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Frequency Domain Analyses of Schottky Signals Using a VME Based Data Server and a Workstation Client

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Abstract

Schottky signals are extensively used for observation, setting-up and operation of CERN's Antiproton rings, namely the AC, the AA and LEAR. Measurement of these signals is, at present, carried out by a series of commercial instruments. These instruments have to be individually controlled and read by each application program. The operational use of the system is limited by the capabilities of the individual instruments. The first objective for the new system was to provide, as far as possible, a true "server". The "client" application program simply requests the data it requires. It is then supplied with measured and processed data. This provides the operator with a fast response by having ready processed data always available. Our second goal was to make the system operationally simple, with multiple windows and presentation on a single screen. This paper discusses some aspects of this implementation and applications for the antiproton production, collection, and storage rings.

INTRODUCTION

The system is to be used on the CERN Antiproton Collector(AC) and Antiproton Accumulator (AA) rings. The Antiprotons are first created by directing a 26 GeV proton beam onto a production target. The antiprotons are then captured, injected and stochastically cooled in the AC ring.

After cooling they are transferred to the AA ring where they are stored, and continuously cooled until needed by the physics programme. This is a multistep process involving rf bunch rotation and debunching, stochastic cooling in all three planes, rf recapture in the AC and bucket-to-bucket transfer to the AA, pre-cooling in the AA, rf capture in the AA and transfer to the stack-tail region and stack-tail cooling as well as core cooling for long-term storage in the AA. To have any yield at the end of this process, all the systems have to be set up to run with very high efficiency. In addition, due to the limited available cooling power, beam blow-up must be avoided at every step. Similarly, non-destructive beam diagnostic measurements have to be made, i.e. without disturbing and blowing up the beams. The technique chosen was spectrum analysis of the Schottky signals produced by the beams [1, 2]. By using appropriately positioned pickups and producing spectra of the revolution frequency sidebands, the beam profile in the horizontal, vertical, and longitudinal planes can be deduced. If the sensitivity of the system is known, the integral of the spectrum gives the beam intensity. At present, four types of spectrum analyzers, from two different manufacturers are used. Differences between these instruments leads to very complex measurement programming. To complement or replace these instruments, a very high speed, fast Fourier transform engine is needed. The VASP16 VME module from Computer General was chosen. This has a Texas Instruments 320C25 digital signal processor, and four Zoran vector processors on the board. The board is capable of performing a 1024 point FFT in 700 µs. The VME chassis is controlled by a Motorola MVME147 board running the OS9 operating system. The Motorola 68030 CPU transfers data from the ADC's (analogue to digital converters) to the VASP16 and services requests for data from the users. The ADC's are triggered to take data by the accelerator timing system.

OBJECTIVES

Replacing these instruments with a VME system, there are four main objectives.

a) To make the results available on request. At present each instrument has to be set up and then the measurement can be made. With the VME chassis data taking and processing can take place continuously, and the results presented on demand.

b) The spectrum analyzers have some real time constraints, they normally expect to acquire data, then process it, then display it. The VME system can acquire data at times fixed by the machine cycle, and fit in the processing between data acquisition.

c) The third objective is to separate the process of data acquisition from the task of presentation. This would allow any operator to access data without interfering with another operator's measurements.

d) This system has to be integrated into the control system. By using the VME system we can produce a standard interface to the control system, with all the specific low-level software hidden from the rest of the system.

SYSTEM OVERVIEW

Figure 1 shows a generalized overview of the system.

The resonant pickups consist of two parallel plates inside the vacuum chamber, one pair for the horizontal measurement, and a pair for the vertical measurement. The signals are brought out with vacuum feedthroughs and fed into a coaxial line resonator. The sum and difference signals are made using a hybrid and the resulting signals are amplified by low-noise amplifiers. The specific characteristics and needs for the respective rings are shown below.

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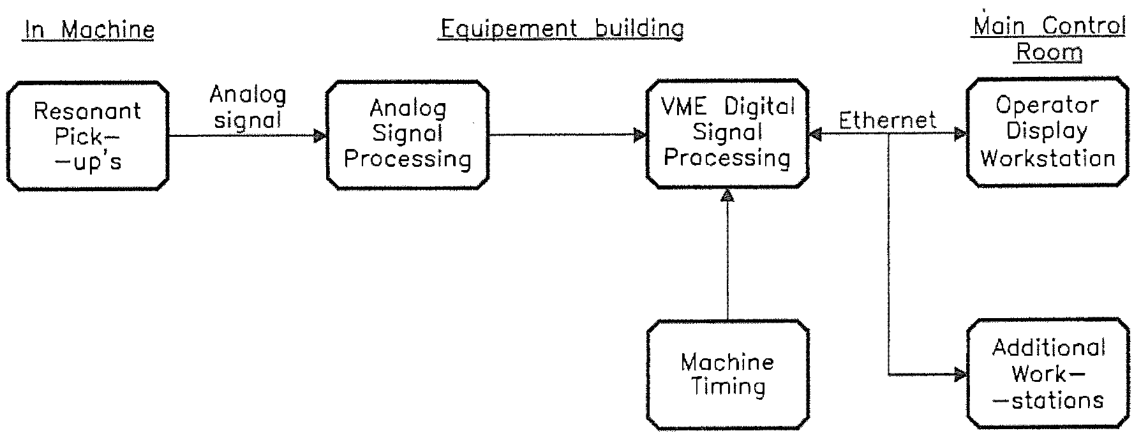

Fig. 1. System Overview

	Center freq. MHz	Bandwidth MHz	Gain dB	Rev. freq. harmonic
AC	49.2202	1.5	60	31
AA	71.9379	4.3	60	39

The system will cater for six analogue signals, i.e. the sum, horizontal, and vertical signals from both the AC and AA rings. There will be six parallel channels up to the VME chassis. The additional workstations could be in the control room, in a laboratory or even in an office, the only requirement would be the availability of access to the control system Ethernet.

Analogue Processing

The signals for each measurement all have similar analogue processing. The signals are first down converted using upper sideband mixers. They are then amplified and filtered by elliptic antialiasing filters, and further amplified to match the full scale range of the ADC's. Figure 2 illustrates this schematic layout.

Digital Processing

The acquisition is started by a timing pulse from the accelerator (AC or AA) triggering the analogue to digital converter. This acquires 8192 samples at four microsecond intervals. When the data is acquired the data reading software is flagged to copy the data to a circular buffer, reset the converter, and flag the data treatment software. The data treatment software has two options. If the data was acquired at injection, it copies 512 samples of raw data to a named data module, and performs a single FFT on the first 1024 data samples. This gives a measurement of the injection process. Data modules here imply the software structures as permitted under the OS9 operating system.

If the measurement was not at injection, it performs 16 sliding FFT's on the 8192 samples and then averages the resulting spectra. All these results are then saved in other data modules ready for any requests via the control system.

In addition the data treatment software adds to the data module any other information that might be needed by a display program, for example, gains, timing information, labels for graph axes.

Communication and Operator Interface

The communication between the VME crate (server) and the DEC-3100 workstations (clients) is established using the standard TCP/IP socket library and Ethernet interface. A user defined port number is used to access the self-written driver installed on the VME crate to serve the clients. To provide the separation between data acquisition on the server and the final display on the

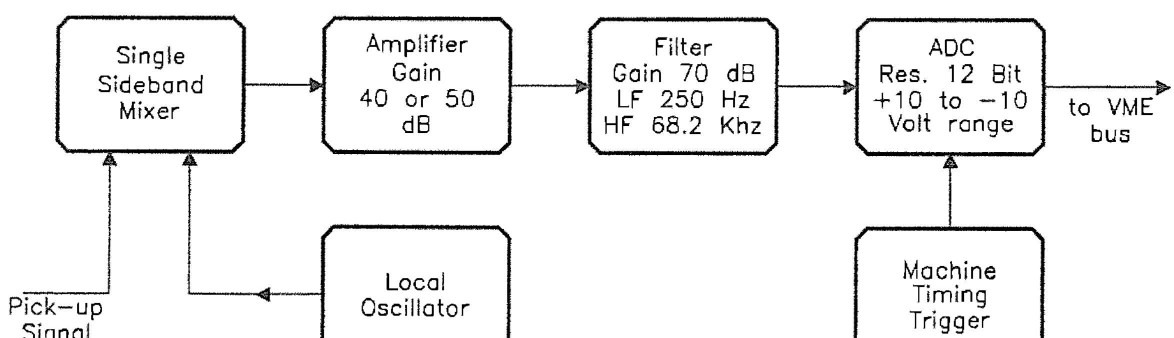

Fig. 2. Layout for analogue signal processing

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client, a prototype database approach has been implemented on the server. A database file contains the names of all the data modules available to the client. This file also permits a multi-name mapping between a user preferred name and the real name of a data module.

Once the server accepts the connection request for a client through the user port, it sends all the relevant information including labels, axes information, etc. relevant to a particular data module to the client. The user selection of a named module is done through the menu-driven selection box on the workstation. This name is translated onto the real data module name and the request added to the active (hot) link table on the server. The data module header contains the date and time information. This is useful and necessary because the server task is continually scanning the date-time stamp in the headers of all the data modules in the hot link list and transferring the latest data blocks to the corresponding clients. The server task also checks if a client request has terminated and the validity of the client-server link. If the link is severed, it removes all the data modules of the interrupted client from the hot link list.

The data from each data module is displayed graphically in a window as shown in Fig. 3. For multiple data modules, a multiple set of windows are put together in a main window to permit a sequential observation of a chain of processes as applicable to the passage of a single beam shot of the antiproton collector and accumulator complex. Depending on the data, each window is individually auto-scaled and re-sized. Using the standard tools of the MOTIF tool kit, zooming, integration of values between set markers or the evaluation of co-ordinates at any one point on the graph is easily permitted.

Some Results

Figures 4 and 5 show the sum signal acquired in the AC ring at the time of injection. Figure 4 clearly shows the appearance of Schottky noise as the beam arrives into the ring while Fig. 5 illustrates the power spectrum of the same data. The spectrum is equivalent to the beam longitudinal profile. Figures 6(a) and 6(b) illustrate the beam spectrum obtained in the AC ring at two different time points. Figure 6 (a) shows the beam profile straight after the rf bunch rotation while Fig. 6(b) illustrates the longitudinal beam size, 4.5 s after injection in the AC ring, i.e. at the end of all cooling processes in the AC.

Conclusions and Future Work

Although the system is not completely operational, it already shows sufficient promise as a good approach for the future. The aim of separating the data acquisition and display software has been achieved; after agreeing to the context of the data structures that have to be exchanged, the development of the two parts of the software took

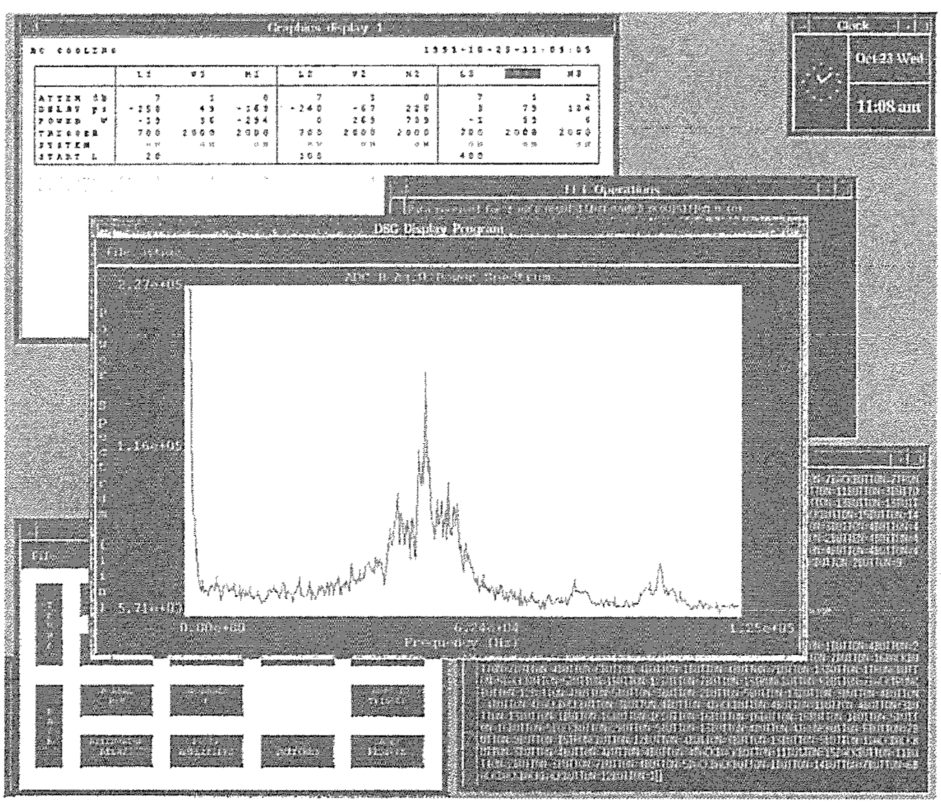

Fig. 3. Typical data module graphical window on a workstation

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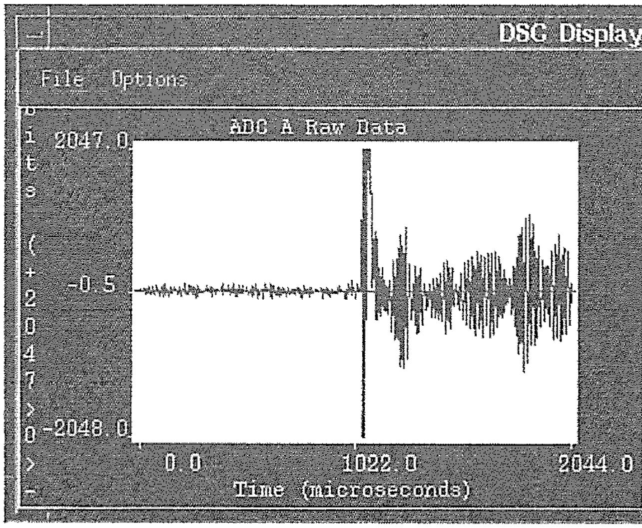

Fig. 4. Beam arrival in the AC Ring

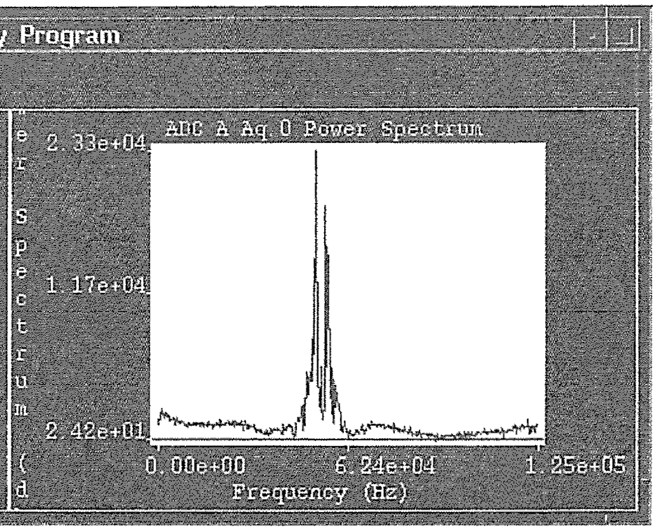

Fig. 5. Power spectrum of the AC injected beam

place completely separately. The aim of having the data available on request from the client has been achieved. The operator can work at his own place, changing the displays as required. The system is pleasant to use, with measurements taking few seconds instead of several seconds in the old system.

At present the data processing is using a prototype program which takes approximately one second to acquire the data, make 16 fast Fourier transforms, and produce the mean of the spectra. The definitive program, when commissioned, will take about 100 ms. Current results show that the resolution needs to be doubled to give a good measurement with at least 10 data points on the fully cooled beam. Similarly, for the injected or uncooled beam an improvement in signal to noise ratio by a factor of two, would give a spectrum which would be much easier to interpret.

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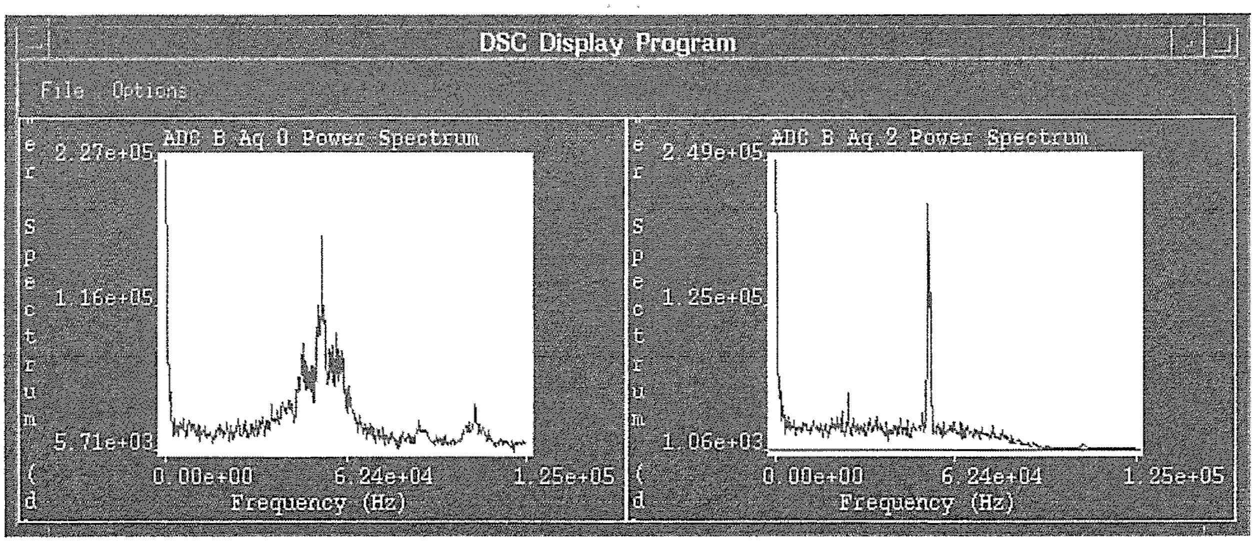

Fig. 6. (a) Beam in AC Ring before cooling and (b) after cooling for 4.5 seconds

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