SPARC CONTROL SYSTEM

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Abstract

We describe the control system for the new injector project in construction at the Laboratori Nazionali di Frascati INFN (SPARC). The injector starts the operation in the autumn of the 2007 and the control system must be full operative and integrate all tools to help the machine operation.

INTRODUCTION

To allow us a fast develops in the control system we made some choices:

- Labview as developing system due to its diffusion in the laboratory and because it is a standard de-facto in the acquisition software;
- GigaBit Ethernet as interconnection bus because it gives the sufficient bandwidth in the data exchange;
- PCs as front-end CPU and operator console because they have sufficient computing power.

The first operation of the control system during the gun test (December 2006) with the diagnostic apparatus called e-meter allowed us to test the architecture of the control system from the hardware and from the software point of view. We developed control applications for magnetic elements, vacuum equipments, RF cavity, and some diagnostics have been developed and debugged on line. We developed an automatic process to store the information periodically and on data change.

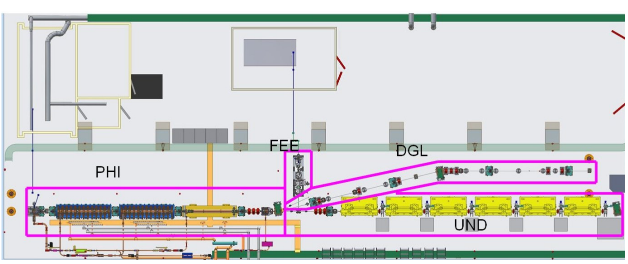

Figure 1: SPARC

SPARC

The SPARC (Sorgente Pulsata e Amplificata di Radiazione Coerente, Self-Amplified Pulsed Coherent Radiation Source) (fig.1) project is to promote an R&D activity oriented to the development of a high brightness photoinjector to drive SASE-FEL experiments at 500 nm and higher harmonics generation. Proposed by the research institutions ENEA, INFN, CNR with collaboration of Universita` di Roma Tor Vergata and INFM-ST, it has been funded in 2003 by the Italian Government with a 3 year time schedule. The machine is under installation at Laboratori Nazionali di Frascati (LNF-INFN) [1,2]. It is composed of an RF gun driven by a Ti:Sa laser to produce 10-ps flat top pulses on the photocathode, injecting into three SLAC accelerating type accelerating sections

The gun has been installed with a diagnostic apparatus called e-meter (fig. 2). This apparatus allowed us to characterize the first 2m of the electron beam. The main component, from the control system point of view, is the emittance measure apparatus composed by a pepper-pot and a YAG target. This part of the e-meter could be moved in any position along 2 m. At the end is available a spectrometer to measure the energy and a toroid to read the bunch charge.

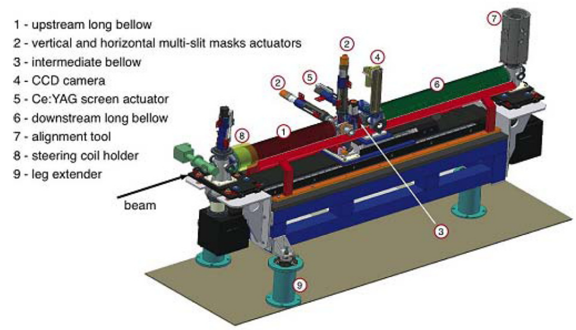

Figure 2: E-meter

SYSTEM DESCRIPTION

The main operation in an accelerator control system is data taking, display of information, analysis, command execution and expandability

Data come from devices distributed over an accelerator area. Developing the SPARC Control System we made two main choices. We decided to use commercial products as much as possible and to use a software environment that privilege easy development and maintenance.

The usage of commercial products helped us to find the best product in terms of performance.

Concerning the software, we decided to use LabVIEW[4].

The SPARC control system has a three levels architecture:

- Console level it is the human interface. Several copies of the software run at the same time on small personal computers;
- Service level is the second and central level of the system. It essentially contains a CPU that acts as a general concentrator and coordinator of messages throughout the system. It automatically logs the commands, the machine status and the errors. A second processor is used at this level with an SQL

database to store automatically the information from the front end processors;

- Front-end level is constituted by some industrial Personal Computers. Each PC performs control and readout of an element of the accelerator. The information can be read by the console on request.

Hardware

First of all we decided that each distributed CPU controls only a type of element. This simplifies the number and type of acquisition board assigned to the front-end processor. We decided to use the right processor in accord with the element to control. We have in our system real time processor, industrial pc and PXI bus.

At console level we need the maximum flexibility in terms of number of screens and possible remote connections. Also at this level, we plan to use PCs. Presently we use 5 consoles with 2 monitors each.

We have also a disk server for storing software and data of the whole system.

In a distributed system the interconnection bus between the different CPUs is important to maximize performance. We don't want to have any evident bottleneck in the data transfer. Furthermore the bus system has to be reliable and affordable. Today in any personal computer the Ethernet connection is a standard: this means that it can be easily used as a robust reliable channel of communication. We use the Gigabit Ethernet to obtain the necessary bandwidth in the data transfer between the different parts of the system.

The realization of a switched LAN gives the possibility to use the network also as a fieldbus infrastructure to reduce at maximum the physical interconnections between the devices and the acquisition system.

Software

In order to reduce the time of development of the SPARC control system, we decided to use well known software. Labview became the natural choice for the following reasons:

- in the Frascati laboratory the use of National Instrument software is very popular (we can say it is a "standard");
- Labview is used as development software in the DAFNE[3] control system. This choice allows us to re-use, when possible, already existing software;
- Labview is considered reference software by a lot of hardware manufacturers that write interface divers in Labview.

ELEMENTS

The e-meter used for testing the SPARC gun allowed us to develop and test the main components of front end and console software.

RF

The radiofrequency operation can be divided in two parts: the power apparatus modulator and amplifier and low power monitoring and synchronization signals.

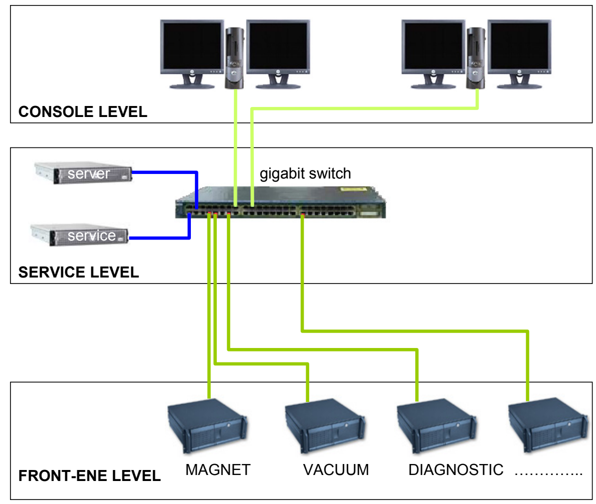

Figure 3: Control System Structure

The interface between the modulator and the control system is based on TCP/IP communication at 10Hz.

The signal monitoring and synchronization is designed using a demodulation board and digitizer cards in an industrial PC, where data analysis and device control are accomplished. The signal apparatus can be seen as a custom multi-channel digital scope, able to display in the control room all the demodulated signals coming from the RF structures placed along the whole machine.

With all this information we implement also a phase feedback that analyses the acquired values and controls a motorized phase shifter to compensate slow drifts.

Magnet

Magnet control means the control of their power supply. We decided to use as much as possible the same interface between the control and the power supply

The following specifications are required to the power supply factory:

- RS232 or RS245 interface;
- the well defined communication protocol Modbus as standard interface protocol to the power supplies.

Vacuum

The main components in the vacuum system are thermoionic pumps and vacuumeters.

The interface between the vacuum pumps and the control system is based on a fieldbus with anolog and digital channels. We found a solution based on Fieldpoint bus from National Instrument. This hardware has been easily integrated in our system.

The vacuumeter allows an accurate measure of the vacuum in some point of the machine. The interface used is a serial interface with a proprietary protocol. The software has been debugged and tested.

Diagnostic

The main machine parameter emittance, bunch length and energy in SPARC are measured with images. The use of a versatile camera system is strategic in the realization of this diagnostic. The rapid evolution in the image acquisition systems allows us to choose the camera and its own interface in a wide variety of products. The IEEE1394 interface gives us the possibility to interface different cameras with different specifications without change the acquisition program The saved images are used by offline analysis. The cameras are acquired by different distributed personal computers that send data trough a TCP/IP channel. We well defined the data transfer structure to full integrate the cameras inside the control system.

Another important component in the diagnostic is the control of motors to move flags and slits to allow the acquisition of the beam image. Also for the e-meter we had to move position slits and flags.

We have written some useful programs to acquire automatically the image to measure the emittance along the e-meter. That stressed the control system during this measure, taking 30 images for each slit position, 13 slit positions each z position, 30 z position for a total of 11700 images and about 450 motor movements for each emittance evolution measure.

SERVICE PROGRAMS

The SPARC collaboration involves different national and international research institutions. Some services are necessary to allow all people to have the information available on the status of the machine and the progress of the work. The old system based on a logbook where the operator writes the data and glues picture on it can be useful but cannot be available from remote researchers. We choose to develop an electronic logbook based on PostgresSQL [11]. These choices allow us to customize and integrate in the control system.

Status Log Machine

During the e-meter operation we started to study the possibility to have an automatic saving of important data: this mechanism could be useful in the maintenance of the machine and in the offline analysis.

We developed a data acquisition system based on a database with a possibility to communicate via TCP/IP. We choose the PostgreSQL database.

Each front-end processor runs programs that send periodically all data of the controlled elements. We have developed some different interfaces program that can correlate the information

The system has been used during the e-meter measurement and demonstrated it is a powerful instrument.

STATUS OF THE ART

During the test of the e-meter the control system software has been completely defined, implemented and tested. We also implemented and started the test of the machine status log.

The PostgresSQL database is now used also in the configuration data for the front-end CPUs.

We started the study how to guarantee the synchronization of different PC in the system.

ACKNOWLEDGEMENTS

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REFERENCES

[1] The SPARC project is financially supported by the EU Commission in the 6th FP, contract no. 011935 EUROFEL and contract no. RII3-CT-2003-506395 CARE.

[2] SPARC Project Team, Sparc Injector TDR http://www.lnf.infn.it/acceleratori/sparc/

[3] G. Di Pirro et al., "DANTE: Control System for DAFNE based on Macintosh and LabView", Nuclear Instrument and Methods in Physics Research A 352 (1994) 455-475.

[4] LabVIEW, National Instruments Corporation, 11500 N Mopac Expwy, Austin, TX 78759-3504 USA (http://www.ni.com).

[5] A. Cianchi et al., "Design Study of a Movable Emittance Meter Device for the SPARC Photoinjector", Proceedings of EPAC2004, 5-7 July, 2004 Lucerne, Switzerland.

[6] Alessandro Cianchi et al., "Advanced Measurements at the SPARC Photoinjector", DIPAC 2007 Venice, Italy, 20-23 May 2007.