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An optical-based active detuning for single and dual channel/loop endoluminal surface coils

I. Saniour¹, A.-L. Perrier², L. Duvillaret³, R. Sablong¹, G. Gaborit², O. Beuf¹

¹CREATIS, Univ. Lyon; CNRS UMR 5220; INSERM U1206; INSA-Lyon; UJM-Saint Etienne; Université Lyon1, Villeurbanne/France,
²IMEP-LAHC, Univ. Savoie-Mont-Blanc, Le Bourget-du-Lac/France,
³Kapteos, Kapteos, Sainte-Hélène-du-Lac/France

Purpose/Introduction: Sub-centimeter endoluminal receiver coils dedicated to MRI are the best candidates for early depiction of colonic diseases^{1,2}. Nevertheless, the clinical use of these coils is controversial because the impossibility of using devices such as RF traps can cause strong local heating³. Besides, the sensitivity of a single-loop coil is orientation-dependent with respect to the magnetic field⁴. Our overall objective is to develop a fully-optical multichannel endoluminal coil ensuring patient safety while achieving high signal-to-noise ratio (SNR) and better radial uniformity⁵. Optical transmission of the NMR signal⁶ combining active optical detuning⁷ could be a secure alternative solution. Here we present an optical-based circuit for simultaneous detuning of two channels/loops endoluminal coil.

Subjects and Methods: A dual-channel/loop (DCL) endoluminal coil was built; it consists of two independent rectangular loops associated to a single active detuning circuit. The loops (resonant circuit) were realized according to previous works^{2,7} and were geometrically oriented in quadrature. Optical detuning was carried out using two photodiodes that generate a DC current when illuminated thus activating the PIN diodes placed in parallel to each loop. The performances of this coil were compared to a reference coil having the same resonant circuit but using a galvanic connection to transmit the DC current for PIN diode activation (classic detuning). Besides, two single-loop coils were built with optical and classic detuning circuits, respectively. Figure 1 illustrates the electronic schematic of the different coils. For DCL coils, the S-parameters were studied to assess the detuning performances and the mutual coupling between the loops (for DCL coils). Finally, these coils were inserted into a cylindrical phantom to acquire MR images in a 3T MRI.

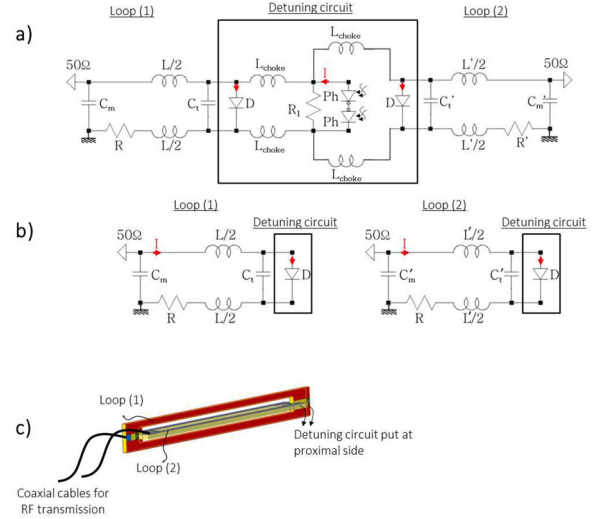


Figure 1. a) Electric circuit of the active optical detuned DCL endoluminal coil. Once illuminated, the two photodiodes deliver a sufficient current to activate the PIN diodes and thus detuning simultaneously the two loops. b) Electric circuit of the two loops used to build the reference coil with a classic detuning circuit. c) The modeled geometry of the DCL coil.

Results: At the resonance frequency, the $|S_{21}|$ -parameters were around -24.86 and -30 dB respectively for the optical and classic detuning DCL coils (Fig. 2). Figure 3 shows that the signal distribution and SNR of images taken by a DCL coil were enhanced compared to single-loop coil images. Finally, MR images of optical detuned coils are very much comparable to those with classic detuned coils.

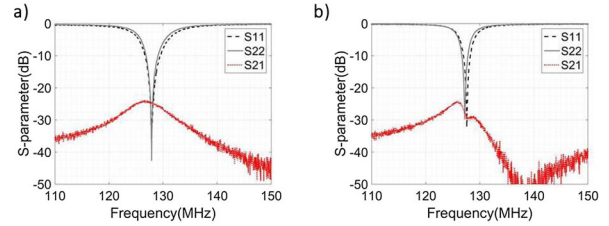


Figure 2. $|S_{11}|$ and $|S_{21}|$ parameters of the DCL endoluminal coil associated to a) an active optical detuning circuit and b) a classic detuning circuit (reference).

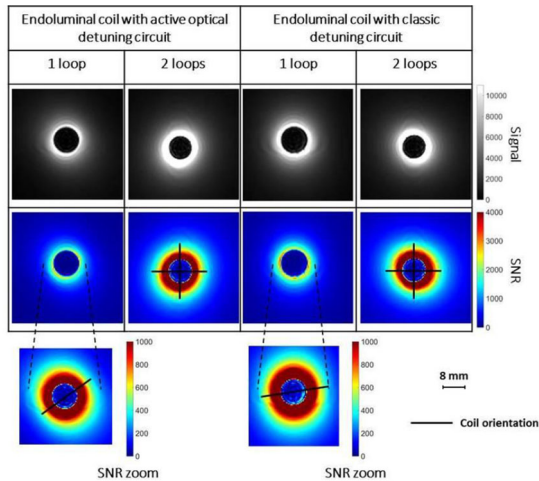


Figure 3. Axial MR images and corresponding SNR images of a cylindrical phantom (filled with a solution of 1.25 g $\text{NiSO}_4 \times 6\text{H}_2\text{O}$ + 5 g NaCl per liter of distilled water to mimic the patient) were acquired using single-loop and DCL endoluminal coils with an active optical-based and classic detuning circuit. A gradient echo sequence was used in a 3T MRI (GEHC discovery MR750). The black lines present the orientation of the coil inserted into the phantom.

Discussion/Conclusion: On the experimental bench, the $|S_{21}|$ -parameter proves that the two loops are geometrically decoupled and independent.

MR images verify that active optical detuning is effective and the generated current was sufficient to detune simultaneously the two loops that cannot be used separately in this particular case (Fig. 1a). The concept of this optical detuning circuit could be implemented whatever the geometry of the coils and the number of channels.

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