Resonator for Co-registration EPR/NMR Imaging and Spectroscopy

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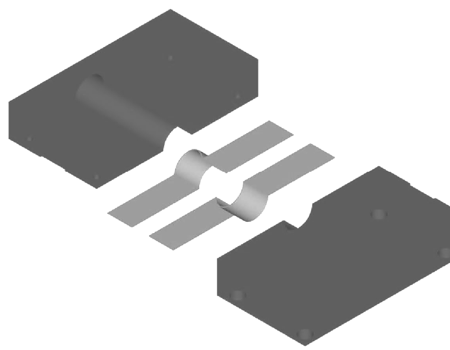
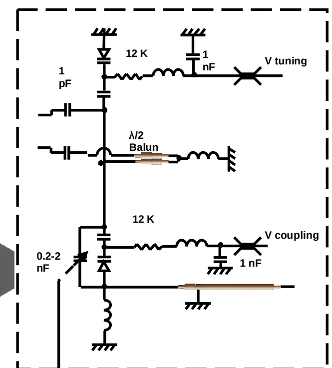
Introduction

Co-registration EPR/NMR imaging has recently attracted more attention as a promising technique [1,3]. In the past, making double EPR/NMR images required two distinct and separated resonators which complicated the setup [1]. Also, modality switching necessitated additional time for tuning and coupling. We developed a double frequency resonator for co-registration EPR/NMR application of *in vivo* imaging of isolated rat heart. The two different frequencies require two different matching circuits. To accommodate the different matching requirements, we used a special two gap resonator design with two quarter wave connection to the gaps. This configuration provides independent feeding to EPR and MRI parts of the resonator. EPR application of the resonator requires shield and modulation coils. To prevent NMR RF interference we made these parts maximally transparent for low NMR frequency. Both matching circuits were electrically coupled. For in vivo EPR spectroscopy and imaging it is necessary to compensate for motional noise [2,3]. We utilized a varactor diode in the ACC and ATC and manual coupling control circuitry for EPR part of the resonator. Performance of the ATC and ACC was adequate to compensate for a beating heart, with an ATC range of 8 MHz and ACC range of 30 dB.

Resonator materials and construction





Left figure shows expanded NMR/EPR resonator view without shield. The body of the resonator is made with two pieces of Rexolite plastic with two 19 mm wide slots and a 22 mm hole. The gap between the electrodes of the resonator is 2.3 mm. The electrode is made from silver foil 11 μm thick. One side of the loop is elecrically connected to another gap through 800 pF capacitor. Both side of the gaps are connected for EPR frequency, making each side of the cavity (loops) connected to the quarter wave length lines. For MRI frequency of 16.18 MHz the resonator is one loop, one gap (800 pF) resonator, and for EPR frequency of 1.2 GHz we have a one loop, two gap, connected to the quarter wave length lines on both sides. The quarter wave length lines acts like isolators for the central 1.2 GHz EPR frequency. A traditional NMR matching circuit is conncted to the 800 pF gap of the resonator throughout the symmetric 100 Ohm impedance ribbon cable. The EPR matching circuit is conncted to the other side of the resonator. Components of the EPR matching circuit were rigidly placed on the surface near the electrically connected gap of the resonator. One capacitor and one parallel varactor were used for coupling. One varactor was used for tuning only. The EPR feeding line is a 50 Ohm coaxial cable. It is grounded to the middle of the resonator. It is necessary to disconnect EPR cable for MRI measurments. Right figure is the equivalent electrical diagram of the resonator.

Results

Co-registration EPR/NMR (1.2 GHz/16.18 MHz) imaging resonator 22 mm in diameter and 19 mm lengh was achived. Unloaded Q of the MRI resonator is 160. Unloaded Q of the EPR resonator is 350. Coupling was adequate for *in vitro* and *in vivo* experiments with sample valume up to 5 cc. The uniformity of the EPR image good enough for a rat heart size sample.

Conclusions

A new small size sample, co- registration EPR/MRI resonator for for in vivo and in vitro application was developed and tested.

References

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