A Multifunctional Magnetic Measurement Control System for NSRL Magnets

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Abstract

A new integrated multifunctional magnetic measurement control and data analysis system has been developed, which can be applied for dipole, multipole, undulator and other magnetic devices. The system was well running for measuring and shimming an undulator of more than 2 meters long which has been installed in HLS storage ring.

1. Introduction

A new version of magnetic measurement facility is necessary to meet the Project Phase II of NSRL. The NSRL possessed a discrete magnetic measurement system. In the system the FUNAC dedicated microcomputer acted as the position controller and two other computers were used for system manager and data acquisition. They are damaged now , but a 2-D mapping machine.

The new system is an intensive unit. An IPC(Industrial PC) is adopted as Central controller and system manager. All interface cards for control and data acquisition are installed on its passive backplane. As an economical consideration, a semi-closed loop is accepted as the positioning control system. Its positioning accuracy is good enough for most of magnets. But for some special objects, just like undulator, it can't fit their requirement on the positioning resolution. In the case of introducing a laser measurement device , a fine positioning resolution of 0.0001 mm has been obtained.

The efforts in software for improving positioning accuracy have been made. With the result that the measurement system is suitable for most kinds of magnets of the NSRL. The system has been used for detailed investigating and shimming an undulator of more than 2 meters long, which has been installed in the HLS. The result shows the measurement system of a high level of performance at an affordable price.

2. Utilization of IPC and PC-based control card

IPCs can be used for high level control, relying on PLCs for the tasks, such as physical-level control and measurement. IPCs have the reliability and flexibility to stand alongside PLC system and provide a variety of services such as data management ,worker-to machine interfacing ,monitoring and hardware/software supports. Serial interfaces or local area networks provide communication with mainframes or PLCs.

Compared with commercial PC, the IPC has been designed specifically for more reliable operation in hostile environments of electrical noise, electrical interference and power surge. IPCs chassis holds more slots on its PC-bus compatible passive backplane than commercial PC, in addition, spare arts for IPCs are usually standard PC spares,. It makes possible to form a more efficient, inexpensive and easy to upgrade.

Figure 1 is the block diagram of the magnetic measurement control and data management system.

As the figure shows, a PC-based 3-axis servo motor control card is the positioning controller joining with

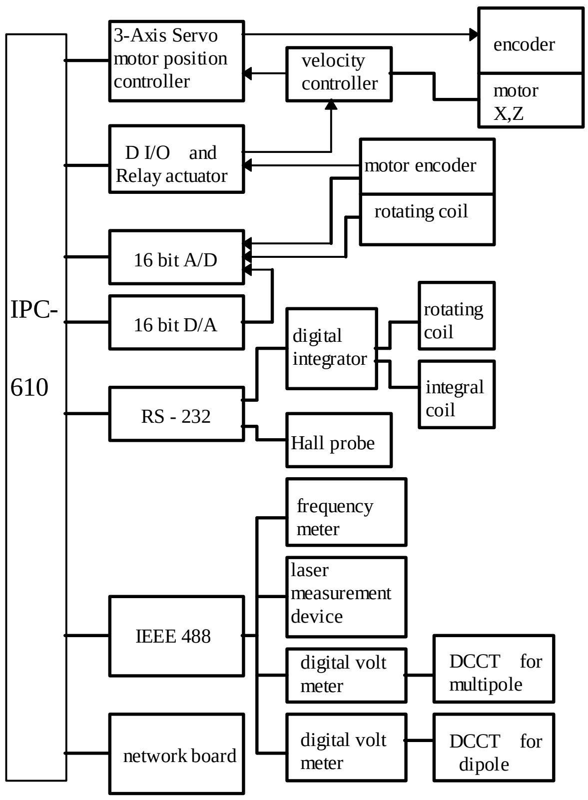

Fig. 1 Block diagram of magnetic measurement system.

the FUNAC velocity controller and the rotating encoder to form a semi-closed controller for the servo motors of the mapping machine.

IPC together with the PC-based 3-axis servo motor control card have given greatly improved flexibility.

Powerful high-level languages are readily available for control and measurement avoiding the costs of custom programming. The control system shows much more economical and efficient than the former FUNAC system.

3. The modularized software

The software of the measurement system has been developed into a modularized package which summarizes

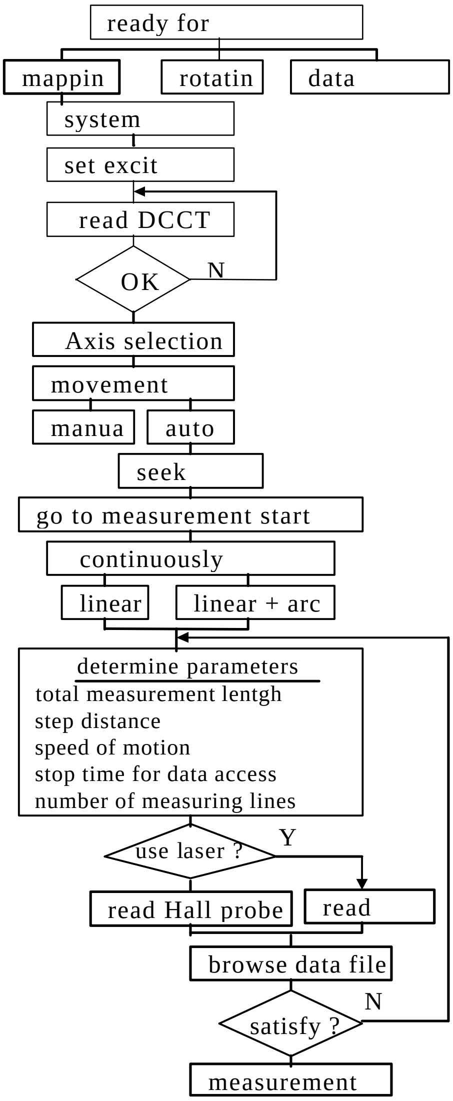

Fig. 2 sketch of the control program for mapping measurement

movement control of the detectors, data acquisition and data analysis together. The sketch of the control module for mapping measurement is shown in Fig.2.

4 Improvement of positioning accuracy by software

4.1 *Creation of the absolute origin point*

As the control mode is semi-closed, there is no absolute origin point on the machine. It is difficult to reduce the positioning repeatability error . The problem is to be

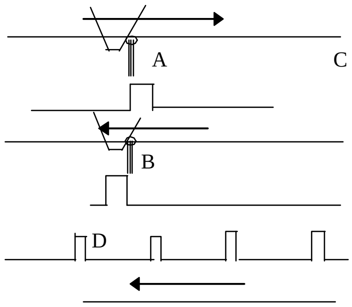

Fig. 3 The principle of setting absolute fiducial point

readily solved by establishing an absolute fiducial point by software. The principle is shown in figure 3.

First, fix a reference switch on the bed of the mapping machine and a knock block on the slide carriage to on/off the switch at A point both in x and z axis individually. When the slide moves along, the knock block knocks the switch, computer gets a signal and asks the slide to stop at C point, then asks it to return. After receiving the switch signal at B point, the computer waits the first index pulse comes from the encoder. No sooner had the computer got the signal than it stopped sending motion instruction to the machine immediately. Finally the slide is driven to stop at D point exactly. The D point is just the absolute fiducial point precisely. The principle hasn't theoretical error.

4.2 *Elimination of the backlash error*

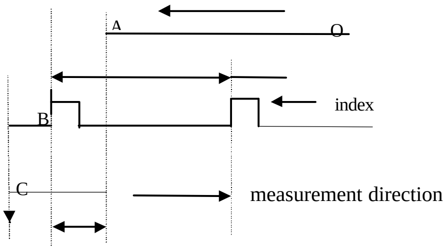

Fig. 4 Elimination of the backlash

The backlash between the shaft and nut or in shaft coupling ,as an irregular factor, brings an extra error to the positioning accuracy. A special program has been developed to eliminate the error. Figure 4 is the procedure.

5 Introduction of the laser measurement device

The mechanical characteristic of the mapping machine has determined the positioning accuracy within $\pm$0.01mm. It lacks enough high position resolution for the detailed investigation of the undulator whose non-homogeneity is as high as 2 Gauss/0.01mm, which would bring a big error to the first integral and the second integral of the magnetic field. The system's flexibility allows us to introduce a distance measurement device of high resolution to perform the special task conveniently. A laser

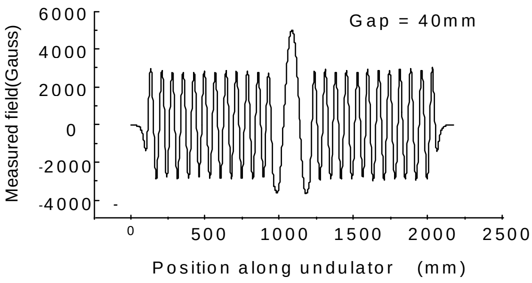

Fig. 5 Measured field of the undulator

dual-frequency interferometer of resolution of 0.0001mm has been added and well used for the undulator. The figure 5 is the measured magnetic field of the undulator.

After shimming, the performance of the undulator has been greatly corrected. The first integral has been reduced from ±282 Gauss×cm to ±100 Gauss×cm and the second integral has been changed from ±24383 Gauss×cm^2 to ±8000 Gauss×cm^2.

6 Conclusion

Application of IPC and upcoming modularized products based on IPC to the magnetic measurement control system has got an universal integrated facility. The system is for measuring field of dipole, multipole, undulator and other magnets. The characteristics of high reliability , open-ended design, convenience of operation, economy and efficiency aren't well matched by the system composed of dedicated micro computer or commercial computer.

Reference

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