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Control and data acquisition systems for high field superconducting wigglers

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Abstract

This paper describes the control and DAQ system of superconducting wigglers with magnetic field range up to 10.3 T. The first version of the system controls a 7 T superconducting wiggler prepared for installation at Bessy-II (Germany). The second one controls a 10 T wiggler which is under testing now at the SPring-8 site (Japan). Both systems are based on VME apparatus. The set of specialized VME modules is elaborated to arrange wiggler power supply control, full time wiggler monitoring, and magnetic field high accuracy measurement and field stabilization. The software for the control of the wigglers is written in C language for VxWorks operation system for a Motorola-162 VME controller. The task initialization, stops and acquisition of the data can be done from the nearest personal computer (FTP host for VME), or from the remote system as well.

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1. Introduction

In order to control the superconducting wigglers (SCWs), two control and data acquisition systems are elaborated in Budker Institute in Novosibirsk. The first one is intended for a 7 T SCW and other one is intended for a 10 T SCW. Both systems are similar. The difference concerns the models of power supplies and interfacing to an existent control system of storage rings, where the SCWs are supposed to be installed.

Both systems solve the following tasks:

1. Technological monitoring (temperature, pressure, He level, power supply currents, on/off states) of SCW during commissioning and normal operation.
2. Power supplies digital and analog control.
3. Precise magnetic field measurement and stabilization with NMR method.

2. Control system hardware

As an example of SCW control system hardware, let us describe the structure of system for 7 T

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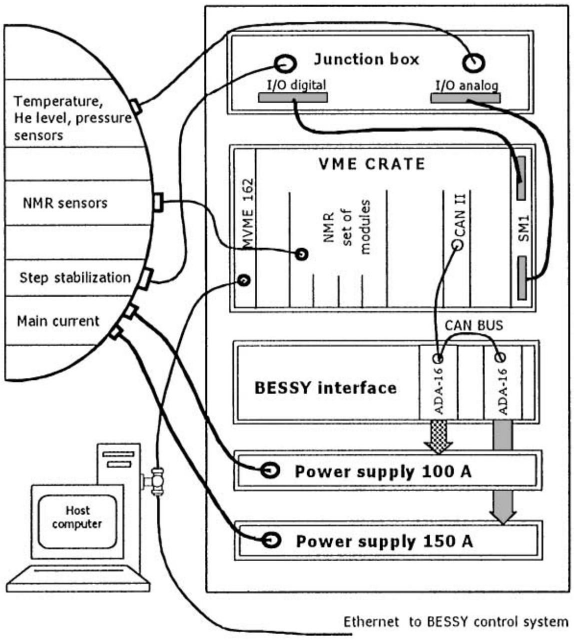

Fig. 1. The structural scheme of 7 T SCW control and DAQ system.

wiggler (see Fig. 1). It consists of five main parts.

1. Intelligent part including host computer (IBM PC Pentium Pro-200) and VME crate controller MVME162-532A (Motorola Inc.) connected to existent storage ring control systems with the help of ethernet link.
2. Technological part—set of wide temperature range sensors and specialized module SM-1 to arrange technological monitoring of SCW and digital control for the device of magnetic field step stabilization.
3. Junction box to connect cables from sensors to VME module SM-1. This box also contains the device of magnetic field step stabilization.
4. Power supply analog control and measurement part. This part consists of two ADA-16 modules placed in BESSY interface box. This box is connected with the VME crate through the CAN BUS interface. The modules ADA-16 set the output currents of power supplies and measure output currents.
5. Set of modules for NMR measurements.

3. Technological measurements

The goal of the technological measurements—monitoring of temperature at different points in the SCW, the liquid He level, He gas pressure, and power supplies current during SCW operation. The 16 diode temperature sensors, liquid He (LHe) levels and pressure sensors are installed inside SCW vessel. Thermosensors are joined in a few groups: magnet temperature sensors, helium tank, superconducting current lead sensors, cooling and recondensing machine sensors, and thermoradiation shield sensors.

In order to monitor the temperature of beam vacuum chamber during warming up, the last one is equipped with two L-type thermocouples. An additional thermoprobe is placed on the wiggler body. The temperature measurement accuracy for most of the sensors in the range of 4–350 K is about 1–2°. This is sufficient to supervise the cooling down, warming up and the day-by-day SCW monitoring. But more precise measurements with an absolute error of 0.1° are required to supervise the heads of the recondensers in the range of 3–10 K. This accuracy is necessary to detect any change in the performance of cooling machine and arrange preventive repair at proximate storage ring stop.

In consequence of the mentioned demand for accuracy, two types of thermosensors were chosen. The first one is the industrial wide temperature range transistor KT921 (in diode scheme). This type of transistor is very convenient due to metal, like-screw case, isolated terminals and low cost. The thermal coefficient of Vbe voltage changes from 0.5 mV/K at low temperature region up to 2 mV/K at normal temperatures. Previously, the calibrating table Vbe versus T was measured for each transistor. The monitoring program uses these data to convert measured voltage to temperature. Practice has shown that this allows an accuracy of about ± 1 K in a wide temperature range.

The second type of sensor is special silicon diodes DT470 (Lake Shore Cryotronics, Inc). These sensors were used for precise temperature measurements of the recondenser's elements.

Output voltage versus temperature for both types of sensors is shown in Fig. 2. As the LHe

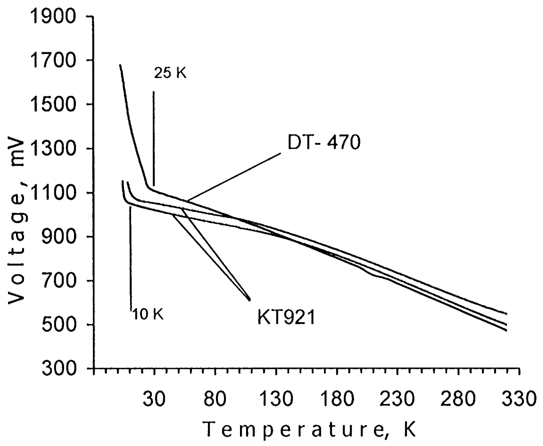

Fig. 2. Output voltage of thermosensors vs. temperature.

level sensor, a piece of straight superconducting wire with length of 400 mm and diameter of 0.1 mm is used. This string is installed vertically in the He vessel and it changes resistance depending on the liquid He level. This resistance can be measured by an ADC and is calculated for He level. At the upper flange of the cryostat is a pressure probe to measure the pressure inside the helium filled volume.

The outputs of the sensors, mentioned above, are connected to the specialized module SM1, which processes all the signals. This module is designed specially to arrange the SCW monitoring. It consists of one 32-channel analog multiplexer, one 14-bit ground isolated A/D converter, one 8-channel optically isolated output register, one 8-channel optically isolated input register, the LHe level meter, the He pressures meter, and 16 current sources (400 μA) to supply the temperature diode sensors.

The use of the SM-1 unit allows us to eliminate a few ordinary VME modules.

4. Power supplies control and NMR measurements

The power supply system includes two power supplies (PSs) and devices for magnetic field step stabilization. These PSs and stabilization devices require digital data to control the switch on/off operations of the superconducting keys and PS elements. The PSs also require analog signals to set output currents.

In order to perform digital control procedures, the 8-bit optically isolated output register, built in SM-1 unit is used. At the 10 T SCW analog, signals are issued by the 16-bit DACs. The resolution of the magnetic field setting in the region 9.5–10 T range is 2.3×10^{-4} T. During non-stabilized field mode, when persistent keys are unfreezing, the user can measure the PS output currents using the DCCT. Two modules of ADA-16, plugged into BESSY interface rack, are used for PSs analog control and measurement at the 7 T SCW.

In order to achieve magnetic field stabilization better than 10^{-4}, precise NMR measurement and step stabilization system are used. The complete set of NMR system consists of five VME units (synthesizer, controller, receiver, detector, decoupler) and two preamplifiers. An operating program takes the measured value of magnetic field, compares it with specified value and controls the step stabilization device through the output register of the SM-1 unit. In turn, the step stabilization device adds, if necessary, a small portion of current to the wiggler coils.

A detailed description of NMR measurement and stabilization system is given in Ref. [1].

5. Superconducting wiggler software

The superconducting wiggler software (SWS) is similar for both wigglers. It operates in the VxWorks 5.3 system environment, interacting with the IBM PC host. The software consists of host and target parts. The host part provides resources for target booting and remote file system. The target part of software provides all functionality of the control system. The host software is based on the Windows 95 operating system. An FTP server is used for disk sharing. It is started automatically when the Windows system is booted. The target software consists of a VxWorks 5.3 operating system, startup shell script file, wiggler control programs and data files.

Two parts of SWS have been written: Functional Library (FL) and User Interface (UI). The FL contains all subroutines for wiggler control under VxWorks operating system: slow measurements, magnetic field value control, magnetic fields stabilization, NMR measurements, etc. The operator of the storage ring can call any wiggler control command from the FL using remote terminal or the storage ring control software. The UI part contains some menus for controlling the wiggler from the nearest PC. Every menu item in the UI part call the corresponding subroutine in FL part. Usually, the UI part is used only at the commissioning stage of the wiggler operation.

6. Summary

At present a 7 T SCW including a control system is prepared for installation at the Bessy-II Storage Ring. A second 10.3 T SCW and its control system are under testing in SPring-8 site.

References

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