Optimization of Coaxial RF Waveguides for Traveling Wave MRI at 21.1 T

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Introduction

High field MRI has shorter wavelengths, which can result in inhomogeneous B_1 fields for near field excitation. Hence, use of conventional RF coils in high field MRI leads to standing waves, which can cause artifacts in MR images. However, these same wave phenomena can be exploited to perform far-field excitation and traveling wave MRI. In this effort, a circular waveguide containing a relatively high dielectric material (namely deionized water) is simulated using coaxial inputs to excite modes. A high permittivity dielectric is used inside the waveguide to modify the cutoff frequency requirement. Coaxial cables help in specific mode excitation and are comparatively easier to build and more controllable than other antenna structures. A dielectric-filled, circular waveguide with dimensions similar to that of the magnetic bore of the 21.1-T system was designed using CST Studio Suite simulation software. Initially, the waveguide was excited using two and four coaxial cables but the eight coaxial cable excitation gives a more homogenous field pattern. Simulations are run at a 900-MHz Larmor frequency.

Experimental

The waveguide was designed to have inner and outer cylinder of diameters 3.5 and 5.5 cm, respectively, and length 30 cm. The inner cylinder is filled with deionized water, which is our dielectric. The coax cables are grounded to the outer waveguide, and the inner conductor enters the dielectric. All the simulations were run using the transient solver and hexahedral mesh with a fast perfect boundary approximation. Initially, the waveguide with 4-coaxial input ports, excited at different phase shifts, was designed and simulated. The simulation was repeated for 8-port coaxial inputs, with and without a 3-cm air gap located between the sets of coaxial inputs to serve as an region for placement of an *in vivo* sample.

Results and Discussion

The intensity of the B1 field drops from 45.8 A/m at the excitation ends to 4.6 A/m at the center of the air gap.

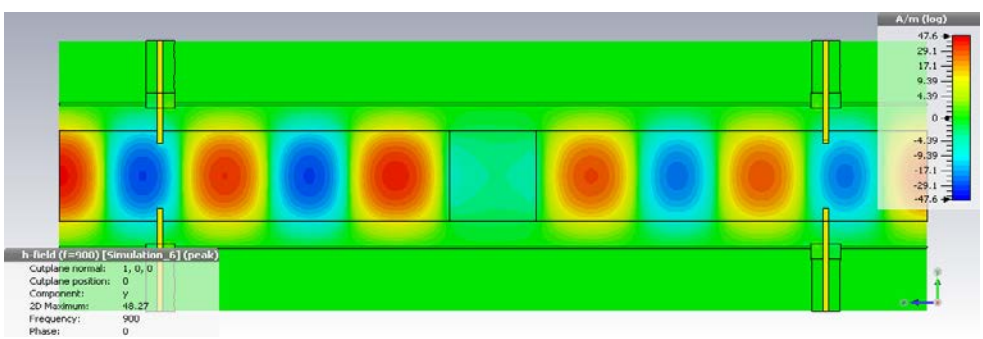

Figure 1: B_1-field pattern on y plane when the waveguide is excited using 8-ports with 0,90,180 and 270 degrees phase shifts, respectively, for each set of 4.

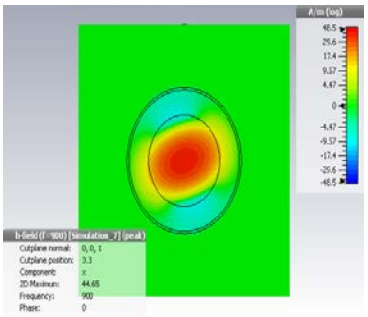

Figure 2: Transverse plane showing TE11 mode.

Conclusion

The intensity of the field pattern generated using 8-port coaxial input is greater compared to the 4-port coaxial input. This results in better SNR of the MR images and a regularity in the B_1 pattern. However, the field pattern generated in the air gap is very weak. Therefore, the coaxial excitation of the circular, dielectric-filled waveguide provides a controllable and high sensitivity B_1 profile with far-field excitation but the cutoff limitations are still evident in areas where air must be present to accommodate an *in vivo* specimen. However, future work will focus on extending the far-field excitation into such a region to minimize field decay.

Acknowledgements

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References

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