Cable Routing in MRI Phase Array Coils

D. Seeber1, J. Jevtic1, A. Menon1, V. Pikelja1, W. Johnson1
1IGC Medical Advances, Inc., Milwaukee, WI, United States

Abstract
A method of routing RF cables along low electric field areas of a local coil in a predictable and reliable manner is presented. A conductive ring is introduced into proximity with the coil loops and connected to the ground shield of the RF cables creating a low electric field area. The RF cables are attached to the conductor along the ring to a point where they exit together as a unified cable. The ring, by defining an area of low electromagnetic field, reduces interference on the cables and coupling between loops allowing for a controlled cable layout.

Introduction
As the number of channels increases in MRI system, layout of the RF cables becomes increasingly important as it is necessary to route the cables from a floating coil to the grounded system. The usual method for cable routing follows the low tangential electric field lines. Unfortunately, the regions of low field strength may shift during use of the coil or be difficult to determine, or may be in areas where the routing of cables is undesirable, interfering with patient access or unnecessarily increasing cable length and contributing to signal loss. Coupling between adjacent cables can be minimized by first by providing a balanced to unbalanced feed to the coil. In addition, by placing the shield of the coaxial conductors on a conductive loop and forcing the loop to be "ground", coupling between the cables can be reduced. The conductive loop creates a know region of low tangential electric field strength necessary for cable routing.

We propose introducing a conductive ring into proximity with the coil loops with the ring connected to the ground shield of the RF cables thus creating a low tangential electric field strength area. The ground shield of the signal cables are attached to the conductor of the ring to run along the ring to a point where they exit together as a unified cable. The ring, by defining an area of low electric field, reduces interference on the cables. As the ring can be defined prior to cable routing, the cables can be placed in a convenient manner for exit to the system or for patient comfort. The ring allows multiple cables from each coil to be collected into a single cable without unduly increasing the electrical interference received by those cables that must have a longer path length. The conductive ring may be substantially parallel or co-planar with the loops of the MRI coil.

Results
For example, when the loops define a plane or surface, the conductive ring may be substantially perpendicular to the loops, or when the loops define the surface of a cylinder with the conductive ring forming a base of the cylinder. To demonstrate the concept, in Figure 1 is a four channel head coil where an extra conductive ring has been placed on the end of the cylinder. Several RF shorting capacitors break the ring. The conductive ring can also be used in a split coil configuration, as in a kneefoot coil. In neither of these examples does the cables effect the tuning, matching, or increase the coupling between the four channels. The conductive cable routing ring can also be used for planar coils as shown in Figure 2. The cables warp around the imaging volume in this torso coil without any additional changes in tuning, matching or increase in the coupling between loops.

As the conductive loop is non-resonant, and only broken by several RF shorting capacitor in locations where the cable do not cross; it is important that the self-resonance frequency of the conductive loop be above the working frequency of the MRI coil. Otherwise standing RF waves form on the conductive ring and render the conductive loop impossible to operate. This becomes extremely important at higher frequency (3T) as the electrical length of the conducting ring becomes comparable to the wavelength. Placing a series inductor in the ring, in a location where cable does not cross, shifts the self-resonance of the cable routing ring above the working frequency of the MRI coil. The inductor has no effect on the performance of the cable routing ring. This allows the cable routing ring to be useful tool at all MRI frequencies.

Conclusions
A method has been presented to allow the coil designer to preposition the RF cables in a manner that does not effect the tuning, matching or increase the coupling between the loops. The conductive ring also allows for easy cable routing in flexible coils. The cable routing ring can be used at higher frequencies by de-tuning the self-resonant frequency of the loop.

References
2. US Patent Pending

Fig. 1. The conductive cable routing ring is shown on the right side of this head coil. All cable grounds are attached to the ring and brought to a common exit point to connect to the system.

Fig. 2. A planar version of the conductive cable routing ring allowing the cables to be placed around the coil in a predetermined manner.