Distributed capacitance method in RF coils - the advantages and potential

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Abstract
This work explored the advantages and potential of distributed capacitance method in RF coil, including E-field improvement, reliability improvement and costs reduction. Reliability improvement using distributed capacitance method is of great importance in flexible RF coils where solder joint break at capacitor terminals has known to be a major failure mode and the distributed capacitance method provides an effective solution.

Introduction
The concept of distributed capacitance in RF coil was first proposed by Su in 1996 (1). However, its advantages have not been fully explored up to day. As patient comfort becomes a major requirement, flexible RF coils are highly favorable. It became clear that flexible coils are often less reliable due to the additional new failure modes. Fig. 1 shows an example of a flexible torso coil where the wings are made of foam material which is flexible, light weight and advantageous in patient comfort. However, the artworks with discrete capacitors in the flexible wings are subjected to failure, leading to reliability issues if no preventive actions are taken. In this work, a distributed capacitance method was applied to replace discrete capacitors in the wings, and therefore eliminating the associated failure modes. Fig. 2 illustrates the concept of replacing discrete capacitor with distributed capacitance. The text in the next section explains the concept.

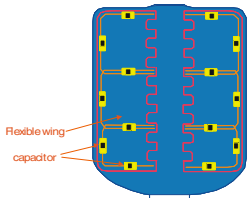

Fig. 1 Flexible torso coil

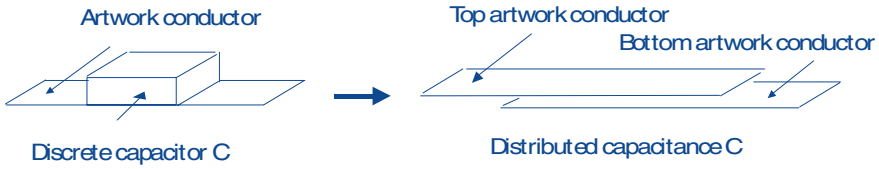

Fig. 2 Illustration of distributed capacitance method

Methods
The artworks of a 12-element torso coil were built using distributed capacitance concept as illustrated in Fig. 2. The anterior artwork and posterior artwork each consists of 6 coil elements. The artworks were made of 6mm-wide copper adhered to 10 mil kapton substrate. Distributed capacitance was obtained by overlapping top and bottom layers of copper traces over a length of about 10cm. Same configuration was repeated at 3 locations along each coil trace. The coil was tuned and interfaced to a GE Signa 1.5T MR system.

Results and discussion
Distributed capacitance was made to be equivalent to discrete capacitors in a reference coil without difficulties. Both coils were tuned with the same circuitry. The coil with discrete capacitors showed visible hump where discrete capacitors were located. The coil with distributed capacitance, on the other hand, has a uniform surface throughout. Another advantage of using distributed capacitance is the E-field reduction. E-field simulation was performed using a commercial EM field simulation software (Ramcom, State College, PA). The results show that E-field is effectively reduced in case of distributed capacitance as a result of more uniform current distribution. Both phantom and human imaging were performed using different imaging protocols with and without acceleration. Fig. 3 shows an example of an axial image with acceleration 2. The result is encouraging. Effort was made in selecting low lost substrate for the artwork. At the time of this work, kapton was the best substrate available. Searching for lower lost substrate is currently on going. If successful, further SNR improvement is possible. Replacing discrete capacitors with distributed capacitance also has the advantage of being cost effective. The elimination of capacitor components alone provides savings. Simplification of manufacturing process adds additional savings. Cost analysis supports such assessment.

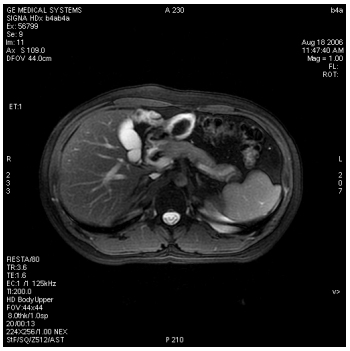

Fig. 3 Axial image FIESTA FS ASSETx2

Conclusion
The potential of using advantageous distributed capacitance in RF coils has been demonstrated. The method is especially valuable for flexible coils that are highly preferred for patient comfort, lightweight and other considerations. The challenge is to select low lost substrate for optimal SNR performance.

References
1. Su, S and Saunders, J., J. Magn. Reson. B 110:210 - 212, 1996