

The Million Turn Data Acquisition System BOSC

A. Burns, W. Fischer, H. Jakob, I. Milstead, F. Schmidt and L. Vos,
CERN

CH 1211 – Geneva 23

Abstract

The data acquisition system BOSC [1] has now reached a reliable operational stage after the phase of designing and debugging its complex hardware and software. The system consists of a VME-crate with a 68030 CPU-card, a timing module, a bunch selector card and 12 ADC cards each with two channels to acquire and store data of up to one million turns. The aim of the system is to measure a wide range of different signals each being recorded in one of the ADC channels. Three such crates are connected via Ethernet and Token Ring to Apollo workstations on the SPS site. Very flexible measurement requests can be sent to the crates in data-structures which are then filled with the requested data and sent back to the Apollo for processing. In the crate a complex control software running under OS9 has been developed, with several application software programs now running on the Apollo. One use of the system is for operational purposes such as tune measurements. Moreover BOSC has been the essential tool in conducting the delicate dynamic aperture experiments where the measurement needs are constantly changing.

I. HARDWARE DESCRIPTION

BOSC is designed as a turn by turn acquisition system. It was originally intended to be used in the SPS to measure the intensity and the position of the individual proton and anti-proton bunches over a full machine cycle. The signals are taken from homodyne receivers. These requirements and conditions lead to the actual properties of this system:

- each acquisition channel is backed with a 1MByte dynamic memory to allow the measurement turn by turn over a period of more than 20s in the SPS
- the bandwidth of the acquisition is 5MHz which is well matched to the bandwidth of the receivers
- the receiver also requires an input signal of level $\pm 5V$

The BOSC acquisition system in its final form is housed in a VME crate. It can handle up to 24 analog signals. They are organised in 12 dual channel electronic cards (*dual sampler*) which contain a memory for each channel and a logic

cell array common to both channels which acts as a slave to the crate central processor unit (68030). The system is mainly intended for the measurement of single bunches. The *bunch selector* picks a given bunch which circulates in the machine. The time resolution of this selection is determined by the bandwidth of the system and is at present at the order of 200ns. Special care has been taken to isolate the low power analog circuits from the high power digital circuitry. The connection between the two is made in the *VME bridge* module. The information concerning the machine cycle time is fed in the system by the *TG3* timing module.

At present three units are installed in the SPS:

- A first one is dedicated to turn by turn position measurements. It is used to derive the machine tunes. A number of channels are connected to 200MHz receivers completely in line with the original specifications. They are well adapted to measure single lepton bunches. However, they are also used to measure the SPS proton beams bunched at 200MHz. Special low frequency FET amplifiers of which the bandwidth is reduced to 5MHz to match the acquisition system are connected to a second set of channels. They allow the measurement of bunched and unbunched beams. The excitor for this measurement can either be a special fast kicker magnet or the deflector plates of the transverse feedback system. The excitation of the latter is controlled by BOSC using the *sequencer* unit.
- A second BOSC unit is devoted to single bunch intensity measurements. The signals are generated by 20MHz homodyne receivers.
- A third unit makes the acquisition of much slower signals generated by DC current transformers, collimators movements and scintillators.

II. CONTROL SOFTWARE

The control software [2], running under OS9 on the 68030 processor, has the following tasks: setting up the communication between the crate and the Apollo workstation, setting & changing some hardware parameters, taking measurement requests from an Apollo workstation, starting the data acquisition on the crate and sending the data

to the Apollo after an acquisition has been made. It is capable of handling several requests simultaneously on the same crate.

The communication is done over Ethernet and Token ring where sockets under TCP/IP are used. For the data transfer in any direction MOPS structures are used [3].

A schematic overview of the system consisting of the crate, the Apollo and the communication part is given in Fig. 1.

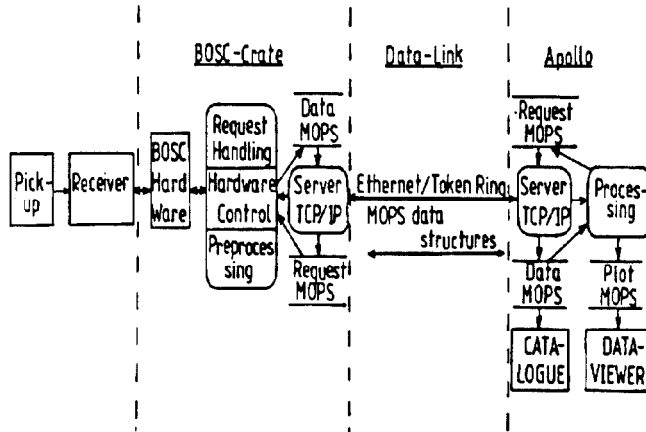


Figure 1: Setup of BOSC

It is possible to change some of the parameters controlling the hardware such as base addresses, gains and bunch selector settings. The use of base addresses allows the translation from physical to logical channel addresses, so as to freely choose channels without the need of swapping cables. The receiver gain can be changed from 14db to 70db in 14db steps, each ADC channel gain can be changed from 0db to 24db in 6db steps.

The MOPS data structure which is sent to start the measurement on the crate in one of its objects holds a coded request (9 integer numbers) which specifies the measurement parameters: on which BOSC crate to run the measurement, the number of super cycles to be measured, the start time of the measurement in the SPS super cycle, the time between blocks of acquisitions, the number of acquisition blocks, the time between sub-blocks of acquisitions, the number of sub-blocks in one block, the number of turns per sub-block and the channels to be used for the measurement. An example of the usage of some of these parameters can be found in Fig. 2. A server program is running on both ends to receive MOPS data structures with measurement requests or acquired data respectively. The data read from the ADC memory and hardware settings like timing information are added to the request MOPS data structure that has been sent from the Apollo.

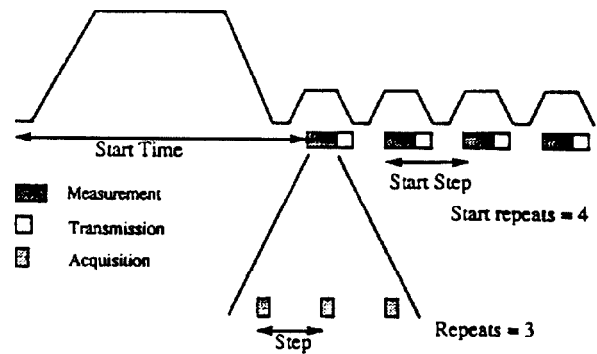


Figure 2: Structure of a measurement

III. APPLICATION SOFTWARE

The application software [4] is an interface for starting a measurement, displaying the data acquired, storing data and performing a detailed post-processing analysis. For displaying data the *dataviewer* program is used [5], the archiving is managed by a catalogue package [6]. BOSC is now used as an operational tool for tune measurement [7] as well as a tool for the dynamic aperture experiments performed on the SPS [8]. In the following we only report on the later application software package. There are two main types of measurements that can be performed:

- Lifetime measurements
- Phase space measurements

In the dynamic aperture experiments we want to investigate effects that influence the particle stability over long periods. It is therefore very convenient to have BOSC for following simultaneously and continuously beam intensity, scraper positions and loss monitor readings. Different phenomena leading to particle loss can thereby be easily distinguished (see Fig. 3). For a phase space measurement the position and intensity signals of one or more pick-ups can be recorded. After having applied a kick to the beam the Fast Fourier Transforms from the position signals give the tunes and the line spectra due to resonances. Fig. 4 shows how readings of two pick-ups separated by a multiple of 90 degrees allows one to depict phase space projections. Currently we take and analyze online two samples of up to 65000 turns, the repetition rate being 30s. This allows a very precise determination of the tune, but also linear coupling correction, chromaticity compensation and identification of high order resonances.

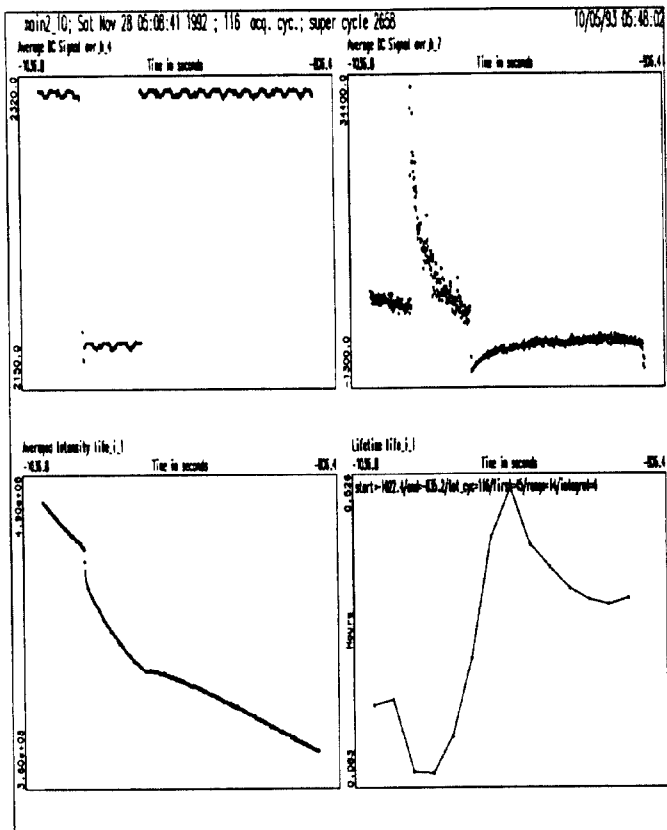


Figure 3: Lifetime measurement

The effect of moving a scraper (upper left) can be seen on the loss monitor, the beam intensity and the lifetime (upper right, lower left and lower right part respectively).

For phase space measurements there is a tool box which contains four programs. The *zero_stuff* program allows to set the position signals in a certain time range to zero. With this facility one can detect changes in the tunes, for instance due to power supply ripple. The *stroboscope* program plots only every n^{th} point in phase space thereby visualizing resonances in the horizontal, vertical and physical phase space projection. The *fake* program has the same functionality as *stroboscope* but uses the information of only one pick-up via relating $x(i)$ with $x(i + \text{skip_step})$. The *smear* program computes the horizontal and vertical decoherence, the decoherence corrected amplitude and the smear.

IV. CONCLUSIONS

BOSC can now be considered an operational tool, especially due to a considerable improvement in the control software part. Operational tasks like tune measurements are now in place. The more complicated requests for dynamic aperture or other experiments can be fulfilled, but there are still many of capabilities yet to be exploited.

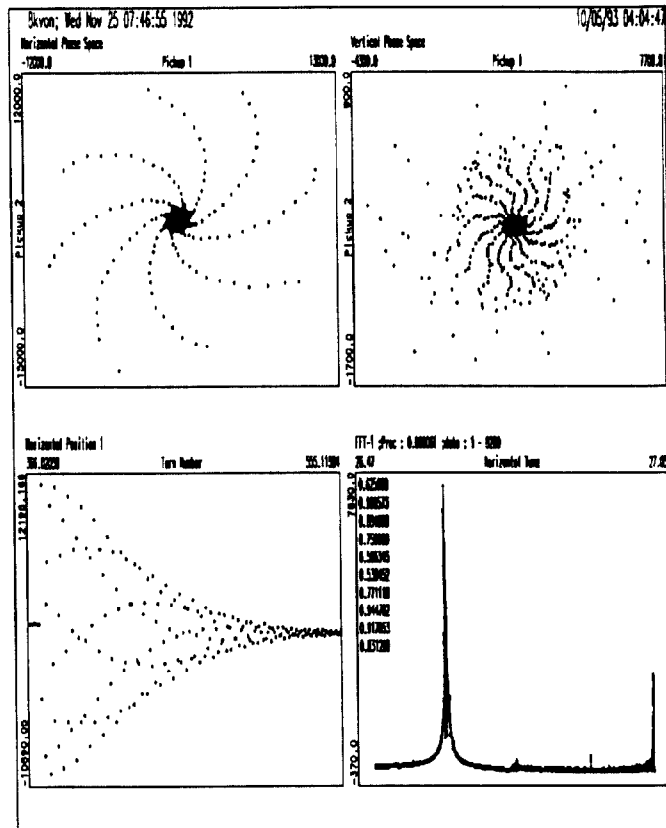


Figure 4: 8th order resonance

Motion is depicted close to a horizontal resonance (upper left) with the kicked and decohered beam and a FFT (lower left and lower right part respectively).

V. REFERENCES

- [1] A. Burns et al., *The BOSC Project*, CERN SL/90-68(AP).
- [2] I. Milstead, *SPS BOSC - Beam OSCillation Data Acquisition System for the SPS, System Users Guide*, Version 3.22, 1992.
- [3] W. Herr, *M.O.P.S. Users Guide for "C" programs*, CERN-SPS/88-43(AMS), 1992.
- [4] W. Fischer and F. Schmidt, *Application Software for the BOSC Data Acquisition System of the SPS, Users Guide*, CERN-SL Note, to be published.
- [5] A. Sweeney, *The Dataviewer Programmer's Guide*, LEP Controls Note 107, SPS/ACC Note 89-11.
- [6] Q. King, R. Schmidt, *The SPS Catalogue Data Structure*, CERN SPS/ABM/Note/88-12.
- [7] A. Sweeney, *Private Communication*.
- [8] W. Fischer et al., *Recent Results from the Dynamic Aperture Experiment at the SPS*, CERN SPS, presented at this conference.