DAΦNE CONTROL SYSTEM STATUS AND PERFORMANCE

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Abstract

The DAΦNE Control System allowed the step by step commissioning of the major subsystems as they were installed, proving to be modular and extensible. Recently the guidelines of the Control System evolution concerned the development of machine operational procedures and the integration of diagnostic tools. Particular attention has been reserved to the problem of saving and restoring element data sets as well as to the DAΦNE general data handling. A system overview including installation status, features, and operation results is presented.

1 INTRODUCTION

The Main Rings of DAΦNE [1], the e^+e^- Frascati Φ-factory, are under commissioning since September 1997 when the mechanical installation was completed. At the present all the efforts are aimed at pushing up the performance of the accelerator complex as a whole since it is expected to provide a luminosity:

$$L = 1.3\ 10^{32}\ cm^{-2}\ sec^{-1}$$

the highest ever reached at the working energy E = 510 MeV.

The Control System [2] for DAΦNE is completely and uniformly based on personal computers.

The choice of commercial software such us LabVIEW ® [3] at all levels and the development of specific hardware, based on Macintosh ™ boards in a VME environment, succeeded in the development of a Control System suitable for machine operation. The Graphical User Interface provides friendly interaction with single machine elements and complex accelerator oriented procedures. The machine devices are driven by many distributed CPUs. A shared memory instead of a network permits fast, straightforward and high bandwidth communications.

The DAΦNE Control System architecture is well established. Important subsystems such as RF and timing, but also many basic diagnostic tools have been integrated in the Control System and run routinely. All the 462 independent power supplies of the DAΦNE magnets can be remotely operated through the Control System user interface.

A summary view of the control system installation status is reported in Figure 1.

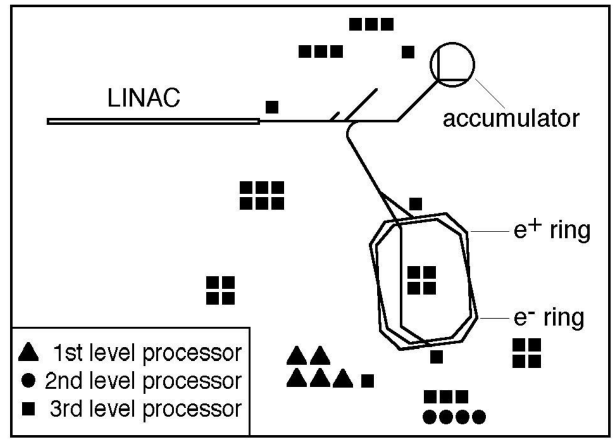

Figure 1: Distribution of processors over the accelerator area. The 3-rd level processors (squares) are located close to the related elements in order to minimize the wiring of local connections. The 2-nd level processors (circles) are located in the central cluster of VME crates where all the commands and messages flow. The1-st level processors (triangles) are located in the control room.

2 OPERATIONAL PROCEDURES

Looking for the best DAΦNE working point, operations such as beam injection, betatron tuning, closed orbit correction and machine setups saving are quite usual. These operations have to be performed in automatic mode otherwise they become heavily time consuming and can compromise the commissioning.

2.1 e^+e^- Switch Procedure

In DAΦNE e^-e^+ beams are accelerated in different Main Rings sharing only the two Interaction regions. However they are supplied by the same injection system that consists of a LINAC, a booster ring, the Accumulator [4] and a complex Transfer Line. Although some Transfer Line sections are specific for a given beam, the largest part is shared by e^+ and e^-, which somewhere run both ways. A timing system [5] synchronizes the pulsed magnets in the Transfer Lines and the kickers in Accumulator and Main Rings providing the right path to each kind of particle.

Due to the DAΦNE characteristic beam life time τ = 2 h the Injection System is expected to switch often and quickly between e^+ and e^- operation mode. This requirement is even tighter during the commissioning when frequent beam losses occur.

For these reasons an automatic switch procedure has been implemented. It is based on the Command Recorder which is a general Control System tool able to record and play back a command sequence learning from the operator action. Using the Command Recorder and loading proper command files the operator can change, with a single action, polarity, setpoint and delay time for all the elements in the Injection System and after a couple of minutes the required beam is available on the proper injection septum.

2.2 Magnet Synchronization

During machine operations it is important to move synchronously the setpoint of a certain number of magnetic elements.

It allows, for instance, to tune the machine optics, to correct the stored beam orbit and to realize local bumps at the interaction regions.

An user interface program allows to load a precompiled file containing the names of the involved elements with their setpoints. The file can be loaded as absolute settings or relative variations as well and the target values can be further modified from the control window. The user enters the number of steps to be used to reach the final working point and then operates two “Forward” and “Reverse” arrow buttons. Each time either button is pressed, the application issues the corresponding bunch of commands with the calculated delta sets for the current steps and monitors the actual readbacks.

In the present version the synchronization is determined by the system software latency time and by the serial communication protocol with the magnet power supplies. The former is much shorter with respect to the second one, which is of the order of tens of ms. In addition to the starting time uncertainty, no simultaneity of current ramps is guaranteed by any means.

In order to get a tighter synchronization the commands PSET and SSLP have been introduced. They preset the desired setpoint and slewrate on a power supply, at this point a TTL pulse, sent to all the power supplies, triggers the start of the current ramp. This “hardware synchronization” has been successfully tested and will be soon operative.

2.3 Save & Restore

The capability to store and recover from disk data corresponding to a certain machine working condition is a primary service that any control system must provide.

During the first commissioning phase it has been decided to adopt a save and restore mechanism based on the concept of operating areas.

The DAΦNE complex has been fragmented into many subsets such as: Accumulator Injection, Accumulator, Accumulator Extraction, and so on.

Each area is in turn structured by element classes which leads to a highly modular file structure.

Dealing with more general framework, the save and restore services have been redesigned including much larger areas that can be stored both as single datasets or as belonging to a general machine configuration. Custom dataset files of elements belonging to different classes and machine areas are still possible.

This new structure is under test and is going to replace the previous ones.

3 DATA HANDLING TOOL

Data in the Control System consist of a large amount of information written into the VME memory in a wide range of different formats. Usually data are fetched by specialized control windows, but the correlation of data all over the accelerator is more complicated.

A process has been developed fetching all the different front-end devices and aligning all the information in a universal format Data Base. This allows to have an on-line uniform memory refreshed with a settling time. The process also dumps data of interest on storage disk for off line and long term analysis.

Based on this on-line data base many diagnostic tools have been implemented such as the "Hunter Dog" task that allows to check the status of all the machine elements, alerting the operator of any possible failure.

4 DIAGNOSTICS

The beam position measurements are fully integrated in the Control System. At the present two different systems are running. One of them is mainly for Trajectory measurements and is used to monitor the beam along the Transfer Line, the first turn in the Main Rings and the first turn and the orbit in the Accumulator. The other one has been designed to measure the stationary closed orbit in the Main Rings and works with stored beam only.

Another primary diagnostic is the Luminosity monitor since it provides an ultimate check of the whole complex tune-up.

4.1 Beam Orbit Measurements

The Trajectory measurement relies on a hardware setup including an RF multiplexer system used to select the four channels of each Beam Position Monitor (BPM), mainly strip line, as inputs for a digital scope TDS 644/A by Tektronix, used to read the voltage signals. A user interface window allows to load the BPMs in the machine section of interest, to configure the digital scope at run time as well as from a file and to acquire the trajectory in one shot or reading a BPM selected by the operator, that is much more useful during the Transfer Line optimization. The beam trajectory is displayed on the interface window in both planes together with the sum over all the pickup signals for each BPM. This number is proportional to the beam current and provides an immediate feeling of the transmission efficiency.

4.2 Beam Position Measurements

The closed orbit measurement in the Main Rings [6] is based on four parallel processors each of them dealing with one fourth of the involved BPMs. The BPM outputs are converted in a couple of DC signals proportional to the horizontal and vertical beam position by Bergoz BPM modules [7]. Then they are acquired using a digital voltmeter and after a linearization process stored as beam positions, at the rate of 5/sec, on a 1 Mbyte circular VME memory available on each processor. Since each beam orbit is spread among four different buffers, all the acquisitions are labeled by a header specifying the date and time and an acquisition progressive number.

The accuracy of the whole orbit acquisition system has been measured. At low current the rms beam position error is inversely proportional to the beam current, then it approaches asymptotically about 0.02 mm above a threshold current $I \approx 3$ mA.

The beam closed orbit is displayed on the Control System user interface by a dedicated window. The operator can decide to visualize only the last orbit or to display up to ten sequential orbit at the same time. A reference orbit can be subtracted from the one presented on the screen. The reference can be chosen among previously saved orbit files or orbits captured at run time in the interface window, which provides a buffer where up to ten reference orbits can be held. Moreover, the operator can decide to stop the orbit monitoring and to look back to past orbits stored in the processor memory buffers.

This diagnostic tool has been particularly useful in the first stage of the DAΦNE commissioning since it pointed-out slow drifts and glitch problems in some magnets.

4.3 Luminosity Monitor

An essential diagnostic tool is the luminosity monitor [8].

The detector consists of a sampling lead-scintillating fiber calorimeter, equipped with a photomultiplier read-out measuring the high counting rate of the single bremsstrahlung (SB) events at the interaction point. The calibration procedure, based on gas bremsstrahlung (GB) analysis, allows to measure the energy cut-off and the resolution. The calibration chain, based on charge ADC CAEN V265 in VME, allows a fast on-line GB spectra analysis up to 1KHz.

Several calibration and measurement procedures have been developed and integrated in the control system.

The counting chain in the luminosity measurement set-up is based on a VME scaler STRUCK str7200 counting the rate of GB noise and the SB signal at the two interaction points in many different configurations.

5 MEASURED RESPONSE MATRIX

Data from beam closed orbit have been used to build an user interface process allowing to measure the machine Response Matrix in a short time, three minutes. The Response Matrix is made up by columns where the orbit variation corresponding to a given perturbation is stored. Perturbations are provided by varying the strength of correction magnets, quadrupoles and sextupoles.

The measured Response Matrix is extensively used for machine modelling and beam closed orbit correction.

6 CONCLUSIONS

The DAΦNE Control System is running for three years. Its general structure has been tested in the overloading commissioning environment and it proved to be suitable and reliable. Many important diagnostic tools and operational procedures have been provided and have been useful both in commissioning DAΦNE and in pointing out subsystem faults.

7 ACKNOWLEDGMENTS

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