# Low cost NMR/MRI spectrometer using industrial boards

C. GOETZ[1], P. CHOQUET[1], J. HYACINTHE[2], A. CONSTANTINESCO[1]

[1]Laboratoire de Biomécanique, Service de Médecine Nucléaire - Hôpital de Hautepierre, Strasbourg, France, [2]INSERM U594, Université J.Fourier, CHU - Pavillon B, Grenoble, France

## Synopsis

Commercial NMR spectrometers are made of several complex, specifically developed high cost devices. We choose to construct a low cost NMR spectrometer based on standard electronic boards integrated through software and whose basic principle rely on direct pass band sampling of NMR signal. At present, the spectrometer allow RF coils wobulation and matching, relaxation times measurements and images acquisition with spin and gradient echo sequences. First results show no difference in image quality compared with standard spectrometer (at 0.1T). This system offer an alternative for low cost applications of MRI (industry, teaching...). To overcome problems and cost due to specific electronic development in a NMR spectrometer, we propose an economic alternative based on standard electronic boards and software developed in a recognized industrial environment.

## Materials and Methods

The NMR/MRI spectrometer use PXI boards, installed in a specific chassis (National Instruments NI, Austin, USA). There were:
- an arbitrary function generator for RF pulse generation (NI PXI-5411);
- an anolog output board for gradients pulses and blanking (NI PXI-6711);
- an ADC board for NMR signal acquisition (NI PXI-5102).

Process control, signal acquisition and image reconstruction were done by the software developed using the graphical programming environment LabView 6i (NI, Austin, EU): in particular it assumes the monitoring of the different temporal elements of the NMR sequence. All test are made at 0.1 T with dedicated resistive magnets.

Spectrometers classically use frequency mixers to sample down the Larmor frequency into a low intermediate frequency compatible with sampling devices capabilities. Instead we used direct pass-band sampling techniques [Perez & al., 'Potential use of the undersampling technique in the acquisition of NMR signals'. Magma, 13(2) 2001]: the high RF frequencies of the NMR signals are directly digitized out of the RF preamplifier at low sampling frequencies. The sampling frequencies are chosen to respect the Nyquist criteria on the original signal bandwidth but not on the Larmor frequency. Digitized aliased signal are then numerically processed to obtain both quadratic signals and are afterwards classically treated to extract NMR information.

## Results

The spectrometer has the following functionalities: characterization of RF coils (tuning & matching), B0 shimming, flip angle calibration, NMR signal acquisitionn and visualisation (Fig.1), T1 & T2 measurements (CPMG, Hahn... methods) (Fig.2) and imaging (spin & gradient echo sequences, Fig.3 & 4). NMR signal undersampling techniques provide the compatibility from ultra-low fields to fields whose value depends on the bandwidth of the ADC (15 MHz in our case).

## Discussion

Pass-band sampling is a legitimate method for NMR signal sampling considering its properties. In our experience, aliasing and multiple folding up of the signal spectra does not affect the original NMR signal information, except for out of band RF noise which can be folded up in the signal bandwidth. Results shown in the different figures are obtained at 0.1T and there is no noticeable differences with results acquired with a standard spectrometer.

## Conclusion

Such a small cost system could take place in industrial or teaching applications.

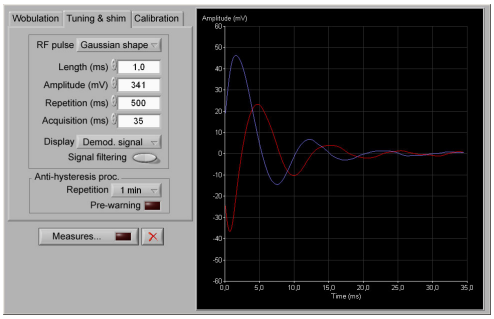


Figure 1:
FID (real and imaginary parts) as displayed during shimming process (snapshot)

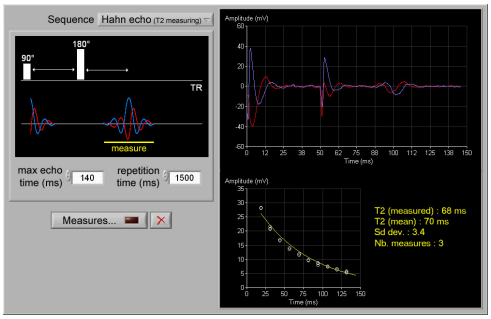


Figure 2:
Hahn echo sequence, one measure and calculation of T2 (snapshot)

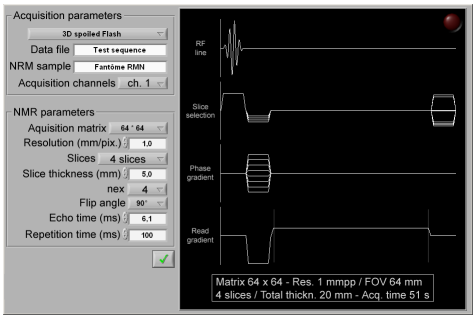


Figure 3:
Chronogram and parameters of FLASH sequence, refresh during acquisition (snapshot)

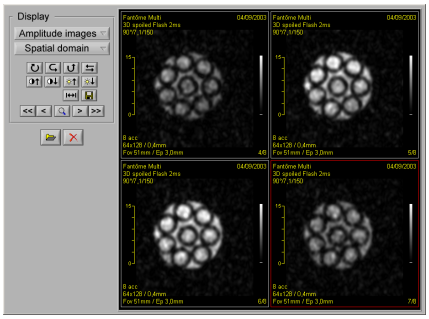


Figure 4:
Phantom MR images obtained and display (snapshot)