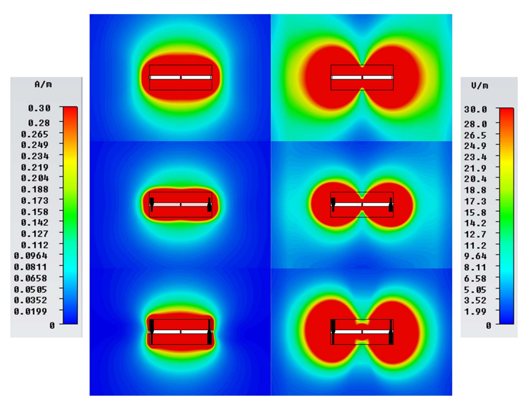

Figure 4: Magnitude of H-field (left) and E-field (right) in the y-z-plane of a MSL (top) and ME with sizes of 27.5 mm (middle) and 50 mm (bottom) for an input power of 0.5 W.