Augmented Tune/Match Circuits for High Performance Dual Nuclear Transmission Line Resonators

M.G. Erickson (VA); M. Elumalai (UF)

Introduction

The advent of hyperpolarized ^{13}C and rare gas nuclei for MRI investigations has provided much impetus for improving dual nuclear MRI coils. The goal of this project is to validate a high performance dual nuclear MRI transmission line resonator design. The mononuclear version of this transmission line resonator has been reported in the literature [1], and its performance is on a par with that of the birdcage resonator and the TEM resonator. It uses conductive elements which are driven with a floating RF common. In contrast to the TEM resonator described by Vaughan [2], the shield is not part of the RF current path. No mechanically complex reentrant element is used. The resonator is driven with a novel high performance quadrature drive circuit which uses high performance broadband current baluns driven by a quad hybrid, or driven directly by DDS based MR transceivers. It should be possible to upgrade the dual nuclear performance of the resonator by placing appropriate frequency selective elements on the matched or low Q side of the tune/match plane for each resonator. This stands in contrast with dual nuclear birdcage designs, which typically use LC traps in the high Q part of the coil [3]. LC traps introduce significant losses, so coils based on this design approach tend to have marginal efficiency.

Results and Discussion

After both bench testing and a review of ferrite parameters, so-called “snap it” beads were chosen for convenience and flexibility for the ^{1}H circuit. Each is approximately 3 cm in length and 1.5 cm in diameter, with a 6.25 mm central hole for RG-223 or Belden 9258 cable. The beads are spit into equal halves, which snap together via a plastic clamp shell. The ^{13}C balun also works well on the resonant frequencies for ^{23}Na, ^{31}P, and ^{131}Xe, though no xenon work is planned at this time. Bench tests on this balun have shown current balance of less than one percent for the ^{13}Na balun. Estimated sheath resistance is around 7500 ohms. Aluminium housings have been fabricated for the four current baluns; each has a removable top cover for easy access. At this writing, baluns are being installed in each of the four housings. Once this operation is complete, current balance will be tested once again for each balun. Next, each balun pair will be inserted into a quadrature drive circuit. Both phasing and amplitude balance will be verified using a wideband digital oscilloscope and/or a vector voltmeter. Finally, the four completed assemblies will be mounted on shelves in the vicinity of the 4.7 T magnet. The static field in the vicinity of these shelves is rather small; selection of this location was dictated by both functional considerations and safety considerations. AMRIS users will have the opportunity to use these devices as feed devices for a wide array of balanced feed coils, both in linear and quadrature operating modes.

A double nuclear surface coil has also been designed, and fabrication will begin in January 2014. This coil will use the same augmented tune/match circuit as planned for the dual nuclear quadrature volume coil. The surface coil will be both easier and cheaper to fabricate. Thus, it will serve as a test of concept device for the frequency isolation scheme.

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References

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2. Vaughan, JT, Magnetic Resonance in Medicine 1994 32(2) 206-18.
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