PERFIDI Filters: A Summary

Ester Maria Vasini1,2, V. Bortolotti1, P. Fantazzini1 and Stanislav Sykora2

Abstract

In the field of Nuclear Magnetic Resonance, the possibility to distinguish or filter the signals of different parts of a sample plays a key role in many applications. For example, in the medical field, such a possibility allows to improve the image contrast and the identification of the different tissues inside the human body. In oil and gas petroliometry, the characterization of different saturating reservoir fluids permits a better optimized exploration [1, 2]. Regarding T2 filtering, literature reports many sequences dedicated to signal selection such as Short Time Inversion Recovery and Multiple Inversion Recovery [3], but usually these techniques allow the selection of only a discrete number of T2 values at which the signal is to be suppressed.

Parametrically Enabled Relaxation Filters with Double and Multiple Inversion (K, S, G) (PERFIDI) is an innovative technique which implements T2 filters but, in contrast to standard selective sequences, it allows to filter the signal associated with a selected range of T2 values. PERFIDI Filters, de facto, act somewhat like electronic band-pass, low-pass and high-pass filters. They have been developed and tested in both Nuclear Magnetic Resonance Relaxometry and in Magnetic Resonance Imaging.

Here we present a summary of this innovative filter technique, up to this point of its development, describing the validation of the method and the application to different kind of samples, all characterized by a continuous T2 distribution, such as biological tissue and oil-water saturated porous media.

PERFIDI Filters

1. The model system and the tomograph:
   - 3. PERFIDI Filter procedure:
     - Acquisition of PERFIDI SE and PERFIDI OFFSET images;
     - Restoration of the signal sign pixel by pixel (by processing the raw data);
     - Linear combination of the PERFIDI SE and of the OFFSET images;
   - 4. Results:

   The application of PERFIDI filters on a synthetic two-component sample produced the expected results. The PERFIDI high-pass and the low-pass filters, acting on components with given T2 relaxation time distributions, have produced high contrast images.

PERFIDI in Imaging: application on porous media phantoms

1. Malta stone:
   - The core has been obtained from a cylindrical sample. The inner core has been filled with saline solution, which is characterised, inside the pore space, by a T2 distribution centred around 700 ms. The outer core has not been filled with saline solution, which, inside the pore space, shows a T2 distribution centred around 70-80 ms. In this way it has been possible to obtain a wide T2 distribution sample.

PERFIDI in Imaging: preliminary results on a biological tissue (pork loins) [7]

Conclusions:

- The application of PERFIDI filter sequences, combined with the use of the PERFIDI sequence mathematical model, on a two-component model sample, produced the expected results.
- The use of the MINI PERFIDI sequences on a sample with a wide T2 distribution, such as an oil-water saturated porous media sample, has shown that these T2 filtering techniques can effectively be used on samples characterized by continuous distributions of T2, showing, for example, the spatial distribution of the fluids.
- The next steps of the research will be the reduction of the measurement time and the enhancement of the image contrast.

References


Notes:

- Image processing made using Matlab.
- Relaxation measurement is made using a full-size coil by Stark (Med, Italy).
- Relaxation T1 distribution elaborated using the OFREG algorithm [8].

Future work:

- Apply PERFIDI in NMR Spectroscopy!!!