High performance NMR local preamplifier associated to microcoil

L. Fakri-Bouchet [1], T. Cherifi[2], L. Quiquerez[2], J-F. Château[2], A. Briguet[1]
[1]UMR CNRS 5012, labo de RMN MIB, Université Claude Bernard Lyon1, ESCPE, F-69622, Villeurbanne cedex, France, [2]LENAC EA 3730, Université Claude Bernard Lyon 1, F- 69622, Villeurbanne cedex, France

Introduction :

The use of implantable microcoil presents a new way of investigation for in vivo study of local metabolites occupying a small volume of living tissue (~0.2 nL) [1]. The inconvenient of this approach is the low sensitivity of the sensor due to the small coil size.
Efficient preamplification with good sensitivity and good signal-to-noise [2] is to set the preamplifier close to the sensor itself. In this study a home made preamplifier associated to a microcoil is presented and its performance are experimentally evaluated.

Materiel and Methods :

The system employed for the studies was based on a 2 Tesla superconducting OXFORD and a SMIS console. The NMR investigations were carried out using two antennas : The volumic transmitter coil was an half birdcage resonator, capacitively matched, balanced and tuned at proton ^1H frequency (85.13 MHz). The receiver coil was a small 4 loop micro-coil, 22 µm diameter with a 20 µm inter-loop and a length typically between 500 and 1000 µm. The preamplifier is a wideband amplifier using a CMOS current conveyor approach in standard AMS 0.8µm (double level of poly-silicon and metal), with following charateristics mesured at 85.13 MHz : –3dB bandwidth 95 to 120 MHz, 42 dB Gain, low input noise ~ 4 nV/Hz$^{1/2}$, chip consumption ~30 mW.

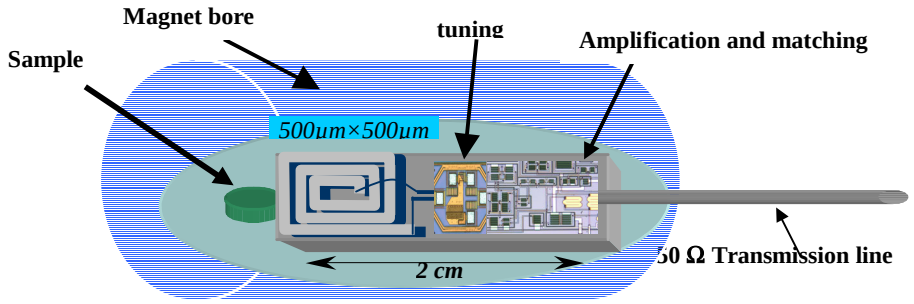

Fig 1 : Preamplifier and microcoil assembly

Results :

Here the sensitivity performance of preamplifier associed to micro coil is measured with a water sample doped with CuSO4.
Spectrum acquisition: Water spectra are taken using a one pulse sequence (τ=50 µs, TR=1s, NAcq = 2). Shimming optimization was achieved and the procedure was considered sufficient when half full with of water peak was within 20 to 30 Hz.
*Spectrum processing and signal to noise(SNR) evaluation:*The spectral quantification was achived using the Amares «Advance

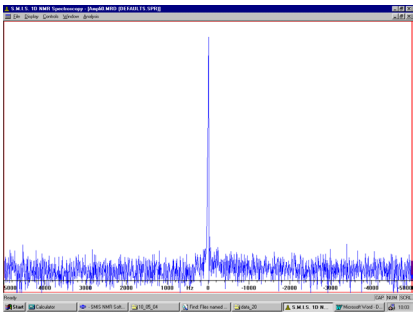

Fig 2 : Water Spectra obtained without amplifier

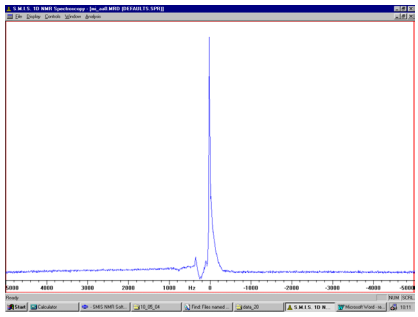

Fig 3 : Water spectra obtained with amplifier

Method for accurate, robust and efficient spectral fitting» algorithm available on the J-MRUI Software [3]. In Figure 2 and 3 the experimental SNR value is obtained by dividing amplitude by the rms noise. Without preamplifier, the signal to noise ratio obtained is SNR = 10.4 and with preamplifier SNR = 242.

Conclusion/Discussion :

The obtained quality spectrum and especialy the SNR improvement by a factor of 24 are representative of the preamplifier performance. The sensitivity of microcoil detection is significatively increased since the losses effects in 50 Ω transmission line are comparatively less important than losses in the radiofrequency coil when using the preampifier design.

References

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[3] Wanhamme L. et al, MAGMA (1997), 129, 35-43.