UPGRADE OF THE MAGNETIC FIELD MEASURING MACHINE

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A computerized high precision measuring machine for automatic and fast magnetic field measurements has been in operation at PSI since 1973 [1]. The control system for the machine and the measurement process has been replaced with a modern system. New measurement programs have been written to accommodate changes in the hardware, magnetic field data acquisition and data processing.

MEASURING MACHINE DESCRIPTION

The measuring machine (Fig. 1) is basically a precise positioning device sliding on compressed air pads over a flat, precisely machined granite block. The position is determined through *Inductosyn®* - the position detection unit with the precision of one half of a micron. The machine measuring arm movement has five degrees of freedom; it can translate along the three Cartesian axes and it can rotate around two axes. For each movement, there is one stepping motor. The measuring arm supports the measuring probe, which is normally a Hall plate detector connected to a constant current source.

Fig. 1: Magnetic field measuring machine with the measuring arm that supports a Hall probe covered with a protective insulating cap.

The measurements are performed in flying mode, i.e. the machine does not stop to perform a measurement. Using the maximum moving speed of the machine along the longest axis (Z), with a span of 2100 mm, the longest drive takes less than one minute per line and is totally independent of the number of measured points. The measurement axis can be any one of the three linear Cartesian axes while the two rotational axes are used only for positioning. The measured field map will therefore correspond to a line, a plane or a volume in a Cartesian coordinate system.

NEW HARDWARE

The control system drives the machine movement and the measurement process and takes the data under real time conditions.

The Hewlett-Packard HP 1000 A-900 under the operating system RTE-A (Fig. 2) has been in operation since 1994 and has now been replaced with a CompactPCI PC (Intel Pentium III 700 MHz, 128 MB RAM, 2 GB HDD) from Inova Computers [2] running under Linux patched to real time functionality with FSMLabs' [3] RTLinux. The new computer (Fig. 3) controls the measurement equipment through the following three types of CompactPCI controllers:

- 1 ICP-MULTI, multifunction I/O card [2]
- 1 CPCI-1710, multifunction counter card [4]
- 2 OMS CIX, four axes motion controller [5]

The magnet current is set by CAMAC equipment (16bit ADC) connected through an RS232 interface.

Fig. 2: The old HP 1000 A-900 computer with two DATA PRECISION 7500 digital multimeters and the electronics for controlling measuring machine position.

NEW SOFTWARE

The measurements of the probe potentials are taken with HP/Agilent 3458A digital multimeters interfaced to the computer with a HP E2050 LAN/GPIB gateway. During the drive along the measurement axis in the flying mode, the computer triggers the multimeter at quasi-equidistant points and the corresponding Hall probe potentials are temporarily stored in the internal buffer of the multimeter. A maximum of 5000 data values can be stored in the buffer but the time between two measurements cannot be shorter than 2 msec. At the end of the line when the machine stops, the data is transferred to the disk and the multimeter buffer is emptied.

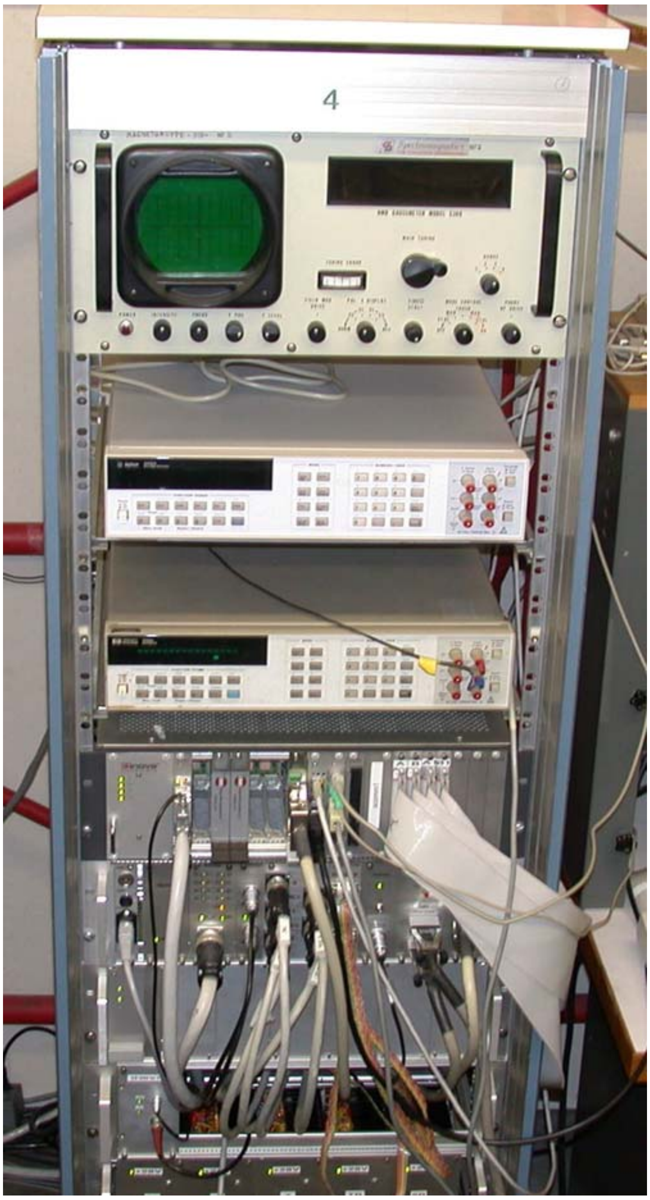

Fig. 3: New control system with an NMR Gaussmeter and two digital multimeters.

Normally, we measure the same line again in the reverse direction but the machine can also be moved on to the next line. Measuring in both directions takes twice as long but helps to cancel possible positional errors and any voltages induced in the Hall plate connections as they move through magnetic field gradients.

The program that controls the measurements is implemented as an RTLinux task, assuring the necessary real time constraints on data acquisition. The user interface is a non real time X-windows application (Fig. 4).

Fig. 4: Graphical interface of the new program for controlling the machine position, setting the magnet current and measuring magnetic fields in time or in space.

Post processing of the raw data is performed off-line, after the end of measurement. First of all, the potential data is converted into the magnetic field values using the corresponding polynomial least squares fit coefficients calculated from the Hall probe calibration. The next step is to extract fitted points onto the desired regular grid. Normally, it is not necessary to save all the measured field data and, by replacing a number of measured points with a single one, the measurement accuracy can be enhanced. The data interpolation method can be chosen among: linear interpolation between adjacent points, a cubic spline from first to last point or a quadratic fit using neighbouring points.

FUTURE PLANS

The time at which each point is measured is also saved along with the potential data. This is used for measuring time varying fields at a point but we also plan to use this information to filter out possible noise in the potential data with frequencies in multiples of 50 Hz. It will also be possible to measure the current through the magnet in parallel to the Hall probe potential measurement and use that as a check or even for further correction of the measurement data. Both of these data manipulations need further investigation.

We also plan to automate the rather tedious Hall probe calibration process by integrating the NMR Gaussmeter into the system.

REFERENCES

[1] B. Berkes, D. Brombach, O. Szavits, SIN internal report.

[2] http://www.inova-computers.ch

[3] http://www.fsmlabs.com

[4] http://www.addi-data.de

[5] http://www.omsmotion.com