Abstract 281

Optical for both active decoupling and conversion/transmission for a MR endoluminal coil

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Purpose / Introduction

An accurate and early detection of the stages of colorectal cancer increases patient survival rates. Spatial resolution of MR images can be improved by using endoluminal coils close to the region of interest [1]. Unfortunately, the clinical use of such coils, deeply introduced in the patient is compromised due to local heating and safety issues in presence of galvanic wires [2]. In the following work, adequate optical solutions both for active decoupling and conversion/transmission of MR signals is proposed and demonstrated.

Subjects and Methods

To be free of any galvanic and wired connection, an optical active decoupling circuit was added to the coil: two photodiodes generate a DC current to change the state of the PIN diode and ensure coil decoupling [3]. The experiments were performed on a 3T MR750 GEHC system to assess the decoupling efficiency based on images. The transmission of the NMR signal was done herein by a coaxial cable. On the other hand and on an optical bench, the optical conversion of the RF signal is realized by associating the endoluminal coil to an electro-optical (EO) Ti:LiNbO3 waveguide [4]. A RF magnetic field was generated and applied to the coil resonating at 128 MHz (figure 1). The optical properties of the waveguide vary according to the induced electrical field (Pockels effect) and thereby the polarization of the emitted laser toward the waveguide is modified. This optical polarization state is maintained during transmission and finally treated to have an analogue electrical output proportional to the field to be measured.

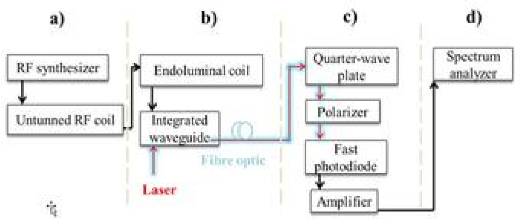

Figure 1. Block diagram of the EO conversion experience. a) Generation of the RF magnetic field. b) The detection of the magnetic field by a receiving RF coil and the EO conversion by a waveguide. c) Optical signal processing. d) Visualization of the output electrical power.

Results

The presence of a galvanic or an optical decoupling doesn't affect significantly the image in term of signal intensity uniformity (figure 2). Besides, the graph in the figure 3 shows an excellent linearity of the results and a dynamic range of the input power exceeding 100 dB. The magnetic field is ranging between 0.3 pT (electronic noise) to 2.10^5 pT.

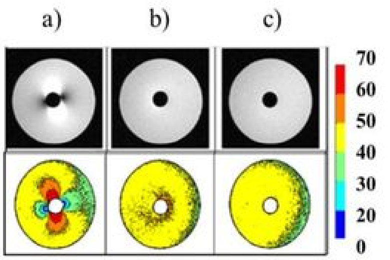

Figure 2. MR images acquired with a gradient echo sequence and the body coil with different endoluminal coils placed at the center of a cylindrical phantom: a) without decoupling circuit b) with optical decoupling circuit with optical fibers; c) with usual decoupling with wire.

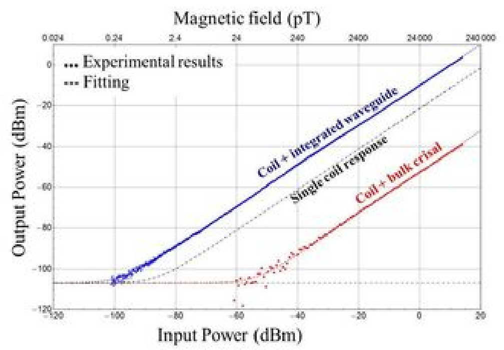

Figure 3. Output power in function of magnetic field and input power. The blue and red points represent respectively the experimental results of the coil linked to a waveguide and a bulk crystal. Black dots represent the response of the reference coil.

Discussion / Conclusion

Based on these satisfactory results, a fully optical endoluminal receiver coil, combining the two described systems, is in development.

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