University of Basel

Department of
Biomedical Engineering

Development and realization of analog, high input impedance preamplifiers for NMR and MRI at low frequency (4.2 MHz).

Master Thesis of Thomas Quirin at AMT-Center.

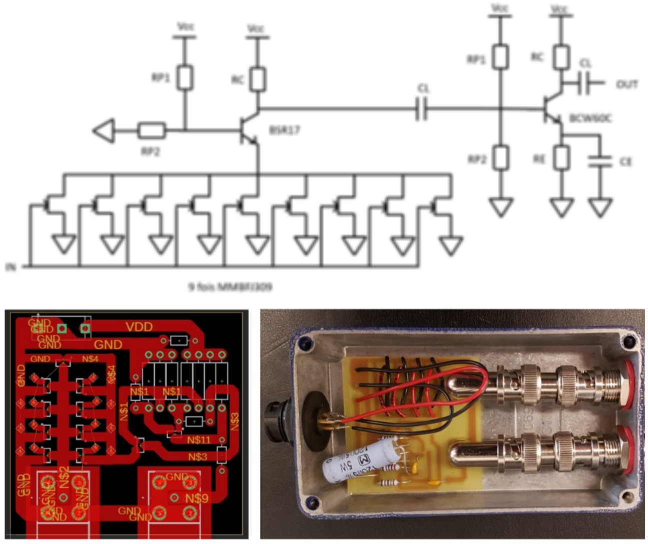

Figure 1: Above: Design and below: Construction (PCB design & integration) of the 2nd generation high-input preamplifier prototype.

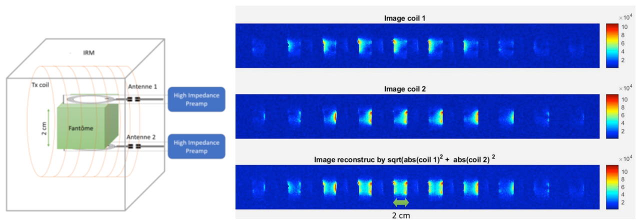

Figure 2: Decoupling performance assessed with MRI. A) Schematic showing two NMR surface coils facing each other, placed inside the MRI scanner and connected to our high-input impedance preamplifiers. B) Images obtained reveal minimal coupling between the two facing coils (image coil1&2), despite their close proximity and potential strong coupling. The combined images allow to nicely depict the imaged phantom.

At low frequency (<5MHz), the noise dominance regime in NMR transitions from sample dominated to the so-called Johnson noise dominated regime, where electromagnetic noise from the acquisition chain dominates. In this context, the noise perceived by multiple detectors can be assumed to be incoherent, and strategies that combine multiples sensors can be leveraged to increase sensitivity. NMR detectors (coils) are resonant systems that include an inductor (L), a capacitive network (C) and some intrinsic resistance (R), and which frequency of operation is being tuned to match the Larmor frequency of Hydrogen nuclei at a particular magnetic field. Unfortunately, multiple NMR coils in close vicinity are subject to strong coupling phenomena that impact their performance, and hence cannot be used as envisioned to increase sensitivity. We proposed to develop custom, analog preamplifiers with a high input impedance in order to attenuate the circulating current in NMR conductors, and hence diminish electromagnetic interactions (coupling) so to favor sensitivity and/or coverage for MRI applications. In this context, we have designed, developed and constructed 2 generations of analog preamplifiers. Their gain performance was assessed, and their decoupling efficiency for imaging was successfully demonstrated in a custom-built phantom placed within the bore of a 0.1 T compact MRI scanner. This original work validates our hypothesis of employing high-input impedance to promote decoupling efficiency in NMR resonators, and opens new perspectives to boost sensitivity and hence imaging performance in low magnetic field MRI systems.

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