Unix Data Acquisition System

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Abstract

The Unix Data Acquisition System (UDAS) is a Fermilab-based prototype for on-line data acquisition and analysis. The system employs a shared memory approach for the storage and accessibility of the large set of data (approximately 0.5 Megasamples) it is capable of handling. It is currently used to analyze turn-by-turn data obtained through two beam position monitors of the Fermilab Main Ring. The data are digitized with a LeCroy 6810 fast waveform digitizer. Recently the system was used to obtain a continuous tune measurement in a single Main Ring cycle after applying a noise signal (white noise or a chirp signal) to the beam through the Main Ring slow dampers.

Introduction

The capture and analysis of turn by turn data, from beam position monitors and intensity monitors, was a central feature of the E778 nonlinear dynamics experiment at the Fermilab Tevatron. The UDAS data acquisition system represents a harden version of the "Mirabile" [1] instrumentation used for E778, with the intent to make it routinely available for diagnosis of Main Ring or Tevatron performance. Turn by turn instrumentation has been succesfully used at CERN to continuously monitor tunes through SPS [2] and LEP cycles [3]. So far the minimum goal for UDAS has been the reproduction in the Main Ring of the SPS's continuous tune measurement capability, although there is good reason to believe that other continuous measurements besides tunes will also be possible.

Hardware

A block diagram of the hardware configuration is shown in Figure 1. The beam is excited or "heated" by applying a noise signal to the Main Ring slow dampers. There are two noise gates, one for each plane, which are referenced to an arbitrary Main Ring event. Normal Main Ring beam position pickups are used to extract direct horizontal, vertical and intensity signals. The signals are digitized with a LeCroy 6810 5-Mhz, 12-bit transient digitizer, with 0.5 Megasamples of onboard memory. The "noise" signal used to heat the beam is digitized as well.

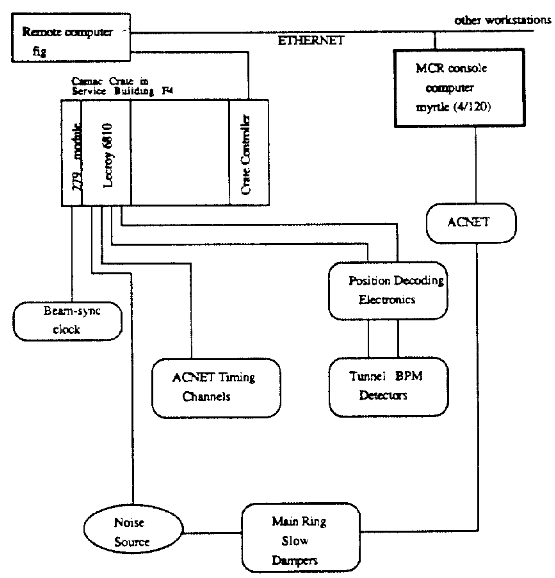

Figure 1: *Hardware configuration of the UNIX system for the Main Ring.*

The sampling clock for digitization is the Main Ring beam-synchronized revolution frequency clock. The 279 modules provide two separate timing pulses with a programmable delay from a Main Ring beam-synch clock. They are used for adjusting the timing of the gate inside which data is taken.

The digitizer, once armed, samples continuously until an external trigger signal, a standard Main Ring event; arrives. The number of samples stored in memory after a trigger event is controlled by the segment size (up to 0.5 Megasamples for 4 active channels), set in the module.

The camac-based LeCroy modules are controlled by a Sun 4 workstation(fig) via the Sun's VME backplane and a CES CBD/8210 camac branch driver. This is to be replaced with a Sparcstation 1E on a VME card in the future. The control and the data flow to the control room workstation is done through the Sun's ethernet link.

Software

The entire data acquisition system is based on the Integrated Scientific Tool Kit (ISTK) package developed at LBL

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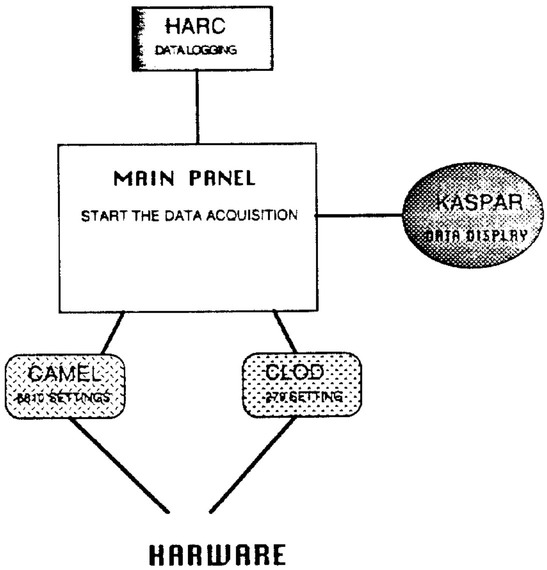

Figure 2: *Sofware configuration.*

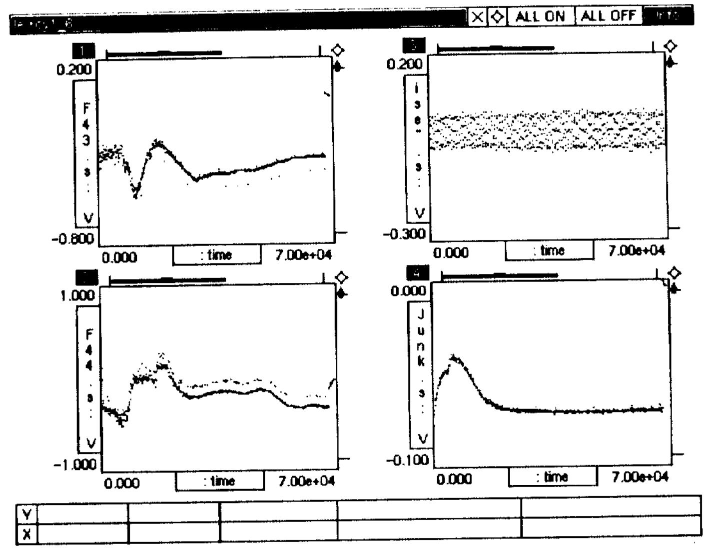

Figure 3: *Typical "kaspar" graphics picture of the digitized signals in UDAS. The vertical axes are in Volts and the horizontal axes are in number of beam revolutions.*

with funds from the SSC Accelerator Division. The ISTK package consists of a set of four tools:

a) "kaspar" graphics
b) "SDS" data management utilities
c) Relational database management system utilities
d) "glish' sequencer language.

Use of the ISTK package allows easy interface of control panels on screen with the actual control programs, written in C++.

There is a general acquisition control panel which controls the whole data taking operation. From this panel one can:

1. Control the data acquisition.

This part of the control panel initializes all the data-acquisition processes, starts the logging of the data to disk, and selects the data taking mode (single shot/auto shot). The logging of data is achieved by energizing another system called "harc" which looks at the shared memory of the remote computer and transfers the data to the disk of the computer at the control room.

2. Talk to individual camac modules.

From this part one makes changes to individual modules, both by turning them on and off and by calling subsidiary panels that make changes to the module settings. The 6810 is controlled by a panel called "camel" from which all the camac settings of the module can be set by toggling on pulldown menus. One has also the ability to save the entire set of module settings in a file for future reference. The 279 module is controlled by a panel called "clod" from which the adjustable delays to the beam-synch clock are set.

3. Control the documentation and display of the data.

From this part one can turn on the "kaspar" graphics for the online display of the data and can also record whatever typed-in comments he wishes to accompany the data. Figure 2 shows a general picture of the software configuration used in UDAS.

Experimental Results

During the last study period of the Fermilab Accelerator the UNIX data aquisition system was tested in performing a continous tune measurement on a single MR cycle. The cycle chosen was a 29 cycle (pbar production), that had a total length of 1.4 sec and a flattop energy of 120 GeV. We used an HP 3582 Dynamic signal analyser as a noise source and applied the noise signal to the horizontal dampers over a gate extending from the beginning of the cycle to near the flattop energy. Two BPMs, one horizontal(F44) and one vertical(F43) were digitized along with the noise signal and the intensity signal provided by the F43 BPM. Figure 3 shows a "kaspar" graphics picture of the four signals for the whole Main Ring cycle chosen.

Two different types of noise source were used, a) periodic chirp and b) random noise. The frequency span of the noise source was varied from 3 – 34 kHz coresponding to different time records. The amplitude of the source was also varied, but remained constant during a particular cycle. We found that with white noise we could effectively excite the beam without any observable degradation. Horizontal tunes were observed by simply taking successive FFT's of the beam responce over the noise source time record. We did not have similar success in tune observations when we used a periodic chirp of a constant amplitude. In this case the beam was killed at an early stage for chirp amplitudes large enough to excite the beam at flattop energies.

In Figure 4 the "kaspar" plots of 16 successive FFT's taken over 4096 turns (0.086 sec) in one 29 cycle are shown. The horizontal tune lines are clear except around transition (13000-20000 turns) up to about 60000 turns or energy of 100 GeV.

By looking at the correlation between the beam response and the random noise signal we could identify the horizontal tune lines up to the flattop energy of 120 GeV, and could sometimes identify the vertical tunes lines due to coupling.

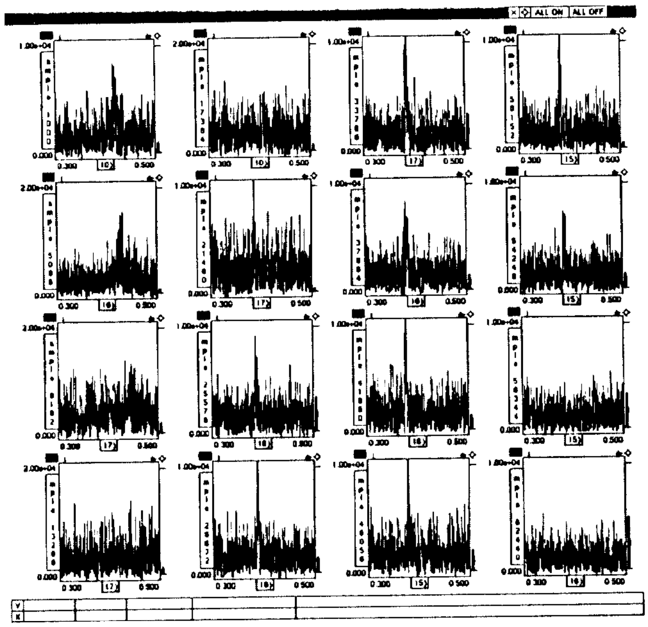

Figure 4: *Successive FFT's of the horizontal BPM signal through the Main Ring cycle for a random noise source drive signal.*

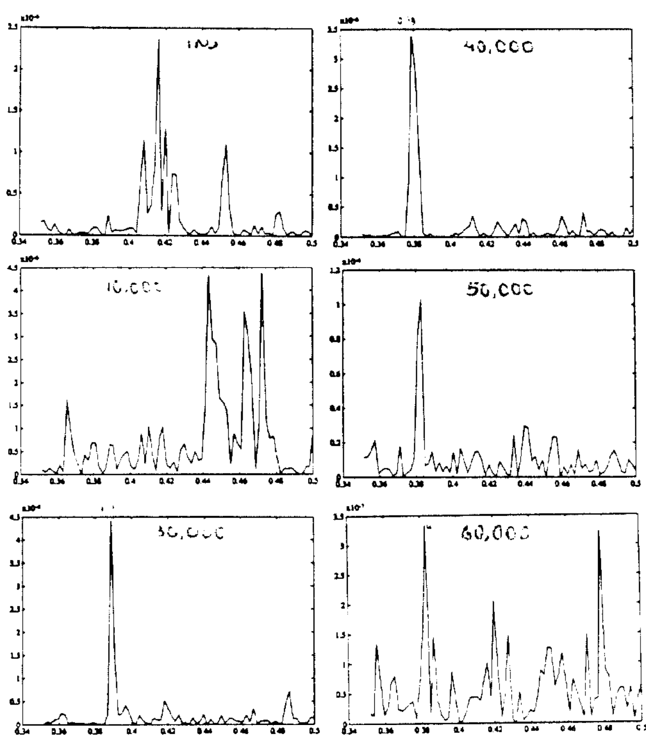

Figure 5: *Correlation function between the horizonal beam responce and the random noise signal at different points in the cycle. The plots correspond to injection, 10000, 30000,40000, 50000, and 60000 turns into the cycle.*

Conclusion

The UNIX data acquisition system was succesfuly tested in acquiring and analyzing turn by turn data to obtain horizontal tunes versus time in a single Main Ring cycle. More work needs to be done in determining the best way of extracting the tunes from the turn by turn data with the least possible beam disturbance and to incorporate this method into an automated procedure of a continuous tune measurement as performed in the CERN SPS.

Acknowledgment

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References

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