

Control System for the 6T Superconducting Wiggler at NSRL

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Abstract

The control system for the 6T superconducting wiggler at Hefei National Synchrotron Radiation Laboratory is described. The system comprises a personal computer and a Industrial control PC. A multithread program running under Windows and a local embedded real-time application on the IPC are developed, to provide both the remote and local functions for controlling the superconducting wiggler and other related devices.

1 Introduction

The 6T superconducting wiggler provides the required value of the magnetic field on the beam orbit by using superconducting coils. It consists of a superconducting magnet, Nitrogen and Helium system, vacuum system, power supplies, and a measurement and protection system.

In normal operation, the wiggler system needs a group of power supplies, which consists of one main P.S., two auxiliary P.S., one heat P.S. and four compensation quadrupole P.S. [1]. These P.S. are cooperated and synchronized especially during ramping process[2]. Meanwhile the LHi and LN2 system should be monitored, the temperature and magnetic field should be measured on-line. The quench protection is incredibly important.

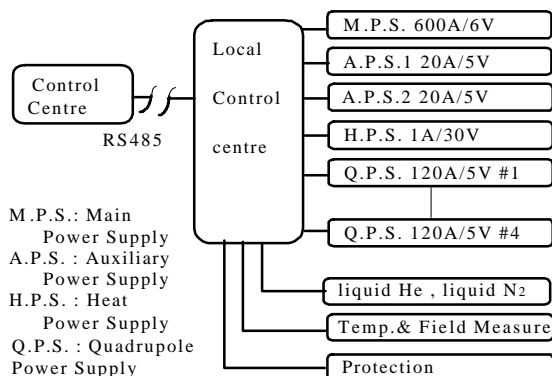


Fig. 1 The block diagram of control system

Consider the remote and local operation, the control system for the 6T superconducting wiggler is a centralized distribution system. It comprises two major parts: a remote control computer in the control room, and a local control IPC in the area near the wiggler. The communication path between the two parts is through a RS485 field bus.

A multithread program running in Windows and a local embedded real-time application on the IPC cooperate to

provide the remote and the local functions, which control and measure the superconducting wiggler and other related devices. The block diagram is presented in Fig 1.

2 Remote control

The remote control unit is an operator interface. It provides the following functions: Devices status display, P.S. ON and OFF control, current setting, current monitor, ramping control, liquid level monitor, field measurement, display and Alarm. Remote control unit gets the control through the local IPC.

2.1 Hardware

The computer for remote control is a PC, including a mouse and a RS485 card installed.

2.2 software

The remote program is a multithread program running under Windows. It has a friendly operator interface, and it is visual programmed, flexible, and easy to use.

The program includes four threads total. The main thread manages the whole program, accesses and manipulates the data files. Another thread is the Timing thread. It sends the request to read the concerned devices in fixed intervals. When the answers coming from the IPC reach the computer, the main thread will analyze them and show corresponding information on screen. Through the main thread, the operator can also send control instructions to the local IPC if necessary. The other two threads, the input thread and the output thread, do the fundamental work for transmitting information through the RS485 serial port.

2.3 Develop environment

There are two versions of remote control program. One is developed in LabWindows/CVI and another is in Delphi. They are both running on Windows platform.

2.4 Communication protocol

The communication protocol of the system accords with the NSRL communication protocol[3]. It is simplified, the length of the data package is non-fixed.

3 Local control

The local control unit is the kernel of the control system. It accepts the assignment from control center and

implements concrete operation. Major real-time functions of the local control unit are: Power Supplies Switch ON and Switch OFF, Current Setting and Checking, Devices Status Inspecting and Protecting, Temperature and Magnetic Field Measuring, and Synchronize the Operating of Power Supplies. These functions are thus useful not only for remote operation, but also for local operation and maintenance.

3.1 Hardware

Local control unit includes an IPC based on X86 processor and several function modules. The IPC has a good effect on electric and magnetic shielding, which is particularly suited to this environment.

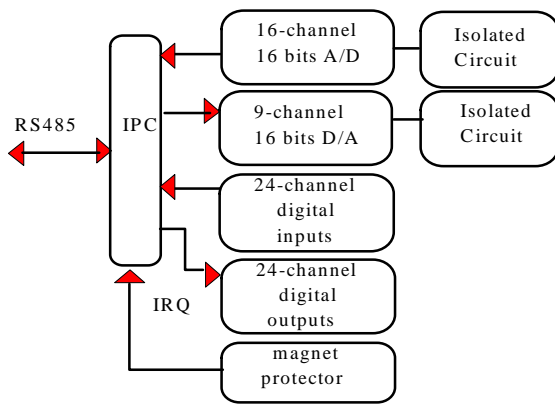


Fig. 3 Schematic of the Industrial PC

3.1.1 Isolated Circuit

To ensure the precision and safety of the devices from mutual interference, the isolated circuit should be used. We use high precision isolated circuit ISO100 and AD202. They are commercial products shown in Fig. 4 and Fig.5. Circuit 1 is for current setting . Circuit 2 is for monitoring and measuring.

3.1.2 16-Channel 16 Bits A/D

The targets of main power supply of the superconducting wiggler:

Current resolution 1×10^{-4} (100% FSR)

Current stability 1×10^{-4} (20% ~ 100% FSR)

It is evident the current measurement must have enough precision. We use 16 Bits A/D converter, its resolution is 1×10^{-5} .

The voltages come from Isolated Circuit are converted to 16 Bits data. These voltages are reference voltages of the current, they are acquired from the DCCT. The 16 Bits A/D converter is used for monitoring the currents of power supplies, measuring the temperatures and magnetic fields, checking the levels of the liquid Helium and liquid

Nitrogen.

Schematic diagram of the 16 Bits A/D convert is shown in Fig. 6.

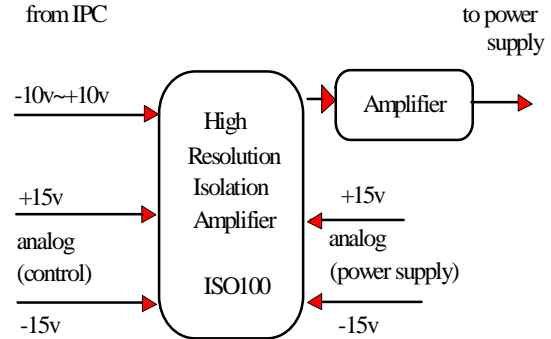


Fig. 4 Isolated Circuit 1

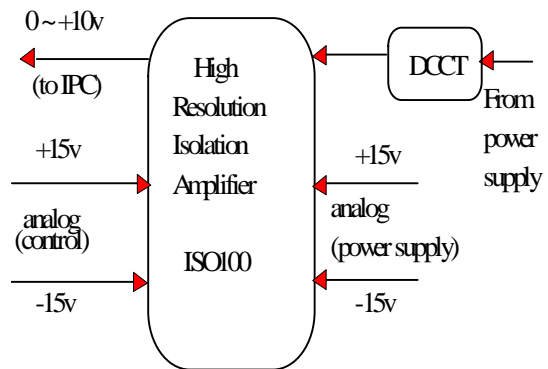


Fig. 5 Isolated Circuit 2

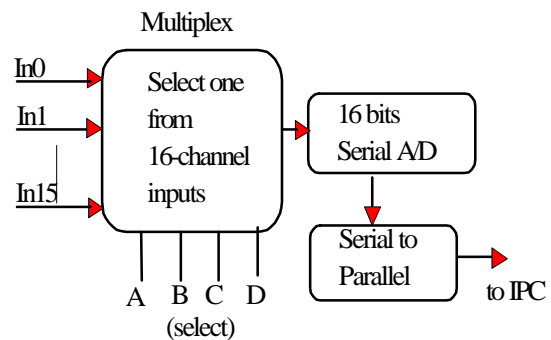


Fig. 6 16 Bits A/D converter

3.1.3 9-channel 16 Bits D/A

The D/A converter acts as an adjustable, high precision reference voltage source to set the current in power supplies. There are three D/A boards, each board contains 3 D/A channels. The DC power supplies for the D/A are isolated.

3.1.4 24-channel Digital Output Card

There is a relay for each channel, which is used for isolation and TTL to +15V adaptation.

3.1.5 24-channel Digital Input Card

We designed an adapter and comparator circuit for each channel to transform various signals into TTL level.

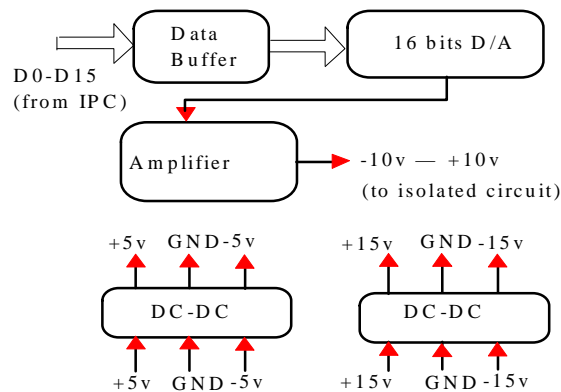


Fig. 7 9-Channel D/A converter

3.1.6 Protection system

The protection system is necessary for safe operation with the magnet system a wiggler. The main idea of the protection is to avoid a high voltage if a quench happens. It consists of a group of Diodes and a precision Voltage Detector Circuit. In the case of a quench, or other situation, the voltage on a coil exceeds normal, the Voltage Detector Circuit will generate an interrupt to the local control IPC to cut off the supply current immediately, so that, quench may be avoided and the power supply will be protected from the voltage damage. During the charging or discharging process, current is not allowed by the protection system[4].

3.2 Software

Local control software must control all devices in high speed and real-time, we designed the application in embedded environment, using Microsoft C/C++7.0.

- ◆ Main functions of the local application:
 - ◇ Turn on/off all power supplies simultaneously;
 - ◇ Programmed current value setting;
 - ◇ Read actual current value;
 - ◇ Check safety of power supplies;
 - ◇ Monitor the height of LHe. and LN2;
 - ◇ Magnetic temperature and field measurement;
 - ◇ Ramping control;
 - ◇ Protection;

- ◇ Communication with the control center.
- ◆ Fault tolerance:
 - ◇ Use watchdog to reset soft faults, use Flash Memory instead of using disk to ensure the reliability.
 - ◇ Add some protection code to avoid error of operation to protect the equipment.

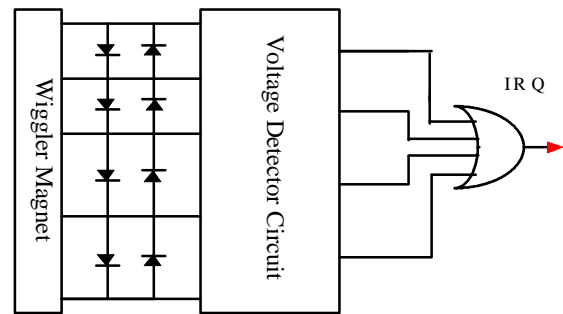


Fig. 8 Protection Circuit

4 Conclusion

The control system for the 6T Wiggler is already being used in the field. It controls devices correctly in high speed and real-time. The designed targets of the wiggler is reached and the magnetic field is measured. It is evident that the system is a successful control system.

In the phase II project of NSRL[5], this system will be modified to be brought into EPICS.

Acknowledgments

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