Volume and Surface Coils

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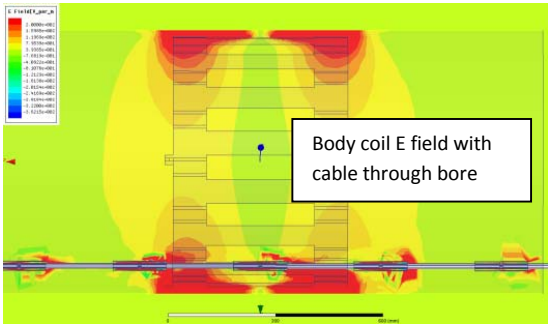
Highlights:

- Transmit volume RF coils are designed to create a uniform B1+ field inside the imaging volume
- E fields in the transmit coils need to be minimized to conform to SAR standards
- Receive surface RF coils are designed for maximum SNR, and reside inside the Transmit coil
- Decoupling circuits are needed in both designs to prevent coupling of RF energy
- Baluns are needed in both designs to minimize cable shield currents

Target Audience: Anyone who wants to improve understanding of RF coils in MRI systems

Objective: Understand the critical design criteria for different types of coils and how to achieve them

Volume Transmit coils



The purpose of a transmit RF coil is to generate a uniform circularly polarized RF magnetic field throughout the imaging volume. This field is required to flip the magnetization vector by a uniform angle. In practice, most MRI systems have a birdcage resonator. We will go over its design and frequency response. Typical B1 fields are on the order of 20 µT, with peak RF currents of 65 Amps, peak voltages of 2 KV, and power needed for a 200 LBS patient around 30 KW at 128 MHz. You will learn how to design the coil to cope with these levels and how to make sure that legally required SAR limits are not exceeded. At frequencies where the wavelength in the patient becomes similar or shorter than the size of the patient, interference effects result in non-uniform excitation. You will learn how to visualize these effects and how to compensate for it. To prepare for the class I recommend the following references: (1) and (2) to learn about electro-magnetic fields and how they interact with matter, (3) to learn about the behavior of electronic circuits and transmission lines at RF frequencies.

Surface receive coils

Unlike the transmit coils, the main goal of the receive coil is not B1 uniformity, although it may be important for some (Head coil e.g.), but it is maximizing SNR. You will learn how to minimize the coil losses, such that the main noise contribution in the image is from the losses in the patient's tissue. During the transmit pulse the Receive coils and cables are exposed to the B and E fields generated by the Body transmit coil. You will learn how to prevent induced currents in the Receive coils and cables. Many receive coils come with integrated pre-amplifiers. They need to be stable, have a low noise figure that dominates the receive chain, and have an input impedance that provides some decoupling between multiple receive coils in an array. We will go over the critical design parameters.

References

(1) B Bleaney and B I Bleaney, Electricity and Magnetism, Clarendon press
(2) J D Jackson, Classical Electrodynamics, Wiley
(3) D M Pozar, Microwave Engineering, Wiley