An 8-channel metamaterial T-R coil at 9.4T

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Introduction

In this contribution, we present a multi-channel T/R coil for use in a 9.4T animal scanner system. Each coil element comprises a composite right/left-handed (CRLH) metamaterial transmission line (MTL). Eight of these elements were arranged in a circular manner to constitute a multi channel coil. MTLs offer the feature of a homogenous current distribution along the line when they are tuned to their 0^{th}-order resonance. This leads to a homogenous T/R sensitivity.

Theory

A CRLH metamaterial transmission line [1,2] is a combination of a „natural“ right-handed transmission line, modelled by series inductors L_R and parallel capacitors C_R and an “artificial” left-handed transmission line, modelled by a series capacitor C_L and a shunt inductor L_L. In this way, the phase shift of a transmission line element is compensated, which leads to a uniform current along the line. The resonance condition is independent of the number of cells. Fig 1 shows the equivalent circuit of a CRLH unit cell in T-network representation.

Experimental

We fabricated a multi channel coil consisting of eight MTLs, each comprising eight CRLH unit cells. It has an inner diameter of 88mm and an outer diameter of 118mm to suit the Bruker 94/20 magnet. The overall length including amplifiers is 270mm. The coil’s mechanical parts were fabricated of PMMA using a laser cutter. Fig. 2 shows a picture of a single MTL element. Fig. 3 shows the whole coil prototype. Each MTL unit cell has a length of 19mm with a separation of 1mm. Their width is 10mm; they were fabricated on a 1.5mm FR4 PCB substrate. Rectangular copper patches, which are separated from a ground plate by 6mm of PMMA,

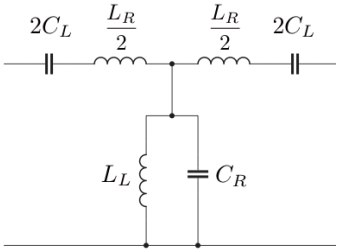

Fig. 1 Equivalent-circuit of a CRLH unit cell.

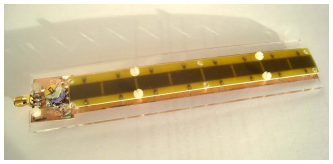

Fig. 2 A single MTL element consisting of eight unit cells.

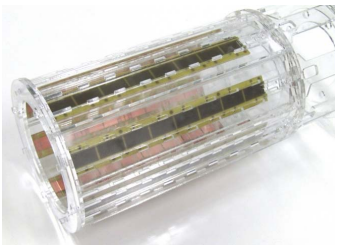

Fig. 3 Coil consisting of eight MTL elements.

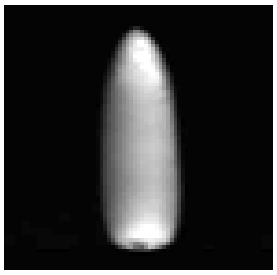

Fig. 4 MR-Picture of a silicone oil phantom (one MTL).

form the inductor L_R and the capacitor C_R. Due to the relatively low resonance frequency - with respect to metamaterials - of 400 MHz, the initial value of C_R is increased by two additional lumped capacitors on the left and the right side in each unit cell. The remaining elements C_L and L_L are also realised by lumped components. The whole structure was tuned to its 0^{th}-order resonance frequency. The input of the line was matched to 50 Ohms by additional circuitry and the end of the line was shorted.

Results & discussion

When loaded with a phantom bottle filled with silicone oil, the MTL shows a homogenous sensitivity as depicted in Fig.4. The scan was done in T/R mode. The homogeneity of the coronal slice confirms that CRLH theory can be applied to MRI. The 8-channel coil was fabricated using a Versa laser cutter and freeware 2D CAD tools. This technique emerged to excellently suit MRI animal coil construction. All parts were cut from 3mm layers of PMMA, which give enough stability. The fabricated coil is easily disassembled to replace its MTL elements and other electronic parts.

Acknowledgments

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References

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