New Wave Form Surveillance and Diagnostics for the LEP Injection Kickers

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Abstract

The introduction of the Bunch Train Scheme in LEP requires a more precise and automatic supervision of the stability of the LEP injection kickers in timing and amplitude. Comprehensive and user-friendly diagnostic tools are required for in-depth investigation of equipment behaviour. A new system is currently being prepared using to a large extent commercial data acquisition hardware and hardware independent software products.

1. EQUIPMENT

The LEP injection kickers [1] are fast pulsed magnets used to inject electron and positron bunches, arriving from pre-accelerators, into the desired beam orbit in LEP. Three kicker magnets, equally spaced along LEP, produce a fast orbit deformation of the stored bunches as shown in figure 1. At the moment when the kicker magnet deflects an already circulating bunch close to the field-free side of the septum, a newly injected bunch arrives at its field side and is bent by the septum magnet nearly parallel to the trajectory of the stored bunches. The duration of the fast orbit deformation must be sufficiently short to deflect only the stored bunch to which the new particles are to be added, and must be perfectly closed to avoid injection losses and residual beam oscillation.

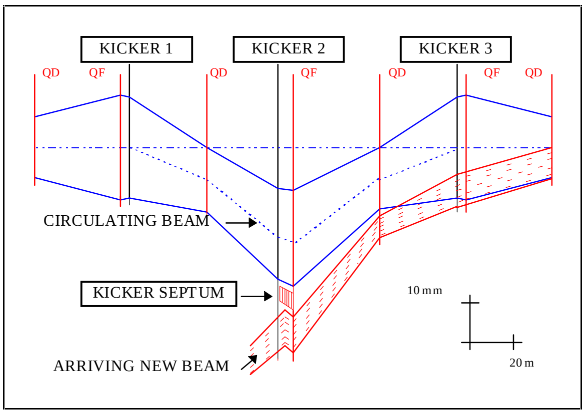

Fig 1. Layout of the fast orbit deflection for LEP injection, (QF, QD: focusing and defocusing quadrupole magnets).

The efficiency of the LEP injection kickers depends on two major parameters: the stability and reproducibility of the kick amplitude (better than 1 %) and the stability and precision of the kicker timing with respect to the injected and circulating beam (better than 25 ns). A typical kicker pulse, together with a signal of the injected beam current, is shown in figure 2.

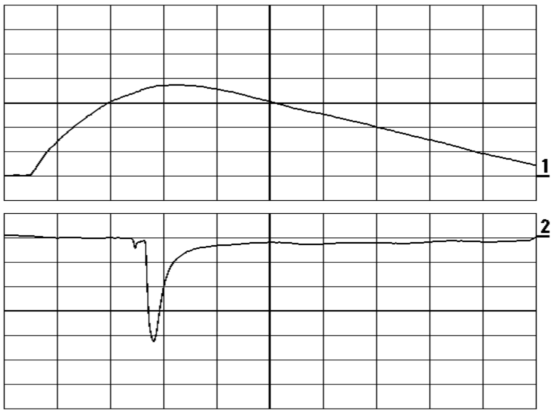

Fig 2. Typical kicker pulse (1) (300 A/div.) and injected beam current (2) (1 µs/div.).

2. SCOPE OF THE PROJECT

So far no permanent surveillance of the LEP injection kicker signals exists. The kick/beam timing synchronisation setup and the stability of the kick amplitude can only be controlled manually from time to time and, in any case, only for following pulses, since no storage of previous pulses is foreseen. Imperfection and faulty behaviour of the equipment can therefore only be confirmed if the symptoms persist. An earlier malfunctioning of the equipment can not be positively excluded. Monitoring of the evolution of the parameters in time to keep optimum performance is manpower-intensive.

Considerable improvements were nevertheless mandatory with the advent of the so-called ‘bunch train scheme’ [2] at LEP in 1995. This project implies a much greater number of bunches circulating in the machine and a more demanding injection scheme. It has now become more important than before to precisely supervise and maintain the performance of the injection kickers and to trace back reasons of faults rapidly and with certainty.

It has therefore been decided to revise the needs and provide better surveillance and diagnostic facilities in the framework of an improvement project. These facilities comprise tools to select, acquire, log, retrieve, and visualise signals from the beam pickup and the kicker system, to analyse them and to compare them with reference pulses. These tools are callable either on request for diagnostic and adjustment, or run continuously in the background for equipment surveillance, informing the equipment specialists of any malfunctioning if desired. Finally, they can be used to readjust the timing and pulse heights automatically, if so desired.

3. GENERAL LAYOUT

In order to use commercial data acquisition hardware, to avoid as much as possible hardware dependence, and to keep a high level of modularity, the application is developed in the framework of LabVIEW [3].

The software part of the application is organized in a client/server scheme and divided into three layers: the data acquisition, the data analysis, and the data presentation. The two first layers constituting the server part are running on a front-end computer located close to the acquisition hardware in order to reduce the data exchange over the network and profit from the event driven capabilities of LabVIEW. The third layer, the client part of the application, is the graphical user interface which runs on HP workstations.

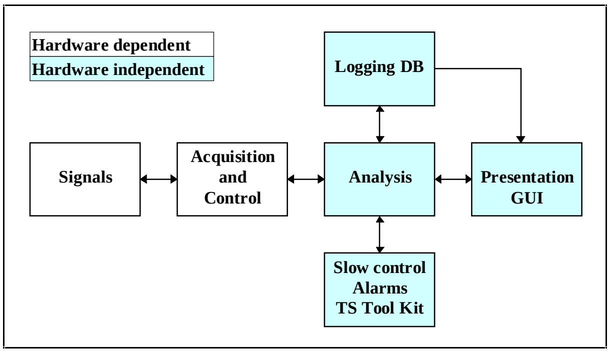

Fig 3. Software structure.

The acquisition layer includes the measurement devices and their integration. The hardware independence is achieved by using the LabVIEW virtual instruments driver library. The analysis layer comprises the tools used for signal surveillance and diagnostic. It also includes utilities through which the system interacts with other systems like the general CERN alarm system, the equipment slow control, or databases. The presentation layer offers an uniform graphical user interface and look-and-feel for the application and can be run simultaneously from many computers without disturbing the acquisition and analysis processes.

The low level layers are seen by the top layer as virtual instruments. The communication between both levels is performed through the LabVIEW network virtual instruments based on BSD IPC using Internet stream socket [4].

4. ACQUISITION and DISPLAY

The kicker magnet, beam, and trigger signals are remotely selectable through multiplexer units and acquired through signal digitizers.

The single shot sampling rate is 500 MS/s for four channels and the vertical resolution is 8 bits. The higher acquisition repetition rate is equal to 1.2s for a signal duration smaller than 2 ms.

The acquisition hardware is connected to the existing accelerator control system (represented by a TCP/IP based Ethernet network) [5] either through a GPIB bus connected to a PC, plug-in DAQ boards integrated within a PC, or a VXI crate with a VXIpc card at the slot 0 position. In any case DOS/MS Windows and LabVIEW are used in the front end computer level.

The main advantage of the VXI solution is the existence of the VXIplug&play standard initiative which simplifies the setting up of VXI based systems. The same holds probably in the PC plug-in DAQ boards solution when using the Windows 95 operating system. The GPIB solution offers the largest selection of instrumentation devices. All three ways of integrating the acquisition instruments are supported by LabVIEW.

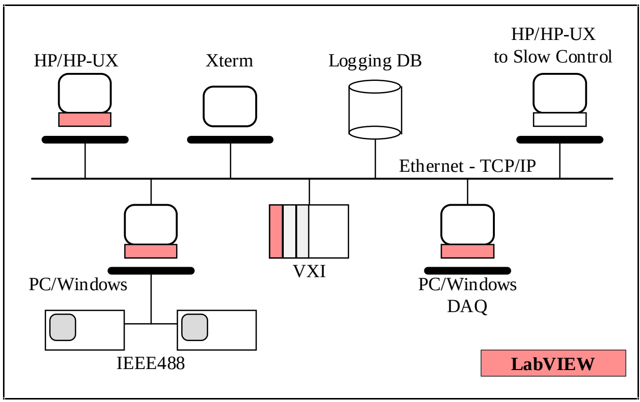

Fig 4. Overview of the high and low level acquisition system.

The wave forms are displayed graphically, on demand, on HP 9000/7xx series workstations, X terminals, and PCs with X emulators, using the X Window system.

A remote on-line Oracle database is used to store the default acquisition settings, the acquired, and the reference wave forms. The connection to the kicker slow control is achieved through a fully configurable, event, and data driven software package running in HP workstation [6].

5. ANALYSIS

The selected wave forms (kickers + beam signals) are permanently acquired upon reception of trigger prepulses, when the system is pulsing, and beam is available. The last acquisitions are logged and kept in a local database, organised as a FIFO. Upon request, the wave forms can be transferred and stored, together with the present timing and voltage settings, on a remote Oracle database as reference wave forms.

Each new acquired wave form is automatically compared with the corresponding reference. In order to detect differences in amplitude or in time, smart trigger facilities (like envelope, level, or window trigger) are used. If the new wave form is outside predetermined limits an internal trigger is generated and the last measured wave forms are automatically stored with the fault reason in a remote Oracle database for later analysis.

Tools to select, extract, replay and display the acquisitions either from the local database or from the remote Oracle database are foreseen.

Upon detection of an internal trigger, a call to an external C function with predetermined parameters is made. This call connects the analysis layer to the existing equipment slow control software from where further actions can be initiated. Beside this interlock facility different levels of alarms (warning, fault,..), depending on the severity of the deviation are provided. These alarms are sent to the general CERN alarm system through a call to the equipment slow control software [7].

For each new acquisition the difference in amplitude between the measured and the reference signals is automatically checked for a predetermined number of points. The difference between both signals for the corresponding points is calculated and sent to the equipment slow control software for pulse to pulse regulation.

6. CONCLUSION

The project is actually in its design phase. Different technical solutions and configurations have been evaluated and it appears that the benefits of using commercial hardware and software products for this kind of application maximize flexibility, minimize obsolescence and reduce development time, effort and maintenance.

The use of a well established, proven, and long-lasting hardware and software solution implies a minimum of specific development, even if the needs or the environment evolve and thus reduces the cost over the lifetime of the system.

Due to manpower limitations, the realisation of the project will be outsourced to industry.

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