A VME-BASED MEASUREMENT SYSTEM FOR RF PARAMETERS IN THE CERN PS

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ABSTRACT

The CERN Proton Synchrotron (PS) is a highly versatile particle accelerator[1]. It delivers beams of protons, antiprotons, leptons and lead ions on a cycle-to-cycle basis. The controls interface to the RF systems of the PS has recently been replaced by six VME crates[2]. As part of the upgrade, a digital system has been assembled which provides a measurement of the essential RF parameters of all cavities, including harmonic number and revolution frequency, every millisecond during the active part of each cycle of the machine. During the deadtime at the end of a cycle, these data are transferred from the VME modules to a VME crate-controller where processed machine-physics data are generated for every time sample. Information that would be very difficult to provide by ordinary analogue means is readily available for display or further treatment. This paper describes the hardware and software principles employed and the results achieved with the new measurement system.

1 INTRODUCTION

The versatility of the principal RF system of the PS derives from the fact that, during any given cycle, different voltage and frequency programs may be distributed to separate groups of the eleven ferrite-loaded cavities (including one spare) around the machine. Since these programs and the matrix which governs cavity grouping change from cycle to cycle, it would be difficult to measure by analogue means the total voltage per harmonic, the relative phasing of a cavity or its instantaneous harmonic number. Such measurements are now routinely made using a VME-based system which samples the voltage, harmonic number and phase of each cavity and processes this information together with a similarly sampled measurement of the beam revolution frequency.

The new system provides operators and RF specialists alike with direct displays of machine-physics parameters and it simplified some of the more delicate and time-consuming tasks at this year's start-up.

2 SYSTEM DESCRIPTION

2.1 Overview

Some fifty parameters (see table 1) are acquired every millisecond during the active part of each PS cycle. Raw data are stored in local memory until the end of the acquisition period, when they are transferred to the VME master controller (so-called DSC) and processed. The 1 kHz sampling frequency is derived from the same oscillator on which the master timing generator of the entire PS Complex is synchronized. This avoids conflicts and makes the system robust.

Parameter	Hardware list	Interface	Resolution
Prog'd & detected voltages	11 ferrite cavities (2.6 to 9.5 MHz) 200 MHz system 114 MHz system	ADCs	12 bits
Frequency	Beam rev. freq. 200 MHz system 114 MHz system	Dual-port RAMs	0.6 Hz 76 Hz 38 Hz
Harmonic number	11 ferrite cavities	Counters	1/128
Phase wrt rev. freq.	11 ferrite cavities	TDCs	200 ps
V. prog. matrix	Ferrite system	Input register	

Table 1: Acquired parameters.

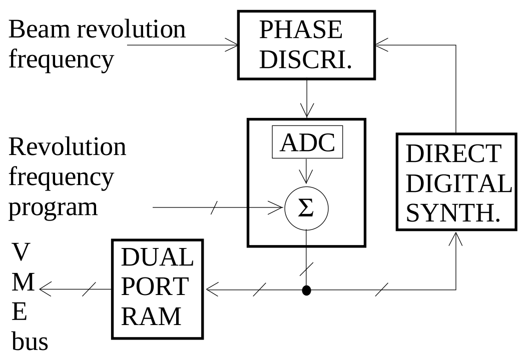

Figure 1: Basic frequency measurement set-up.

2.2 Principles

- Frequencies are measured with a relative accuracy of the order of 10^{-6} using the set-up of fig.1. The principle relies on a Direct Digital Synthesizer (DDS) which is phase-locked onto a beam revolution frequency marker generated by the beam control system. The digital word controlling the DDS constitutes the measurement and is written every millisecond into a dual-port RAM.
- Harmonic number is measured by counting the number of RF periods during 128 beam revolutions.
- Cavity phase is obtained by measuring the time interval between an edge of the beam revolution frequency marker and a positive zero-crossing of the cavity gap voltage. Phase is computed from this time interval by taking into account the revolution frequency and cavity harmonic number acquired at the same sample time.

3 SOFTWARE

3.1 Overview

The software hierarchy (see fig.2) is based upon the new PS control system architecture[3].

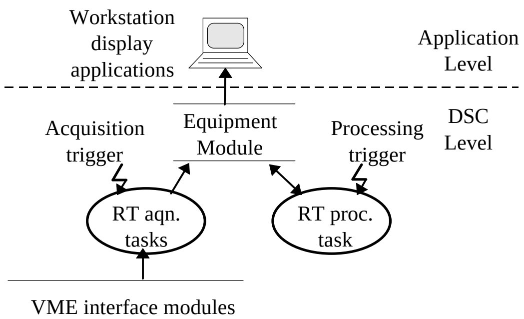

Figure 2: Software hierarchy.

The DSC hosts all the real-time software governing the operation of the system. Various real-time (RT) acquisition tasks obtain from the VME interface modules measurements of all the raw RF parameters. A passive Equipment Module (EM), providing the standard interface between the DSC and application program levels, serves as a temporary storage buffer. The data are thus available both to application programs for direct display and to an additional RT task[4] for further treatment. The latter task is triggered only after completion of all the acquisition ones.

The entire process is repeated continuously on a cycle-to-cycle (so-called PPM) basis.

3.2 Real-time Programs

The RT software has to meet severe timing constraints. A large amount of data must be acquired during the deadtime at the end of a cycle and, thereafter, treated by the processing task (see fig.3). Several refinements of the code were necessary to make these tasks run in the time available.

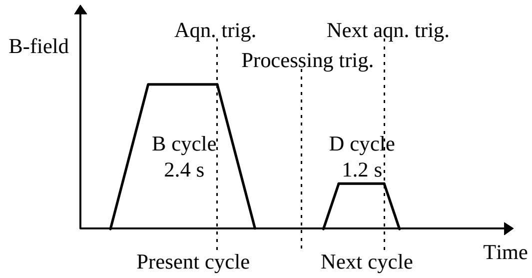

Figure 3: Timing constraints.

The work of the acquisition tasks begins upon receipt of an acquisition trigger. This signals the end of sampling for the present machine cycle. Each of the tasks then acquires the current data, performs any necessary processing, and sends the resultant raw measurements to the appropriate locations in the data tables of the EM. These operations must all be completed before the start of the next cycle, when the processing task is triggered. This computes the resultant voltage and phase components of the principal RF system by summing vectorially over all cavities that are on the same harmonic. It also computes the phase error, with respect to the phase sum for the appropriate harmonic, of each ferrite-loaded cavity.

All programs are written in C and run under LynxOS. A separate program is dedicated to each type of interface module in order to facilitate maintenance.

3.3 Application Programs

Application programs using the X-Window and Motif Tool Kit provide a graphical user interface to display measurement results. A generic program allows both the raw and processed data to be viewed with zoom, cursor, and scaling options (see fig.4).

An additional application has been developed to display the maxima and minima of the measurements for all cavities in the same group (see fig.5). The individual cavity data at the current cursor timing may also be listed.

4 CONCLUSION

A digital measurement system has been assembled which provides RF data sampled at 1 kHz during all cycles of the PS machine. It has proved reliable and robust and all performance requirements have been met.

Experience has shown it to be a very useful tool for machine physics and during start-up.

Extensive use of the data by more sophisticated application programs is now foreseen to make high-level information available to machine physicists.

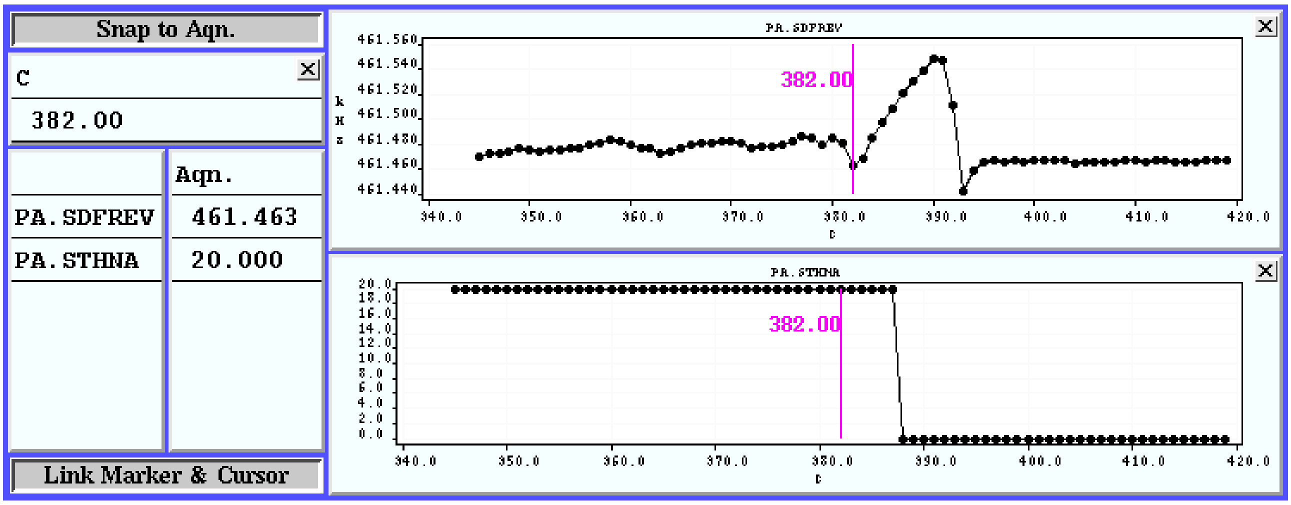

Figure 4: Beam revolution frequency and harmonic number measurements.

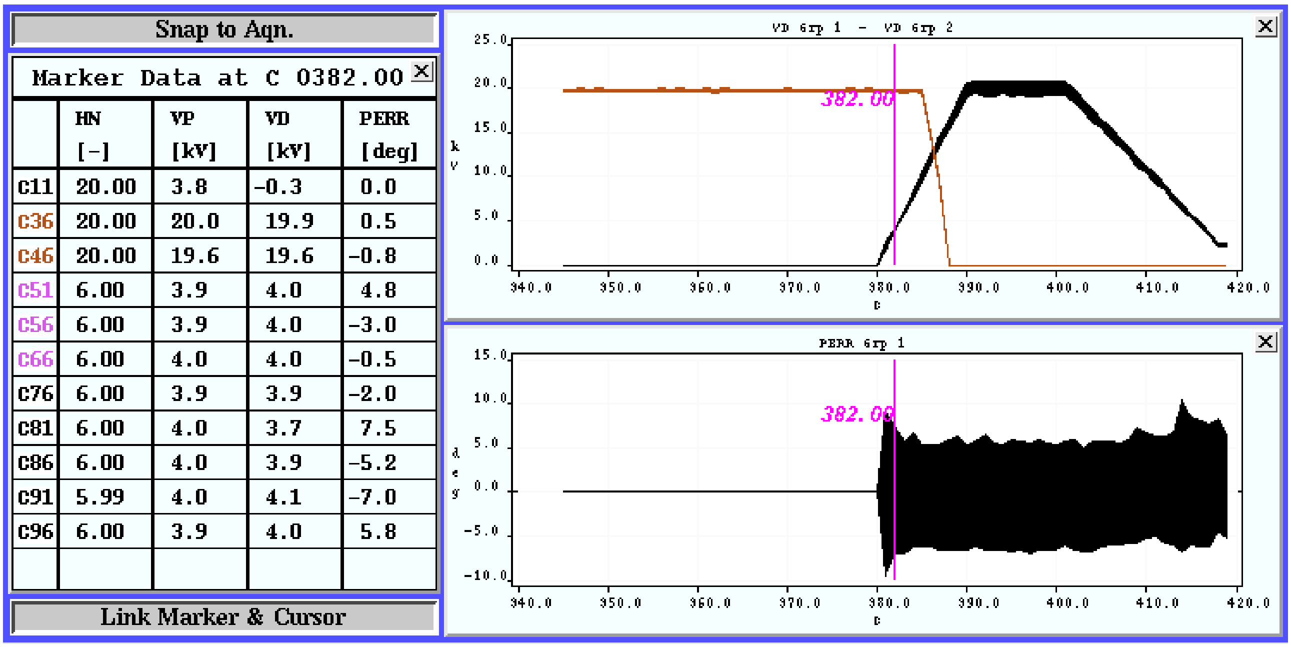

Figure 5: Detected voltage and phase error extrema by cavity grouping.

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