REMOTE DATA ACQUISITION FOR SPS 352 MHz SUPERCONDUCTING CAVITIES

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Abstract

The SPS Machine is equipped with four SuperConducting Cavities (SC). These are used to accelerate the beams during the electron and positron cycles of LEP. During the last two years the control system for these cavities has been upgraded to the LEP standard environment but, as the diagnostic capabilities were not sufficient to ensure their reliable operation, it was decided to build a Data Acquisition system based on commercial products. The present system is based on National Instrument PXI (an extension to CompactPCI for instrumentation) with 166 MHz Pentium running Windows NT and Labview5.1. In order to meet the user requirements, in terms of portability and speed, a client/server approach has been used. The Server can acquire 16 signals at a rate of 1 ms during the whole SPS supercycle.

The Client is composed of a virtual oscilloscope interface (one or four channels) with on-line signal and timing selections and automatic data and user setting storage capabilities. The Client can run on the two platforms used at CERN (PC and HP/UX).

1 INTRODUCTION

The SPS (Super Synchrotron Accelerator) is one of the key elements as injector for the LEP (Large Electron Positron Accelerator) and for a large variety of fixed target experiments. In order to accelerate different kinds of particles (electrons, positrons and protons) the SPS is equipped with dedicated RF systems.

Since the beginning of LEP the SPS has been equipped with a set of four SC Cavities running at the nominal LEP frequency (352 MHz). The hardware used for the control system of these cavities was recently upgraded in order to improve reliability, maintenance and to take advantage of new technologies.

The 352 MHz SuperConducting RF system, from the controls point of view, is similar to the LEP RF system. Therefore it was decided to use the same type of hardware implementation (one VMEbus Controller for each Cavity). The upgrade has been successfully carried out.

The SPS Supra RF system is pulsed only during the LEP cycles, to accelerate leptons, and during other cycles a strong feedback is applied to the Cavity Drive Amplifiers in order to reduce the impedance seen by the beam. It appears clearly that more sophisticated and flexible diagnostic tools are necessary. The new Control System gave us the possibility of adding such tools.

2 REQUIREMENTS

2.1 Specifications

In normal operation we need to store 15 parameters from the four cavities for each of the three LEP cycles and display them at the end of the supercycle. This will allow the operator to detect possible problems during the LEP filling phase.

We also need to acquire some important cavity parameters during the whole supercycle with a 1mSec sampling time and some global parameter like the Total RF Voltage seen by the beam.

A total of 16 signals have to be connected to the system and sent to a user interface at the end of the supercycle. A trigger signal will be delivered by the Timing System.

2.2 Basic Ideas

We decided to implement two acquisition systems:

- TUN_DATA will take a snapshot of the relevant cavity parameters just after the beam extraction to LEP for every lepton cycle (test, electrons and positrons).
- CAVITY_DATA will acquire drive power, cavity tuning Reference and cavity power for the whole SPS cycle, a total of 13500 points per channel per cavity with 12 bits' resolution.

3 SYSTEM COMPONENTS

3.1 Global Definitions

The new cavity controllers are connected directly to Ethernet and can be queried with our propriety communication protocol called SLEquip.

The general Timing system has been programmed to provide two extra pusles.

One to trigger the TUNE_DATA acquisition occurring 20 ms after ejection from SPS to LEP on each of the three lepton cycles and another to start the SPS_ DATA server occurring 275 ms before the beginning of the SPS Supercycle.

The values for TUN_DATA are stored in a double buffer in the Cavity Controller memory and can be sent to the User Interface on request.

A separate Data Acquisition Server has been installed using CompactPCI [1] based hardware and Labview5.1 [2] software.

3.2 The TUN_DATA System

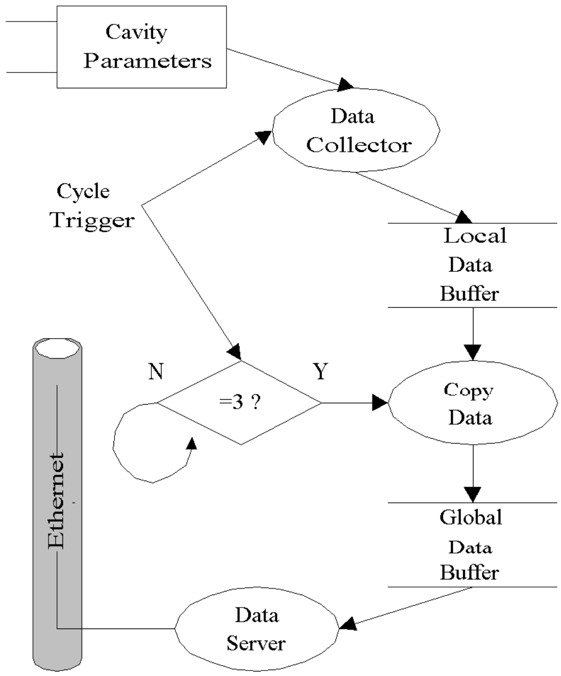

Figure 1: TUN_DATA block diagram

A cycle trigger triggers the cavity controllers on every lepton cycle. Upon trigger an interrupt is generated for the Data Collector process that will stores the cavity parameter in a local buffer. After the third trigger the Local Buffer is copied to a Global Buffer and it is ready to be sent to the client interface on request.

The client interface has been developed using Labview, the graphical programming environment from National Instruments.

The data from the four cavities are retrieved with one call to each cavity controller and presented in a table format. Using a double buffer the data are consistent within an SPS Supercycle.

Multiple clients can simultaneously run the TUN_DATA display either on PCs or on HP workstations and obtain the data related to the last SPS Supercycle.

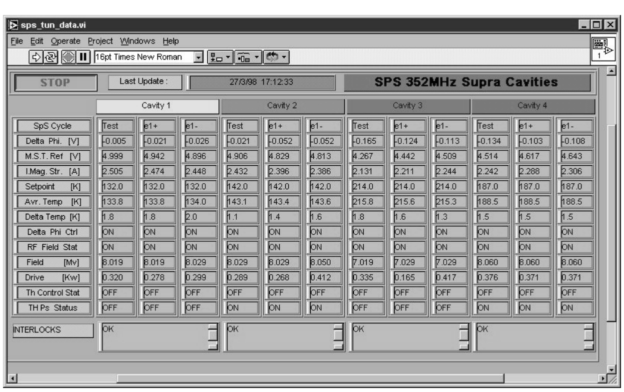

Figure 2: TUN_DATA Display

3.3 The CAVITY_DATA System

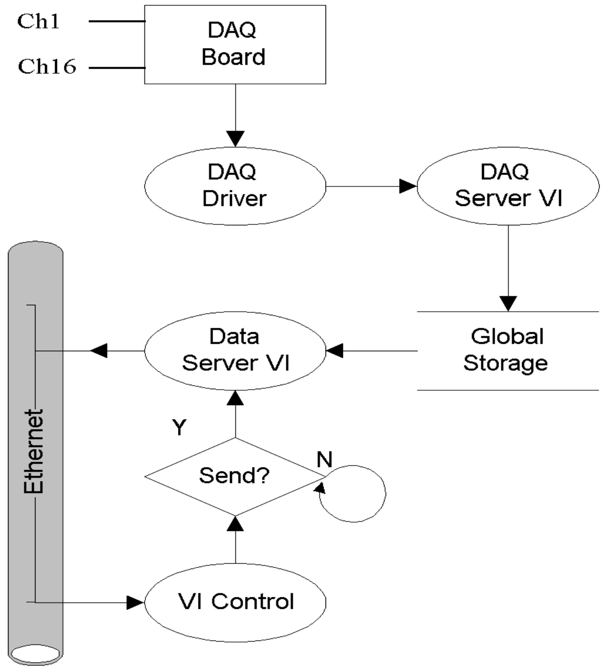

Figure 3: CAVITY_DATA block diagram

The CompactPCI bus standard has been extended for instrumentation and control, under the name PXI [3] (CompactPCI Extension for Instrumentation), by National Instrument. The PXI combines high-speed processor and a wide range of Data Acquisition boards at a competitive price.

For this application we used a Pentium 166MHz processor board running Windows NT and a 12-bit, 16-channel, 250Ks/Sec Acquisition board. The software is based on Labview 5.1.

The software structure is organized in four VIs (Virtual Instruments).

A "DAQ Driver VI" is used to configure the acquisition board in terms of speed, number of points, trigger option and memory exchange with the main processor.

This VI is then connected to a "DAQ Server VI" that holds all the settings executes the acquisition process and stores the raw data in a Global Storage area. These two VIs are the building blocks of one of the three processes running on the PXI controller.

The raw data stored have to be formatted for the client interface. This is the task of the "DATA server VI".

The formatted data are sent to the client interface on request through the "VI Control" interface.

A very powerful feature of Labview, the "Call VI Reference", provides an easy way to build a client/server application by passing the reference of the I/O connections of a VI between computer connected with Ethernet using TCP/IP protocol.

By this means the reference to the “DATA Server VI” is passed to the client interface.

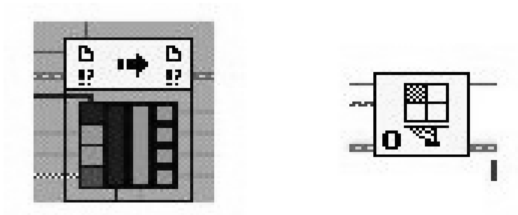

Figure 4: Call by Reference VI and node

An internal interrupt mechanism called “DAQ Occurrence” allows a multi-thread operation inside Labview so the processes “DAQ Server”, “DATA Server” and “VI Control” can run in a time-sharing manner. The client interface has one or four waveform displays. By means of pull-down menus the operator can select any of the 16 channels for the whole SPS supercycle or for an individual cycle. Other features like hardcopy picture (postscript) or data saving (Excel format) and automatic data saving have been implemented.

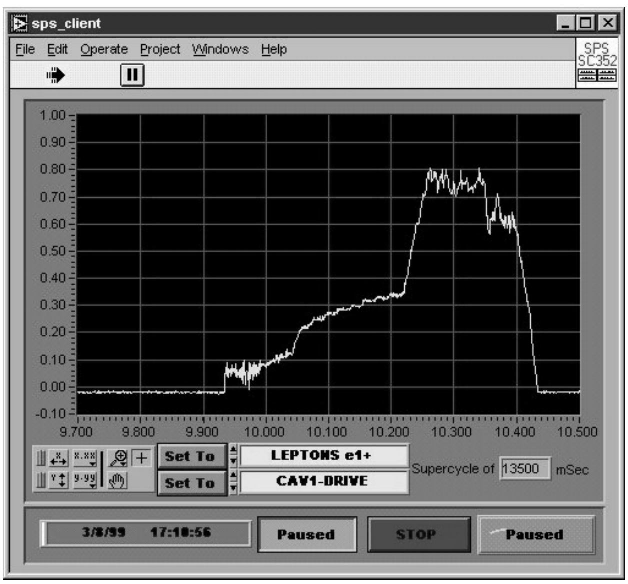

Figure 5: CAVITY_DATA One Channel Display

4 RESULTS

The tools described above are now operational and used in daily SPS operation.

Up to ten clients have been running simultaneously without any effect on the PXI CPU performance. (25% was the maximum CPU usage recorded by the Windows NT Task Manager.)

The CAVITY_DATA System was also very useful during special machine development and start-up phases.

The automatic-save feature was extremely useful as a long-term diagnostic tool during operation.

5 FUTURE APPLICATIONS

The PXI standard is very promising for future small data acquisition and control systems. The “Data Server” was developed in a modular and general-purpose way that can be easily reconfigured for other applications.

We have installed a copy of the SPS CAVITY_DATA system in LEP as a portable Data Acquisition System to monitor the Cavity Field variation during operation.

Only the Client display was changed for this new application.

6 REFERENCES

[1] The CompactPCI Short Form Specification (Revision 2.1) from http://www.picmg.org/
[2] http://www.natinst.com/labview/
[3] Specification PCI eXtensions for Instrumentation An Implementation of Revision 1.0 August 20, 1997 Copyright © Copyright 1997 National
[4] http://www.natinst.com/pxi