Computer Control of the SMC Polarized Target

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Abstract

The SMC polarized target is controlled through VME crates driven by CPUs working under the VxWorks operating system. The CPUs are connected to a SUN workstation which provides the user interface thanks to a graphical package named SL-GMS. This results in user friendlyness, high modularity and flexibility.

The system allows the control of: (1) the superconductive solenoid and the transverse dipole: control of the power supplies; automatic reversal of the spin direction by field rotation; acquisition, display and storage of the electric and cryogenic parameters; generation of alarms. (2) the dilution refrigerator: evaporator level control; acquisition, display and storage of ≈ 100 cryogenic parameters; generation of alarms.

1 Introduction

The SMC target [1] includes two cells, polarized in opposite direction, the direction of spins being reversed from time to time. The extraction of the asymmetry requires the assumption that the ratio of the acceptance for the two cells is a constant at the time scale of a polarization reversal. The fluctuation of this ratio then represent a major source of systematic error in the experiment.

In the original EMC experiment [2] the polarization was reversed once a week by repolarizing with microwaves. The situation was improved for the first run of SMC in 1992 [3] when we achieved three reversal of the spins per day by rotating the magnetic field. This rotation was performed thanks to the combination of a main 2.5 T solenoid and a transverse 0.2 T dipole. However this transverse field was a bit low and the procedure was partially manual, quite delicate and lead to a polarization loss of at least 2% at each reversal.

A new target was built for the 1993 run [4] with new magnets [5] including a 0.5 T transverse dipole. Also a modern control system was developed in Saclay with the technical support of DAPNIA/SIG engineers. It allows an automatic rotation procedure which is now performed five times per day with only ten minutes without data taking. For the 1994 run this system was extended to the dilution refrigerator control.

2 General description of the system

The control is done through a SUN workstation and two VME crates. One controls the magnet supplies and the other controls the dilution refrigerator. The control of the NMR system [6] is described elsewhere.

Each VME crates is driven by a CPU (Matrix MD-CPU334) which includes a Motorola 68030 processor running at 25 MHz, a floating point unit and 4 Mo of RAM. The interfaces with the instruments are made with 8/16 channels 12-bit DACs boards (ADAS ICV712), 12-bit ADC boards with multiplexers for 64 channels (ADAS ICV150) and a digital input/output board for 96 channels (ADAS ICV196). Most channels are optically isolated in a signal conditioner. Finally, several devices are read through GPIB by a VME GPIB controller (National Instrument 1014P).

The VME crates are then connected to a SUN Sparc10 workstation through a private Ethernet network. The SUN provides development capabilities and a graphical interface.

3 The graphical interface package: SL-GMS

The Sherrill-Lubinski Graphical Modeling System (SL-GMS) provides a very powerful graphical interface. The developer can design his own graphical objects without any coding thanks to a drawing software. One is not limited to a set of predefined graphical objects, since it is possible to draw with a mouse any kind of geometrical items and give them some dynamical properties. The appearance of the object will change depending on a (set of) real world parameter(s).

One can design passive objects to represent any real world variable. This can be for instance just a numerical display, some histograms versus time, some LED-like objects that change color with the status of some parameter(s), some analog-like meters, a valve that will appear open or closed. Interaction objects (buttons, sliders ...) can also be designed and connected to C-functions through a "callback" mechanism. This allows both graphical actions, like opening of a new window, and real world actions.

The C-code is organized in well identified modules which are automatically activated by the SL-GMS main loop. Basically, an "activate method" is used for initialization, an "update method" is activated periodically by a timer in order to read the probes and to refresh the control screens, a "deactivate method" is used when a screen is closed. The event handling (mouse, keyboard, windows) is done by SL-GMS which in turn calls the user defined callback function. This results in a very clear organization of the code which is moreover common to all SL-GMS programs.

4 The VME operating system: VxWorks

The VME CPUs use the real-time operating system VxWorks from Wind River System. the VxWorks package is resident in the SUN workstation and is loaded into the CPU at booting. Only a few booting parameters are permanently stored inside the CPU; The code is written in ANSI-C and compiled in the SUN by a cross compiler. The object files are then loaded into the CPU and the corresponding tasks can be activated. This system allows multitasking and definition of priority levels.

The software is organized in several layers. (1) the upper layer (application layer) where one can find the alarm generation task, the data logging tasks and specialized tasks like the rotation procedure (see next section). (2) The intermediate layer which provides the Application Programming Interface (API) to access the real world devices and parameters. This API offers transparent access to the equipments independently of the calling program location (local or remote VME, SUN workstation). This feature allows a great flexibility for the software: no change needs to be done if one program is moved from one system to another. (3) The lower layer which consists of the drivers used to access the VME interfaces and of a protocol (UDP on Ethernet) to achieve the communications between the intermediate layer and remote devices.

Our philosophy has been to design one task per controlled device, together with the drivers themselves and the storage and alarm generation tasks.

5 Magnet control

The solenoid supply is directly read and controlled by the CPU through a RS232 line. A high precision measurement of the current inside the solenoid is also available thanks to a current transducer (Danphysiks ULTRASTAB 860R), read though GPIB. The dipole and trim coils supplies are controlled by a DAC and read by an ADC. The ADC is also used to read magnet cryogenics parameters. A hardware magnet security system can force the supplies slowly to zero (slow trip) or even open the magnet contactors (fast trip). The status of this system is read through a logic/logic board.

An automatic rotation procedure has been developed which is started just by clicking one button: the solenoid is ramped down to 0.5 T; the dipole is ramped up to 0.5 T while the solenoid is ramped down to zero; the trim coils and the solenoid polarity is reversed; solenoid is ramped up to – 0.5 T while dipole ramped down to zero; solenoid is ramped up to baseline field and rotation procedure is paused for baseline taking [6]. Finally the solenoid is ramped up to – 2.5 T. The rotation is performed five times per day, it requires about 35 minutes, but data taking must only stop for 10 minutes while the dipole is on.

At the beginning of 1993 proton data taking, there was some loss of the negative polarization during rotation due to the so-called super-radiance effect. To get rid of it, we had to make the field inhomogeneous during the rotation by intentionally setting the trim coils polarity to opposite value. This meant reversing this polarity three times, in the beginning, at zero solenoid field and in the end. This modification in the standard procedure could be include and tested in a few hours, which demonstrates the flexibility of the system.

6 Dilution refrigerator control

The dilution refrigerator system includes about one hundred channels. There are 26 Pt100 platinum resistors for normal temperature reading (pumps, NMR system, . . .). They are read through a bridge to an ADC, the bridge is actually a VME board itself (VMIC 3413). A DAC is used to control the still and the mixing chamber heater together with some valves. All the other devices are read through GPIB: Two Schlumberger 7061 9-channel multimeters read cryogenic diode thermometers. Three AVS-46 bridges with 7-channel multiplexer read temperature resistors. A datlogger/plotter (Siemens MULTIREG C1732) provides 32 analogous inputs; they are used for pressure and level probes, for flow-meters and for an oxygen monitor located in the ^{4}He recovery line.

The graphical interface can be seen on fig. 1. It provides an histogramation of the most relevant parameters (top right), Some pull-down menus are available (top left). The "display" menu allows to open windows for the numerical display of all the parameters (The pre-cooler temperature window is open on bottom right). The evaporator level is controlled and the control parameters can be modified in the "evaplevel control" window (botton middle) which can be openned with the "control" menu.

There are alarm thresholds on all the parameters for minimum and maximum values and for maximum time variation. the "set alarms" menu provides the possibility to set threshold values and enable or disable alarm for each channel individually (see partially covered window on botton right). When an alarm occurs a horn starts and a window appears indicating which alarm occurred at what time.

7 Off-line capabilities

The parameters of the magnets and the dilution refrigerator are stored every minute in a file and a new file is started every week. This file can be read by another SL-GMS application. Up to ten channels can be plotted together versus time and one can also plot correlations between two channels.

8 Conclusion

We have developed a control system for the magnets and the dilution refrigerator of the SMC polarized target with a very user-friendly graphical interface. It has proven to be very efficient and reliable and at the same time quite flexible. There are now plans to extend this system to the control of the micro-waves as well.

References

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