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DATA ACQUISITION AND DATA PROCESSING SOFTWARE FOR MAGNETIC MEASUREMENTS FOR NICA MAGNETS

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NICA and FAIR accelerator complexes need to create more than 600 magnets at all. All of them must be qualified. To complete this procedure the automated software was made, which has been used at the magnetic measurements test bench. The magnet measurement software controlled all the process of measurement process like data acquisition, sensor position or current supply management. RAW data were collected during magnetic measurements and needed to be filtered to get results that are more valuable. Filtering and smoothing algorithm based on wavelets and splines was developed as a part of the data processing software.

Keywords: NICA magnets, DAQ software, National Instruments, NI LabView, NI cRIO, EtherCAT, servo drive, Kollmorgen, signal filtering, wavelets

1. Magnet measurement software

NICA and FAIR are accelerator complexes presently under construction at the Joint Institute for Nuclear Research (JINR) in Dubna, Russia and in Darmstadt, Germany, respectively. More than 600 superconducting (SC) magnets will be assembled and tested at the test facility at the Veksler and Baldin Laboratory of High Energy Physics (VBLHEP), JINR. The magnets qualifying procedure includes warm and cold magnetic measurements. Both types of test benches have the same characteristics:

- 24-bit ADC/DAC;
- 200 000 samples/s per channel;
- Saving data type – RAW;
- Sensor positioning better than $1 \cdot 10^{-4}$ rad;
- 2^{20} steps per rotation of a sensor.

More details on qualifying procedure and construction of test benches are expounded in [1].

The same software is used for both types of magnetic measurements and both types of test benches, respectively. Automated software allows decreasing time of magnetic measurements; avoid operator mistakes and the most important decreasing personal needed to qualify magnets. In addition, the same software is used for most types of magnets.

The user interface of the measurement program is presented in Figures 1 and 2.

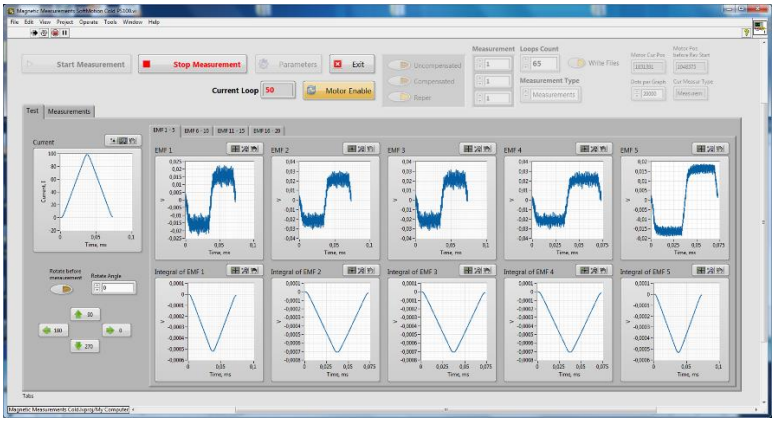

Figure 1. The measurement program interface – actual signals from sensor coils

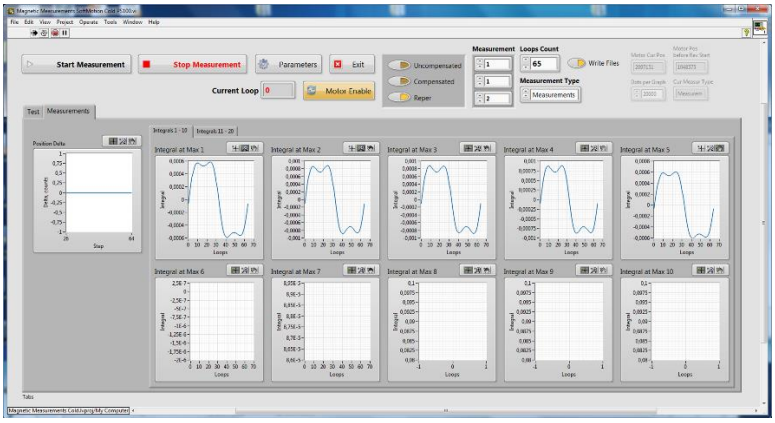

Figure 2. The measurement program interface – integral data of measurement cycle

The measurement program is written on National Instruments (NI) LabView and works on NI equipment or LabView compatible equipment. The principal architecture of the measurement software

is presented in Figure 3. Data acquisition and triggering is based on NI DAQmx modules. Kollmorgen servo drives are used for the sensor positioning. Management of servo drive works on EtherCAT infrastructure with the help of NI cRIO real-time controller. Communication between the real-time controller and the measurement software is carried out by LAN. Other equipment is managed by GPIB / IEEE-488 and TIA/EIA-485 (RS-485) protocols.

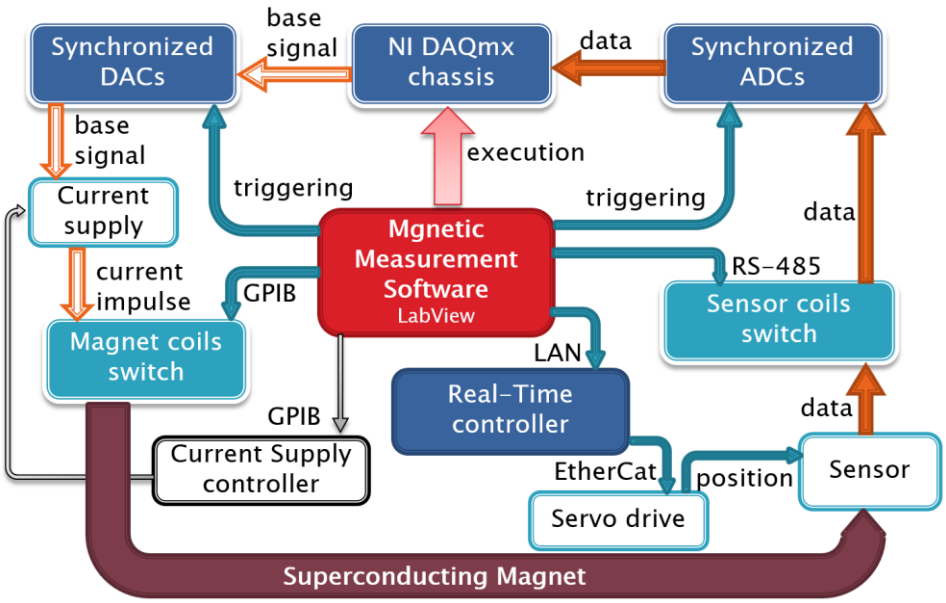

Figure 3. The principal architecture of the measurement software

2. Signal filtering system based on wavelets and splines

Gathering of RAW data allows using more sophisticated algorithms in order to preprocess the data before getting any results from them. The data flow of acquiring data is given in Figure 4. Wavelet filtration is used to filter RAW data of magnetic measurements as standard preprocessing procedure.

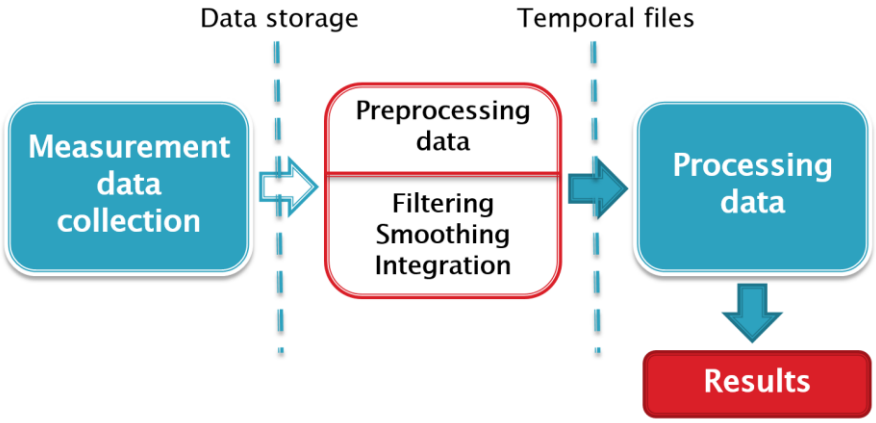

Figure 4. Magnetic measurements data flow

Wavelet filtration with some improvements gave good results with the highly noised signal. The additions are wavelet peak detection and spline interpolation to replace the peaks. Wavelet peak detection is used to find parts of a signal with the highest amplitudes of noise. Then the peaks are replaced by spline for 4 points interpolation. The algorithm steps are given in Figure 5.

Peak detection is based on multiresolution wavelet analysis. Continuous wavelet transform coefficients of unfiltered data processed by series of undecimated wavelet transforms with biorthogonal (boir 3.1) wavelet to get peak places [2].

Effectiveness of the algorithm is confirmed on data that is presented in Figure 6. The results of filtering are presented in Figure 7. Average accuracy of signal recovery is 10^{-6}. Errors with values of 10^{-3} were got in the worst conditions.

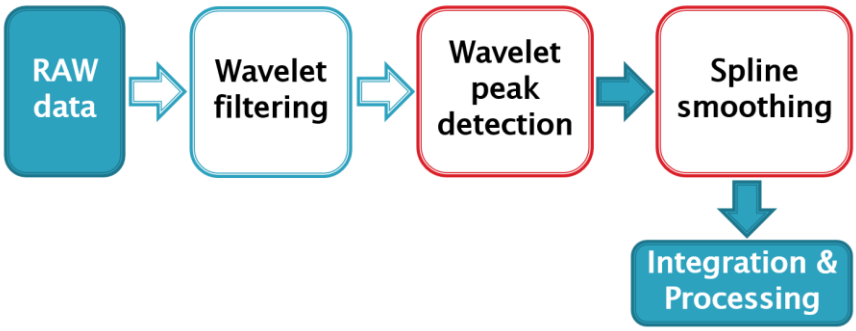

Figure 5. Steps of wavelet and spline based filtering algorithm

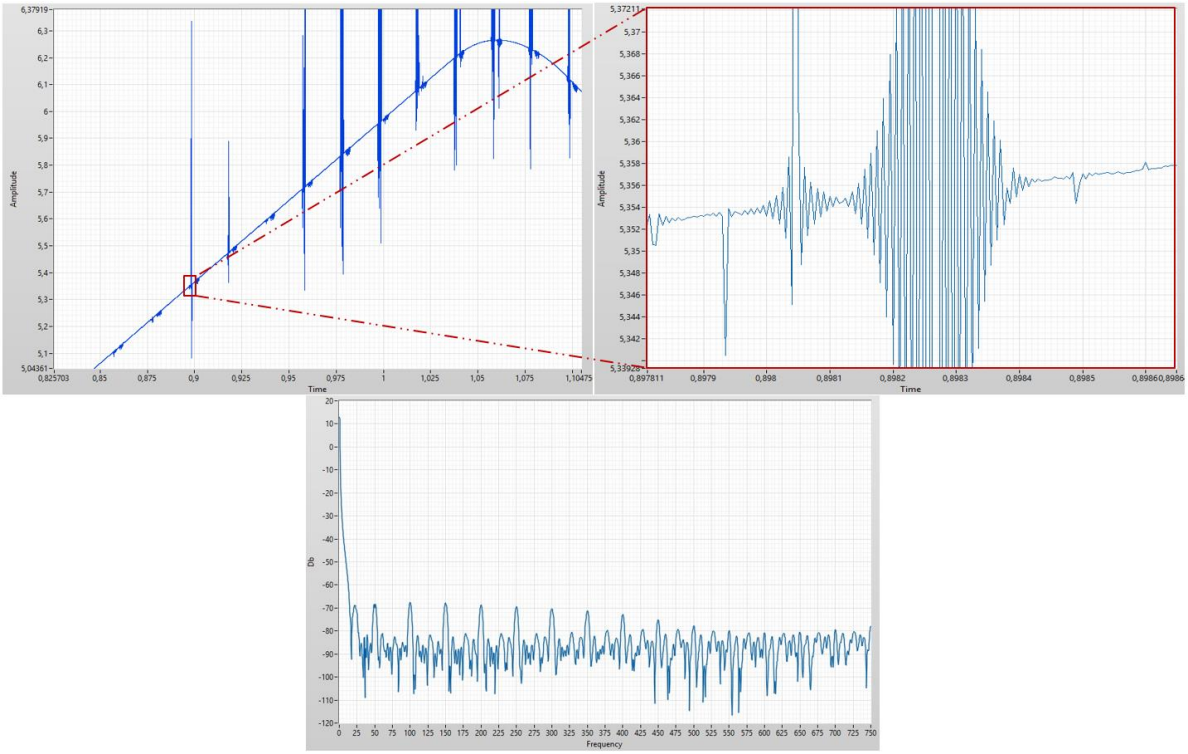

Figure 6. Noised signal and its power spectrum

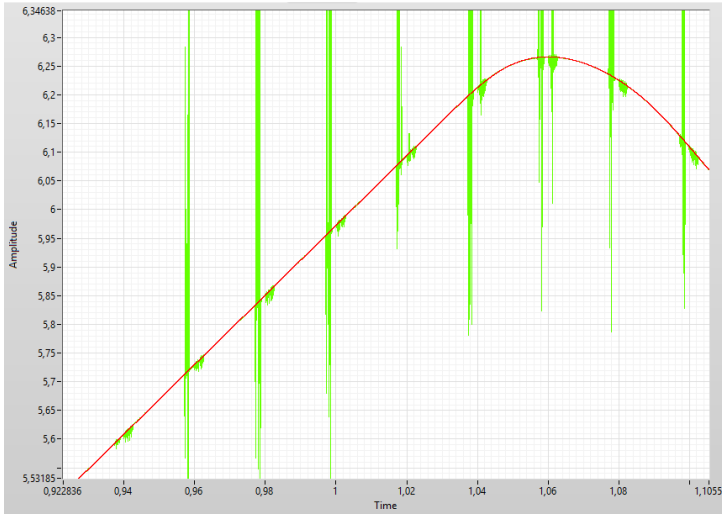

Figure 7. Noised and filtered signal

3. Future plans

Creating distributed magnetic measurement system between several chassis synchronized magnetic measurement software allows decreasing quantity and length of analog cable lines. In addition, this allows processing qualify procedure simultaneous for several magnets by a single operator without using any remote desktop software.

4. Conclusion

The necessity to qualify more than 600 magnets of NICA and FAIR complexes required to use highly automated test benches. Automated software has been used to achieve this goal. This allows decreasing personal necessity. In addition, this decreases time of magnetic measurements and avoids operator mistakes.

Saving magnetic measurement data in RAW format allows using more sophisticated, time-demanding and precise methods, like wavelet filtration and wavelet based algorithms, in order to preprocess the data before calculation of magnet characteristics.

References

[1] Kostromin S.A. et al. Measurements of magnetic field parameters of NICA booster dipole magnet // Physics of Particles and Nuclei Letters, ISSN:1547-4771, eISSN:1531-8567, 2016, vol. 13, No. 7, pp. 855-861.

[2] Wavelet-Based Peak Detection. Available at: http://www.ni.com/white-paper/5432/en/ (accessed 03.11.2017).