Using Slotted Waveguides for RF Excitation in Magnetic Resonance Imaging at 7 T

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Ultra-high-field, i.e., magnets of 7 T and above, is currently one of the most researched upon topics in the engineering development for improving the magnetic resonance imaging (MRI). Inventing/designing RF coils for ultra-high-field MRI scanners is extremely challenging due the high frequency of operation of the RF field, $\mathbf{B}_1$. Currently birdcage coils, stripline coils, dipole antennas, loops, and patches are some of the approaches used in most of the state-of-the-art RF coils. At UHF, the principal goals for RF coil design are acceptable level of power efficiency, strong right-hand circular polarized (RCP) RF field, $\mathbf{B}_1^+$, high spatial uniformity of the $\mathbf{B}_1^+$ field inside the phantom (subject), strong coupling of the field/wave with the phantom and strong field penetration in the entire phantom or the imaged part of the subject, and low specific absorption rate (SAR) levels.

In order to address these demands and challenges, we present and investigate a method for 7-T RF excitation based on slotted waveguide arrays. This novel RF coil has multiple slotted waveguides arranged in a circular fashion around the imaging region. Each slotted waveguide is fed separately and is time-phased in a way to generate a strong RCP RF field, $\mathbf{B}_1^+$, inside the phantom (subject). Our study aims at improving the $\mathbf{B}_1^+$ field and power deposition inside the imaged sample. We achieve this by carrying out extensive modeling and simulations of various subject-loaded slotted waveguide array RF coil designs with different kinds of phantoms for 7-T MRI systems. In our study, we vary design parameters such as slot size and position, phasing, number of slotted waveguides in the array, and number of channels.

In simulations of slotted waveguide array RF coils at 7 T, performed in ANSYS Electronics Desktop HFSS, we have observed very good $\mathbf{B}_1^+$ field strengths, high power deposition in the phantom, and excellent power efficiency. With various optimization algorithms, we can carry out $\mathbf{B}_1^+$ shimming in order to obtain more homogenous $\mathbf{B}_1^+$ field inside the phantom, as well as be able to steer the field and focus it at a particular spot inside the phantom. Being a multi-channel RF coil system, this coil has the potential of providing capability for parallel imaging and acceleration.