CONTROL SYSTEM OF THE SUPERCONDUCTING 63-POLE 2-TESLA WIGGLER FOR CANADIAN LIGHT SOURCE

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A control system of the superconducting 63-pole wiggler fabricated at the Institute of Nuclear Physics in Novosibirsk (BINP) for Synchrotron Radiation center in Canada (CLS) is described. Specific electronics and software, which provide continuous monitoring of all the superconducting wiggler parameters as well as full control and monitoring of power supplies and cryogenics machines, have been designed. The control system is VME-based. A client/server architecture of the software allowed us to integrate easily this system into the CLS distributed control system.

PACS: 07.05.Dz, 85.25.L

1. INTRODUCTION

The superconducting 63-pole wiggler with maximum magnetic field 2 Tesla (SCW) was designed and fabricated at BINP as a generator of synchrotron radiation for Hard X-ray micro-Analysis station in CLS. In January 2005 the SCW was installed on the CLS storage ring.

The SCW control system design was defined by the CLS control system architecture. The CLS control system architecture is based on a distributed control system. The heterogeneous collection of computers is interconnected predominately using Ethernet. Operator Interfaces (OPI) at the top tier provides a means for the operator to interact with the system. Linux-based workstations are used as the main operator consoles. MS-Windows 2000 workstations are used for a variety of semi-autonomous systems that are part of the control system. Input Output Controllers (IOC) hardware provides a mapping between device level hardware and the operator interface.

The SCW control system is a VME-based system with MVME172 single-board computer running VxWorks 5.3 operating system. This architecture (see Fig. 1) allowed one to carry out all necessary tests of the device before its installation on the ring and to integrate easily the control system to the CLS one.

2. THE SCW CONTROL SYSTEM MAIN FUNCTIONS

A superconducting wiggler is a multipole magnet inserted into a special liquid helium cryostat. The inner liquid helium vessel is surrounded by two shield screens with vacuum insulation between the helium vessel, the both screens and an external warm stainless steel vessel to reduce the heat flux. Two Leybold Coolpack 10MD coolers are used to cool the shield screens.

The magnet consists of 126 coils placed symmetrically relative to the median plane and surrounded by the ARMKO-iron yoke. The magnetic field on the wiggler axis is created by 122 central coils. Two power supplies are used to energize superconducting magnet (one for all coils and one for central ones). This design allows one to zero the first filed integral easily by current redistribution between the power supplies while the summarized current through the central coils (and so the magnetic field) remains constant.

Two additional coolers (Leybold 4.2GM One Watt System) are connected to the current leads (high temperature superconducting ceramic parts) to reduce the temperature.

Such magnet design defines main functions for the SCW control system:

- cryostat system monitoring;
- magnet system control;
- reliable interlock protection;
- remote equipment control and monitoring.

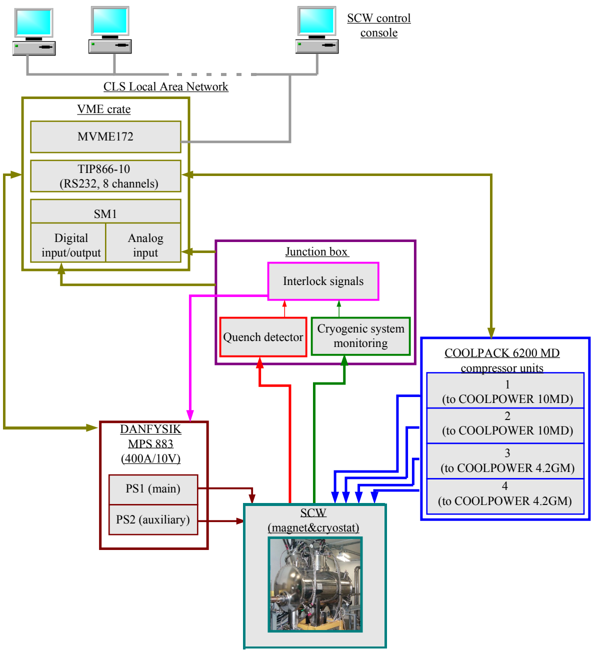

Fig.1. The SCW control system architecture

2.1 CRYOSTAT MONITORING

To provide reliable and safe wiggler operation continuous monitoring of an SCW system state is useful, namely:

- LHe level monitoring;
- GHe pressure monitoring;
- insulation vacuum monitoring;

- temperature monitoring;
- GHe flow monitoring.

2.2. INTERLOCK PROTECTION

To protect the SCW system interlock logic is integrated into PLC. The interlock events are:

- quench;
- high current leads temperature;
- low LHe level.

The superconducting coils are protected from damaging by shunts (0.1 Ohm) and cold diodes (Fig.2). A conventional bridge circuit is used to detect a voltage unbalance between lower and upper coils during a quench.

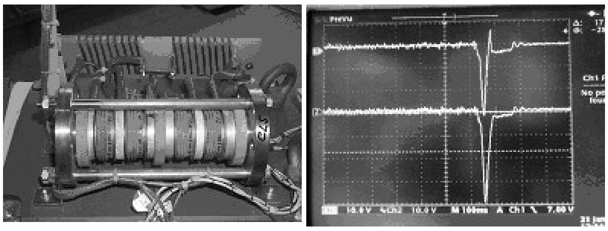

Fig.2. Cold diodes and quench oscillogram

To prevent the HTCS current leads from a quench an interlock signal occurs if the temperature on the even one current lead is higher than 78 K.

The temperature sensor (without a heat-conducting path) is used for registration the LHe level interlock. The temperature behavior of this sensor is shown in Fig.3.

2.3. REMOTE EQUIPMENT

The power supplies and cryocoolers are the part of the SCW system. RS232 interface is used to control these devices and to get status information.

3. SCW CONTROL SYSTEM HARDWARE IMPLEMENTATION

The control system hardware includes:

- instrumentation for system diagnostics;
- Junction Box (special electronics);
- VME boards;

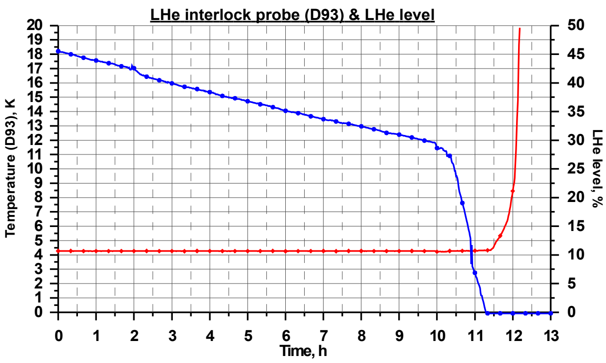

Fig.3. The temperature behavior of the diode sensor

3.1. JUNCTION BOX

Junction Box (JB) was intended for SCW signals gathering. As a matter of fact JB is a main element of the control system. The outline scheme of the JB is shown in Fig. 4.

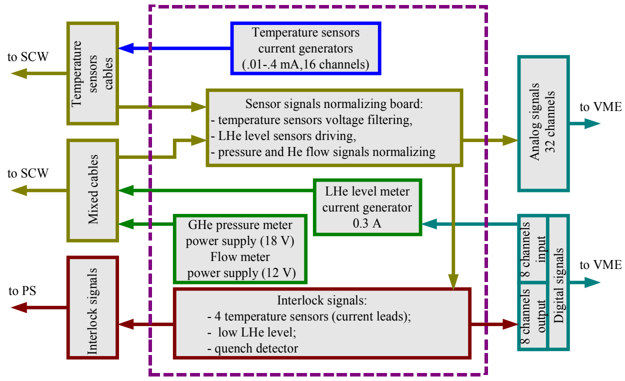

Fig.4. The outline scheme of the JB

Analog and digital output connectors for VME board are available on the JB front panel (see Fig.5). Two connectors for signal cables from cryostat as well as an interlock output connector are placed on the back panel. JB has an independent power supply to ensure reliable and safe operation of the device.

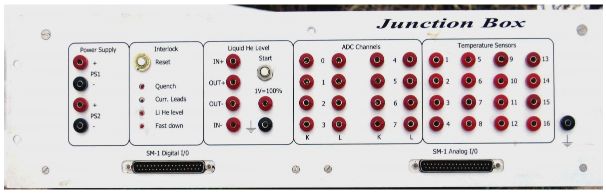

Fig.5. The Junction box front panel

3.2. SCW DIAGNOSTIC INSTRUMENTATION

16 temperature sensors placed in various points of the cryostat give full information about system state during routine operation as well as during system cooling down and warming up. In the system described, silicon diodes are used for temperature measurements.

LHe level sensor is a superconducting wire with length about 400 mm and diameter of 0.1 mm. The resistance depends on the LHe level.

The industrial pressure transmitter PAA-23S with absolute pressure range 2 Bars, 10 V output is used as a pressure sensor.

The industrial gas-flow meter F-112AC-HAD-33-V with gas-flow capacity 100 L/min, 5 V output is used as a He-gas flow meter.

SingleGauge^{TM} controller TPG 261 (measurement range $5\cdot10^{-11}\ldots55000$ mbar, RS232 interface, analog output 0…10 V) is used for insulation vacuum monitoring.

3.3. VME BOARDS

The following VME boards are used in the SCW control system:

- Motorolla MVME172 processor board;
- RS232 8 cannel interface to control power supplies and cryogenic machines;
- SM1 module includes 14 bits 32 channels ADC and Input/Output register. This VME board was designed in BINP.

4. SCW CONTROL SYSTEM SOFTWARE

Characteristic features of the SCW control system are the following:

- Distributed multilevel software hierarchy with classic client/server architecture;
- Software is divided into two parts: an embedded part (target) and a high-level (host) part;
- The target part of software operates on industrial equipment under VxWorks 5.3 operating system;
- The host high-level part is a client user interface application;
- The interaction between these two parts is realized via Ethernet.

The architecture of the SCW control system software is shown in Fig.6.

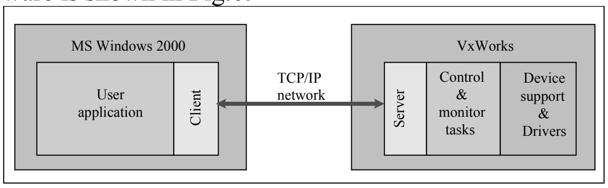

Fig.6. The SCW control system software architecture

Main functions of the SCW control system software:

- monitoring of all SCW parameters;
- remote equipment control and monitoring;
- alarm processing;
- convenient representation of all actual data.

The target part is the main one as it provides information processing from the hardware devices and realizes all of algorithms for the SCW control. The host software is a high level user interface program which allows users to obtain all SCW data and to control the machine. The example of the user interface screen is shown in Fig.7.

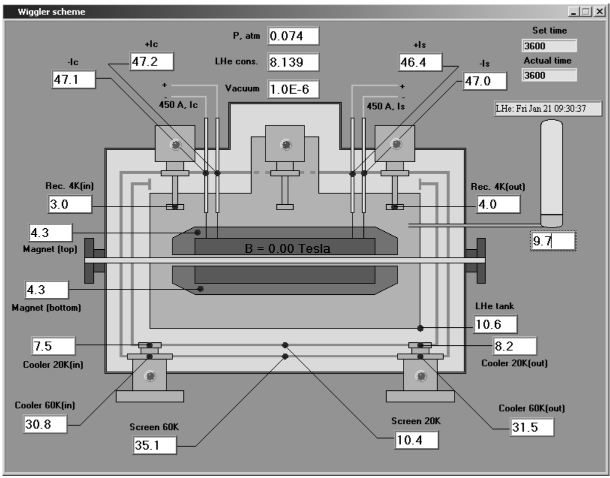

Fig.7. User interface screen

5. SUMMARY

The control system designed for the multipole superconducting wiggler supports the routine operation and provides reliable device protection. The VME-based architecture allows the SCW control system to be integrated into the CLS one.

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СИСТЕМА УПРАВЛЕНИЯ И МОНИТОРИНГА 63-ПОЛЮСНОГО 2-ТЕСЛА СВЕРХПРОВОДЯЩЕГО ВИГГЛЕРА ДЛЯ КАНАДСКОГО ЦЕНТРА СИНХРОТРОННОГО ИЗЛУЧЕНИЯ

Э.А. Купер, Н.А. Мезенцев, Е.Г. Мигинская, В.В. Репков, В.М. Цуканов

Описана система управления и мониторинга 63-полюсного сверхпроводящего вигглера, изготовленного в ИЯФ СО РАН для источника синхротронного излучения CLS. Были разработаны специальная электроника и программное обеспечение, обеспечивающие непрерывный мониторинг параметров сверхпроводящего вигглера и управление источниками питания и холодильными машинами. В системе управления использован конструктив VME. Архитектура программного обеспечения клиент/сервер позволила легко интегрировать данную систему в распределенную систему управления CLS.

СИСТЕМА КЕРУВАННЯ І МОНІТОРИНГУ 63-ПОЛЮСНОГО 2-ТЕСЛА НАДПРОВІДНОГО ВІГГЛЕРА ДЛЯ КАНАДСЬКОГО ЦЕНТРА СИНХРОТРОННОГО ВИПРОМІНЮВАННЯ

Е.А. Купер, Н.А. Мезенцев, Є.Г. Мігінська, В.В. Репков, В.М. Цуканов

Описано систему керування і моніторингу 63-полюсного надпровідного вігглера, виготовленого в ІЯФ СВ РАН для джерела синхротронного випромінювання CLS. Була розроблена спеціальна електроніка і програмне забезпечення, що забезпечують безперервний моніторинг параметрів надпровідного вігглера і керування джерелами живлення і холодильних машин. У системі керування використаний конструктив VME. Архітектура програмного забезпечення клієнт/сервер дозволила легко інтегрувати дану систему в розподілену систему керування CLS.