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UPGRADED MAGNETIZING AND MEASURING SYSTEM FOR COMPENSATION FERROMETERS

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New upgraded magnetizing and measuring system for compensation ferrometers (SSTs) was developed. The analogue/digital exciting and data acquisition PC plug-in boards Keithley KPCI–3110 are used. The upgrade brings system simplification, higher system rate, higher magnetizing and sampling frequency, effective magnetic flux waveform correction, real possibility for MMF compensation method digitization, easier system control (hardware, software).

Keywords: compensation ferrometers, magnetizing and neasuring system, data acquisition plug-in boards, control software

1 INTRODUCTION

Compensation ferrometers are special single sheet testers based on the original Czech MMF compensation method [1] that were designed for the measurement of open specimen soft magnetic materials parameters at AC magnetization. The developing series of compensation ferrometers has been realized at the Czech Technical University in Prague for stationary (not moved specimen) research laboratory testing and on-line industrial one. Last version of compensation ferrometers (KF9 / KF9a) was constructed in 2008. The original KF9 magnetizing and measuring system actual upgrade is presented.

2 ORIGINAL KF9 SYSTEM

The original KF9 magnetizing and measuring system is in Fig.1. The main system components [2] are digitally controlled magnetizing preamplifier EA, power magnetizing amplifier MA, measuring amplifiers BA and HA, induced voltage (magnetic flux) waveform correction preamplifier VA, compensation preamplifier RA, power compensation amplifier CA, and power source PS. The system KF9 is controlled by the PC (PC – port USB – local control unit CTRL) equipped by three special plug-in boards AD14PCI. One of them serves as an generator of two different independent analogue signals (exciting signal u_{ex} and auxiliary compensation one u_{out}). Two others serve as the measured signals ($u_B \sim B(t)$, $u_H \sim H(t)$) acquisition ADCs.

Magnetizing equipment consists of magnetizing yoke Y, three sections of magnetizing winding MW2–MW1–MW3, voltage winding VW, two sections of compensation winding CW–CW and Rogowski-Chattock potentiometer RCP.

The classic analogue MMF compensation feedback loop RCP–RA–CA–(CW–CW)–RCP is completed by auxilliary analogue/digital branch RA–AD14PCI/u_{err}–AD14PCI/u_{out}–CA increasing MMF compensation efficiency.

The similar efficiency increasing function has auxilliary analog/digital branch BA–AD14PCI/u_B–AD14PCI/u_{ex}–EA completing the classic analogue correction feedback loop VW–VA–MA–(MW3–MW1–MW2)–VW (induced voltage waveform (magnetic flux waveform) correction).

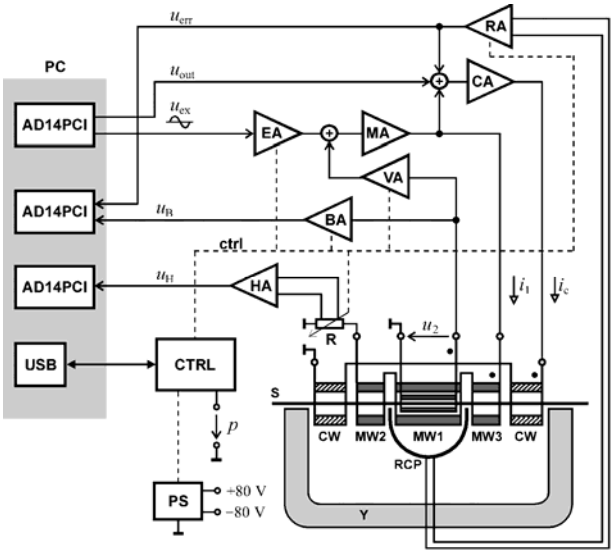

Fig. 1. Original KF9 magnetizing and measuring system with three AD14PCI plug-in boards

The plug-in board AD14PCI operates in three modes:

- **Analogue signals generation**
  - 2 independent analogue outputs
  - output voltage range: 0 – 5V / ±5V
  - DAC: 12 bit
  - transient time: typ. 10 μs
- **Analogue signal sampling – data acquisition**
  - 16 multiplexed analogue inputs
  - input voltage range: 0 – 10V / ±5V
  - programmable gain amplification: 1, 2, 4, 8
  - ampling rate: max. 250 kSamples/s
  - ADC: 14 bit
- **Direct digital communication**
  - 16 digital inputs (TTL/HCT compatible)
  - 16 digital outputs (TTL/HCT compatible).

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3 PC PLUG-IN BOARD KPCI-3110

The original magnetizing and measuring system was upgraded by the replacement of the analogue/digital PC plug-in boards AD14PCI by the Keithley KPCI–3110 ones (Fig.2 to Fig. 4).

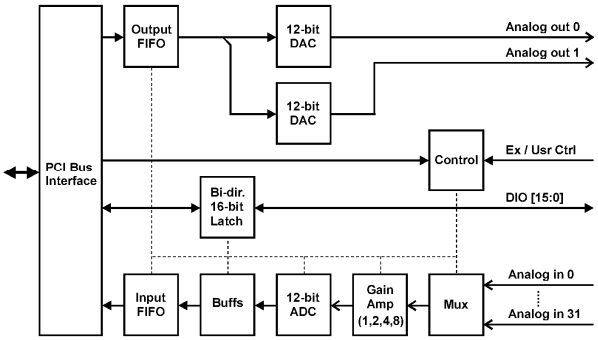

Fig. 2. Block diagram of KPCI–3110 plug-in board

Fig. 3. KPCI–3110 plug-in board

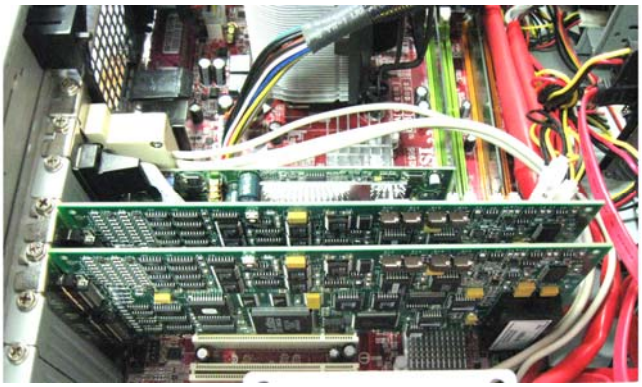

Fig. 4. Two KPCI– 3110 boards plugged-in PC slots

Analogous to the AD14PCI plug-in board the upgrading KPCI–3110 one is also constructed for 3 operation modes:

- **Analogue signals generation**
- 2 independent analogue outputs
- output voltage range: 0 – 20V / ±10V
- DAC: 12 bit
- output "sampling" rate: max. 500 kSamples/s

- **Analogue signal sampling – data acquisition**
- 32 multiplexed analogue inputs
- input voltage range: 0 – 20V / ±10V
- programmable gain amplification: 1, 2, 4, 8
- sampling rate: max. 1.25 MSamples/s
- ADC: 12 bit

- **Direct digital communication**

16 independent digital inputs/outputs DIO.

In comparison with AD14PCI, the main KPCI–3110 plug-in board advantages are:

- capability to operate in all 3 modes simultaneously
- greater voltage input and output range
- higher output "sampling" rate
- higher input sampling rate
- higher multiplexing rate
- more comfortable programming (card drivers).

4 UPGRADED SYSTEM

The upgraded magnetizing and measuring system developed on the ferrometer KF9a is in Fig.5.

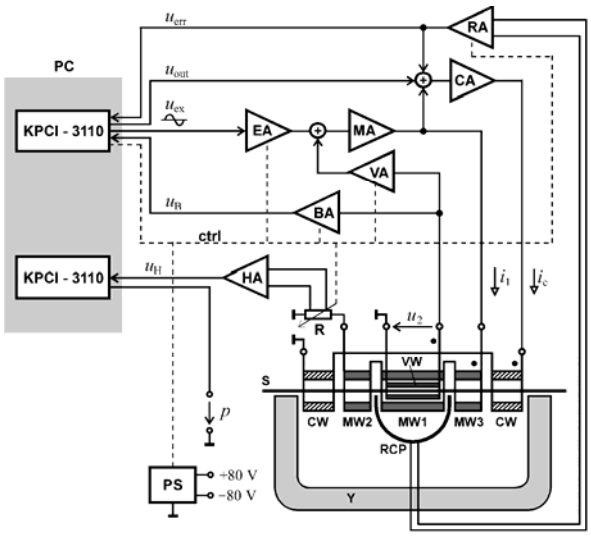

Fig. 5. Upgraded KF9 magnetizing and measuring system with two KPCI–3110 plug-in boards

The system upgrade consists in:

- Three plug-in boards AD14PCI are replaced by two advanced KPCI–3110 pieces
- Higher rate, higher sampling frequency
- More effective magnetic flux (induced voltage) waveform correction
  – Real MMF compensation method digitization
- Two–stage control system is replaced by more simple direct control
- Local control unit CTRL is cancelled

USB serial port is not used

- Simplification of control software

- No need of local control unit CTRL programming
- No need of USB programming
- AD14PCI programming is replaced by more simple KPCI–3110 one

5 MEASURED RESULTS

Correct function of the upgraded system was verified by series of measurements with compensation ferrometer KF9a. The measurements were done on sheet specimens of classic silicon steel EO10 500 x 500 mm, width 0.35 mm, magnetized in special magnetizing yoke at sinusoidal magnetic flux density with amplitudes 1.0 T and 1.5 T, respectively, and magnetizing frequency 50 Hz. Good MMF compensation efficiency was verified. Hysteresis loops measured without (blue) and with (red) MMF compensation (MMFC) were compared (Fig. 6 to Fig. 9).

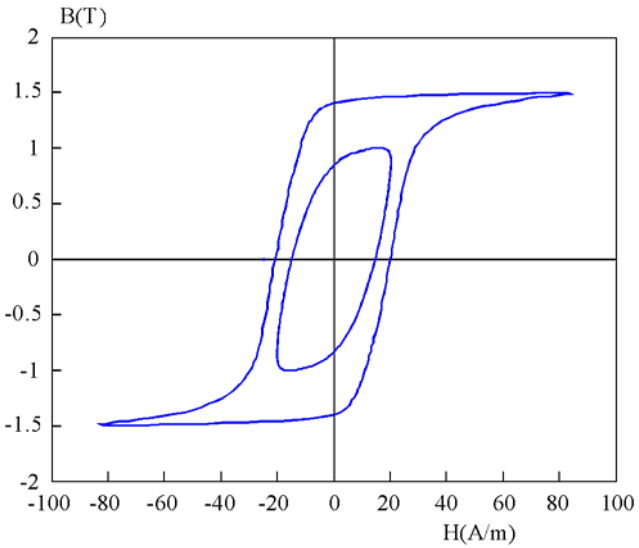

Fig. 6. Hystersis loops: 1T / 1.5T , 50 Hz

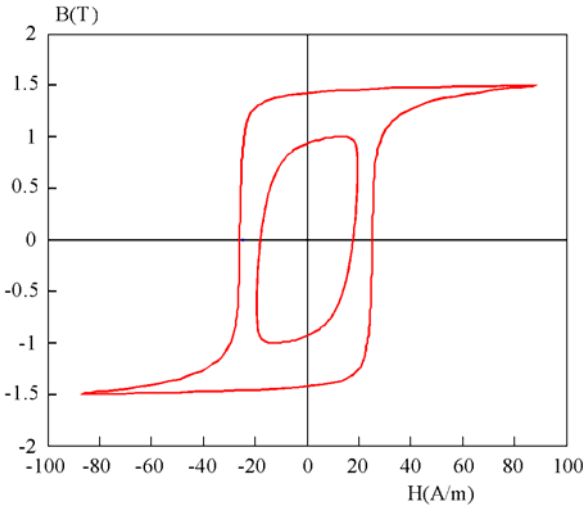

Fig. 7. Hystersis loops: 1T / 1.5T , 50 Hz, MMFC

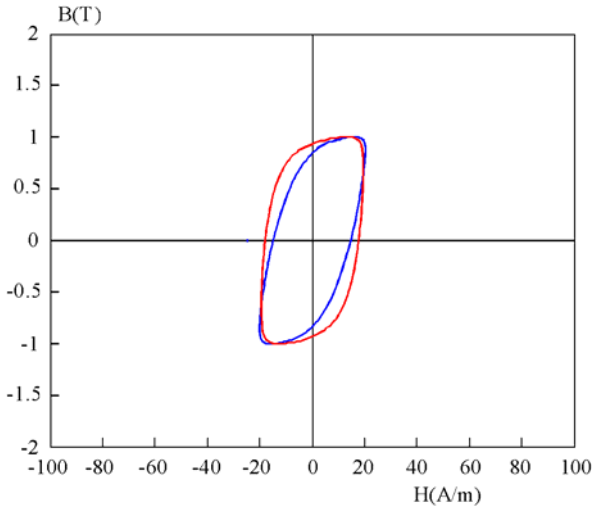

Fig. 8. MMFC influence, 1T, 50 Hz

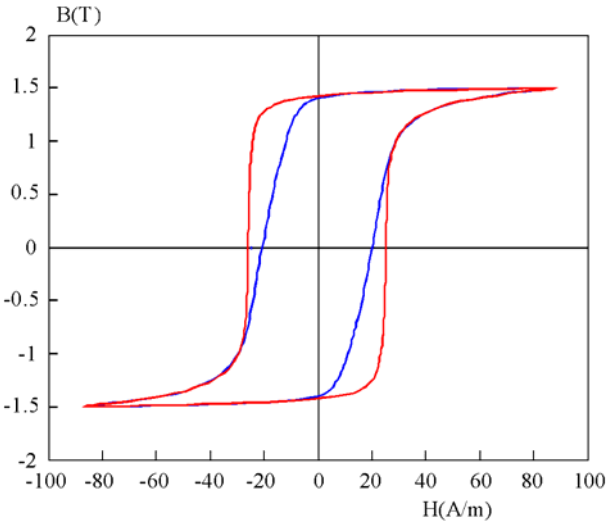

Fig. 9. MMFC influence, 1.5T, 50 Hz

6 CONTROL SOFTWARE

New version of the control software was developed in Visual C++ of the Visual Studio 8.0 supported by the routines and libraries of the Measurement Studio 7.1. as the Windows XP application executable on standard PC completed by two KPCI-3110 plug-in boards.

The control software concept is based on user friendly dialogue mode. There is one main object – main dialogue window consisting of many other small objects – control, editing and indicating elements (buttons, numerical and boolean controls, indicators, knobs and graphs). The small objects serve as the simple system inputs and outputs. All these objects (their member functions – methods and member variables) are also methods and member variables of the main object. In this case all methods and variables can be used as “public” ones (usable for all system functions and procedures).

The most system functions are hardware independent. The interface to the KF9a hardware layer is realized by the KPCI-3110 firmware. Special class “Card” was written for simple KPCI-3110 board programming. The main

control program dialogue window is in Fig. 10. The dialog window consists of editing and indicating element groups that offer simple communication with the KF9a and visualization of all measured and computed results.

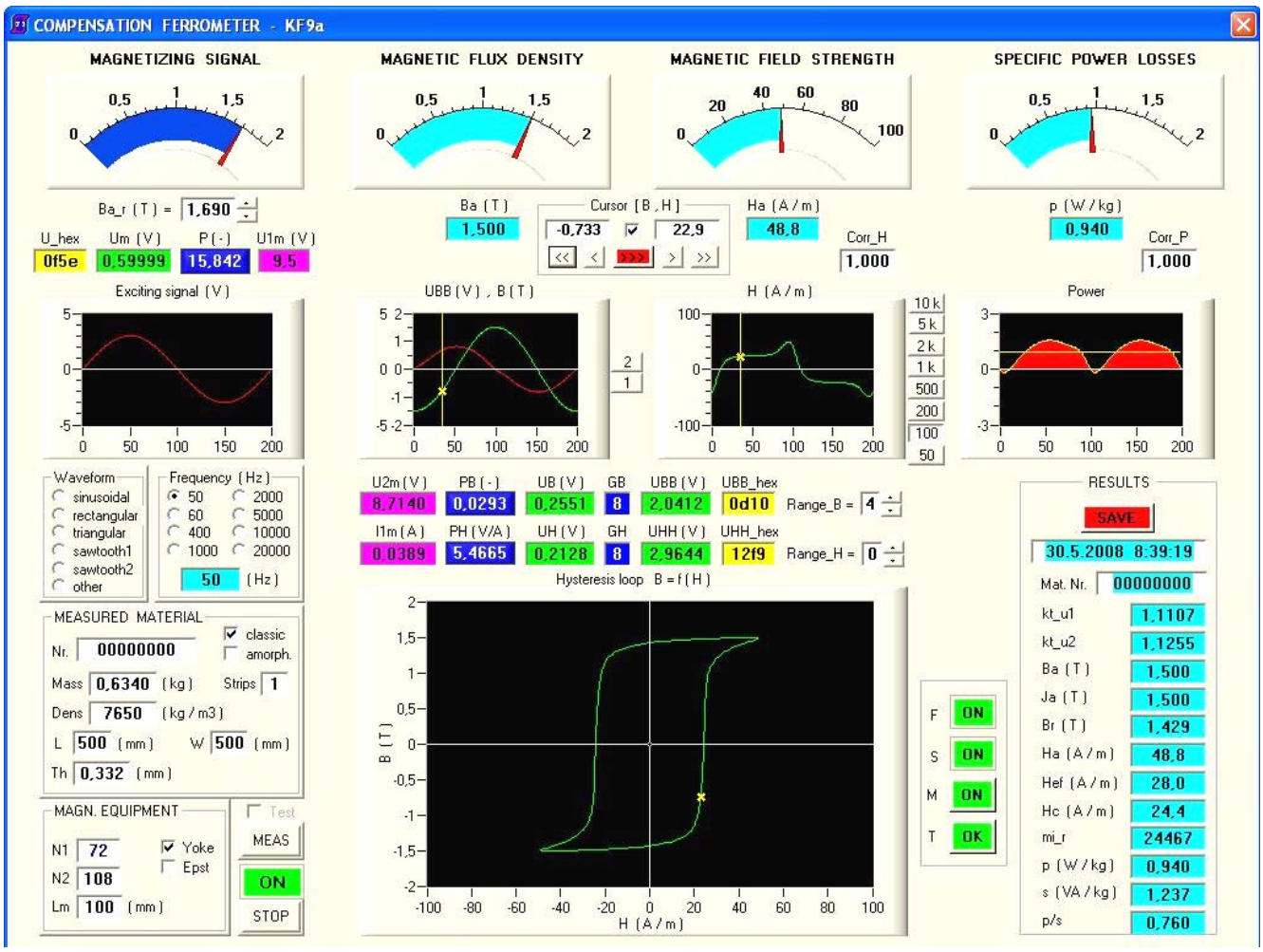

Fig. 10. Main control program dialogue window

7 CONCLUSION

New upgraded magnetizing and measuring system for compensation ferrometers was developed and verified in laboratory. Higher sampling rate gives possibility to increase testing (magnetizing) frequency up to 20 kHz. The upgraded magnetizing and measuring system of compensation ferrometers can be also used for modern amorphous magnetic materials testing.

Acknowledgement

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