16-Channel Interface Boxes for Adaptable MRI Array Systems

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Introduction

Coil hardware used in research environments must be adaptable to diverse and unconventional measurement situations. The modular approach described here reuses designs and hardware to focus on the problems specific to the particular measurement. A standard interface box accepts receiver coils of various shapes and sizes which are constructed as separate units and can be used in any combination. Different body sizes are easily accommodated by varying the number or overlap of the individual elements. Diverse shapes are covered by rearranging (Figure 3) or using elements of different sizes and shapes. All of these modifications can be made immediately prior to scanning without requiring electrical adjustments for tuning or decoupling. Tidy cabling with a single connection exiting the magnet bore facilitates proper grounding and avoids safety hazards introduced by long coaxial cables. A typical application is the investigation of coil geometry on parallel imaging performance. Changes to the array, such as number (1), size and arrangement (2) of the coils, are made quickly within the same scanning session to find a configuration that gives optimal performance. A unique and novel application, requiring dissimilar coils operating simultaneously, is monitoring gradient fields during image acquisition, where signals from imaging coils and NMR field probes (3) are measured simultaneously for artifact-free image reconstruction (Figure 1).

Technical Details

Surface Coil: A schematic of a basic surface coil is shown in Figure 2. Active detuning (4) is provided using a PIN-diode-switched LC trap, connected to one end of the coil loop. The opposite end of the loop is connected directly to a matching network and high-impedance low-noise amplifier (LNA), both housed on the same board as the detuning circuit. Avoiding a cable between coil and preamp facilitates matching and minimizes the system's noise figure. The low-pass Π matching network (5) acts as a transformer whose voltage transformation ratio, n, at resonance is given approximately by the ratio of capacitors C_A and C_C. It is chosen to provide a good noise match to the preamp as well as high-impedance decoupling (6).

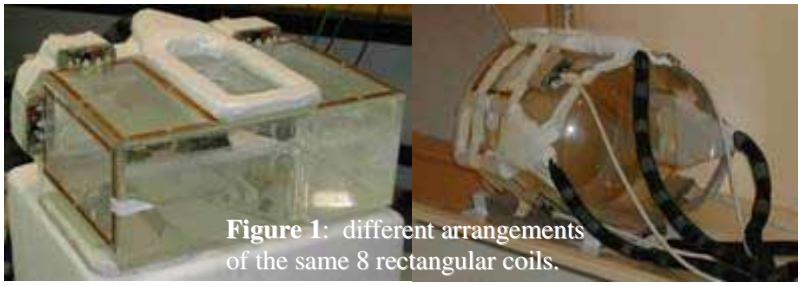

Figure 1: different arrangements of the same 8 rectangular coils.

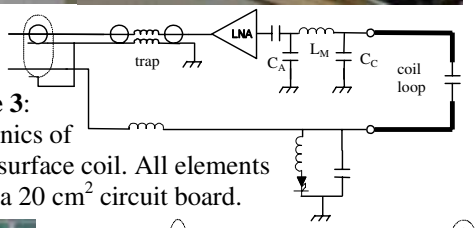

Figure 3: electronics of single surface coil. All elements are on a 20 cm^2 circuit board.

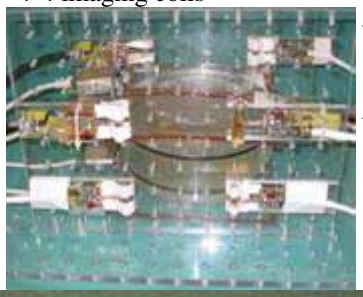

Figure 2: gradient monitoring setup + 4 imaging coils

Coil Cables: Cabling and related grounding are critical parts of any array. Poor cabling can create additional coupling between the channels, transmit RF distortion and even heating hazards. Although these effects are geometry-dependent, a high safety margin is achieved by introducing a cable trap (7) at the coil end of each surface coil cable (8) (Figure 2). Additional shield current blocking sleeve baluns are not required (9). Coil cables are, however, covered with foam padding ~ 2 cm in diameter to prevent close contact between cables as well as between cables and the patient. This prevents large parasitic capacitances which create dangerous ground loops that pick up RF power during transmission. Maximum cable length is about λ/4 to avoid resonant lengths.

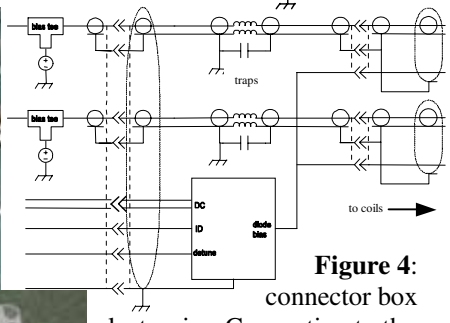

Figure 4: connector box electronics. Connection to the MRI system is on the left.

Figure 5: external view of the 16-channel connector box. Dimensions are 24×8×8cm.

Connector Box: A schematic of the connector box is shown in Figure 4. The control hardware inside provides coil identification to the system and supplies bias voltages to switch the surface coils from detuned (transmit) to tuned mode (receive). Individual connections to the coils are made through circular plastic connectors (Hypertronics, USA) which house single contacts for DC as well as one coaxial connector for RF (Figure 4). Inside the box each coaxial cable runs through a second cable trap, and then directly to the MR system through a composite cable containing 16 coaxial cables plus all the necessary DC power and control lines. A photograph of the complete 16-channel connector box is shown in Figure 5.

Conclusion

The connector box system avoids duplicating hardware for each array while maintaining a high margin of safety and flexibility. It is especially advantageous for arrays of individual and diverse coils. Arrays of up to 16 coils are readily assembled.

References

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