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Graphical User Interface and Data Handling in for a Nuclear Quadrupole Resonance Software Defined Radio Spectrometer

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Abstract

Running the Software Defined Radio (SDR) which is used for the Nuclear Quadrupole Resonance (NQR) spectroscopy an intuitive Graphical User Interface (GUI) and a automatic Data Handling system is essential for a efficient testing and measuring. A automated structured overview minimises the risk of experiment errors an the loss of important acquired data. Additionally a Sequence generator was implemented with the ability to dynamic select, from one pulse up to ten pulses. The GUI is also able to be used to set the represented Phases from $\varphi_{min} = 0$ up till $\varphi_{max} = 2\pi$ for every pulse and all the hardware specific parameters.
As one of the requirement was that the Software will be used for a lab exercise with students, it should include precaution for protecting the hardware from destructive settings. On the other hand for experienced user it has the ability to load standardised .cfg files from the system.

Contents

List of Figures

1 Introduction

Nuclear Quadrupole Resonance (NQR) is a technique to analyse samples in solide state with absence of a external magnetic feel like in nuclear magnetic resonance (NMR). With a radio frequency pulse the samples gets excited. If the sample gets exited at its resonant Frequency a significant greater signal gets back induced into the coil. For maximum signal yield a tuned and matched resonator circuit at Larmor frequency is used. With this conditions it is possible to get, from the experiment, the best possible Signal-to-Noise ratio (SNR).
Single frequency measurements and broadband measurements are made in the very high frequency (VHF) range. [1]

The task of the this thesis was to implement the existing setup, which was a proof of concept, to design a intuitive software to automate the measurement with a Graphical user Interface. Extending, also a sequence generator was implemented for a fast and easy setting of the sequence parameters. All Parameters for a standard sequences are predefined, additionally for extended options, there is the option to set the own sequence in the GUI. Rounding the system off, a file handler for structured saving of all data acquisition is implemented.

1.1 Preparations for Extending

Preparing for the future in order to ensure that an automatic tune and matching unit can be easily extended, many features were already predefined for a later easy extending of the software.

2 Methods

All the software is available on the Git repository, additionally there is also the description of the complete software in the wiki section.
The software is developed to run on a Linux machine, but a limited number of features also run on a windows system. This can be used, for example, to generate sequence files in advance or reload measurement data for inspections.

2.1 Download links

Repository:
http://www.github.com/OE9NAT/bacharbeit

Wiki:
http://www.github.com/OE9NAT/bacharbeit/wiki

3 Results

3.1 What it can do

The Software was designed to handle user input on a structured designed graphical user interface. A set of standard sequences are pre-configured and can be selected from the main window, but there is also the option to generate one for itself. It will update the set sequence as an info in the main window. From the main window after selecting the data, if the resonant circuit is tuned, the measurement can be started with the specific sample.

As the LimeSDR is a duplex capable software defined radio, starting with the sequence the signal logging will start.However, boundary conditions must be set beforehand so that the recorded signal is cut to a desired size. The cut should be chosen sow that the re-induced signal will be completely enfold in the recording. This information will be plotted and saved in the predefined file structure for further analyses.

3.2 What can it do not sow well

Repetitive tuning and matching is done manually for measuring ever frequency. As this is very tedious task and can manually only be done to a certain accuracy in a given time an automatic system needs to be developed. As this feature is foreseen, arrangements have been made to easily implement this in the future.
On the other hand after the acquire, the information from the last run is shown in the plotter on the main window. The basic plotter should give a short overview, but for an additional analyses cornerstone have bin set to developed a more detailed plotter.
For broad band frequency measurements safety precaution have to be made. Now for a new measurement for the ascending frequency the old result will not be overwritten but will be appended. This type of acquire is special as this will fill in the plot from the starting frequency to the end frequency.
Error handling is only checked for plausibility. It is mainly done throw structured logical entry of the Parameters. Before saving all not pre-set values will be checked if they are in the right format.

3.3 What can it not do

Fly to the moon.
It has the Potential to be more intuitive from setting the Parameters. While doing the experiment it can be more obvious to put some settings and Parameters in different locations.
Error handling can be implemented for more cases. Parameters are not check for hardware specific limitations. Additional it could also be an option to do an automatic correction of Parameters witch are set incorrect.

4 Conclusion and Future Work

4.1 Main Window

In the main window all relevant data for the experiment will be presented and set. The initial start of the system will also be run from there.

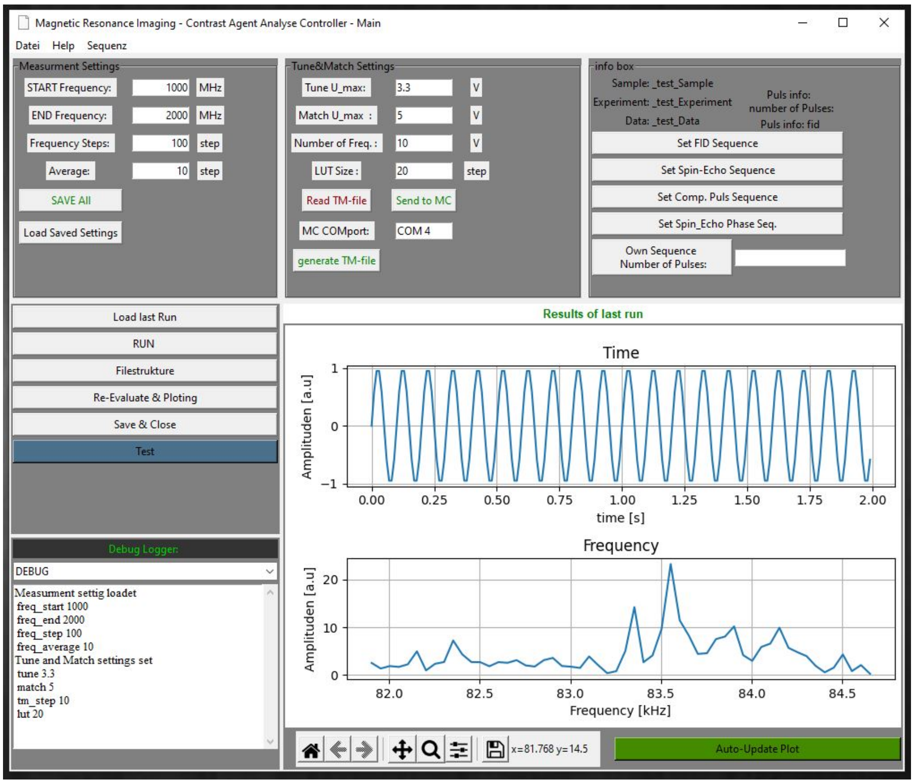

Figure 4.1: Main window, where all controls flow together

4.2 File Handle

All relevant file handling parameters can be initially set and also be changed in a later state. In this additional window at the beginning and end of every experiment comments can be added which will be logged to a .txt file.
For now it is hard-coded to save all measurement data in the folder named

Storage_vault but this can be changed very easily sow that it can also be automatically to a decentralised file handling server.

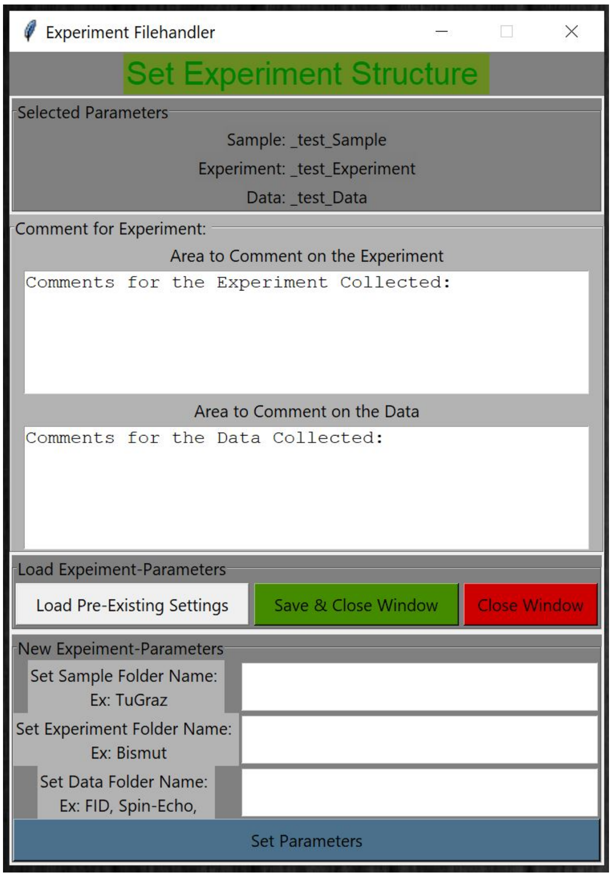

Figure 4.2: File handler window, used for editing the structure of storage

4.3 Sequence generator

All Standard sequences can be directly called from the main window. It includes the the free induction decay (FID) sequence, the Spin-Echo sequence, the Composite Pulse sequence, the Spin-Echo phase sequence and an own to be defined sequence. With the own sequence an arbitrary sequence can be generated with up to ten pulses and their respective offsets.

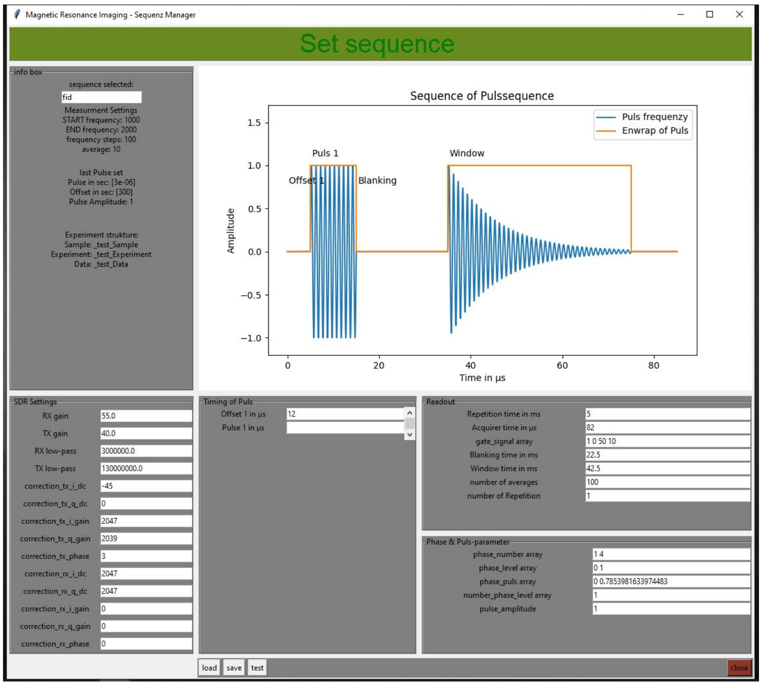

Figure 4.3: Sequence manager window, specific prepared for the FID

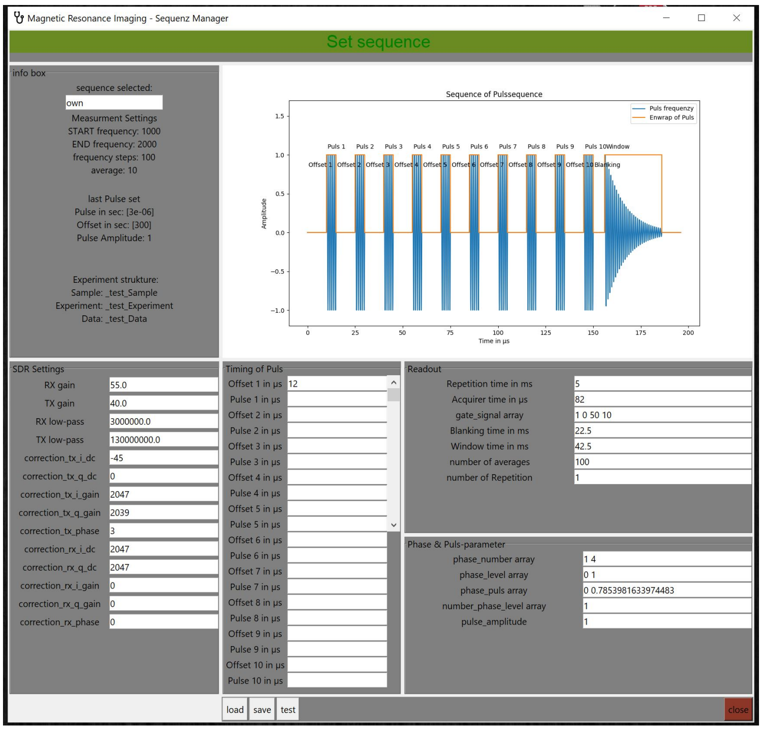

Figure 4.4: Sequence manager window, displaying the maximum number of 10 pulses and all possible set Parameter

4.4 Future

Options for expansion are numerous, as this interface is only the start of the Project of using an SDR for NQR analysis. Initially it was only a proof of concept and starting now onward with multiple improvements it will develop into a stable robust stand alone system.

Shortly after, the development on a automatic tuning and matching system, started. Manual tuning and matching is very time consuming and to set up a broad band measurement it is essential to have a certain accuracy.

A great potential lies in evaluating and comparing recorded measurements afterwards. This could look like, recorded files will be selected and loaded together into the same plot. Such options are prepared to be implemented in a later state.

The ability for a better design is always possible. For a modern design this can be done with coloring and shaping of button and ares of entry. Moreover there is also great potential in the back end handling of variables an measuring data.

Bibliography

[1] Hermann Scharfetter. An electronically tuned wideband probehead for NQR spectroscopy in the VHF range. *Journal of Magnetic Resonance*, 271:90–98, oct 2016.