RECENT DIAGNOSTIC IMPROVEMENTS FOR THE PSI ACCELERATOR

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INTRODUCTION

Two recent developments for the PSI proton accelerator are presented: a) a new remote control system that is being implemented for the numerous wire scanner based profile monitors of the proton accelerator, b) a new current monitor as replacement of an older system.

CONTROL SYSTEM FOR PROFILE MONITORS

A new remote control system [1] for the profile monitors has been developed and is being currently implemented on various beam lines of the proton accelerator. The development of this new system was motivated by maintenance difficulties due to an aging system, by some shortcomings related to the old technology and by the better performances offered with the electronics of today.

Shortcomings of the old system

The profile monitor controlling system has been in operation for 20 years. It is made of 3 multiplexed systems controlling all together more than 200 profile monitors.

Several shortcomings motivated the development of a new remote control system. First, the maintenance of this aging system is problematic because some critical electronic components are no more available. Furthermore, the multiplexed nature of the system has a negative impact on the system availability. The wire current measurement of the old system relies on a linear circuit. The correct amplifier gain setting is most of the time requiring several profile measurements. These repeated scans have a negative influence on the longevity of the wire. In addition, the analysis of the raw data is difficult because of the particular ADC used. Indeed, with the old system, the data are sampled at regular position intervals and not at regular time intervals. FFT or time based filtering of the data is then not possible.

Improvements

Improvements addressing these shortcomings are: i) a distributed system structure based on an internally developed CAMAC board controlling up to 8 profile monitors ii) a fixed gain logarithmic measurement of the wire current covering the whole operation range iii) the new control of the DC motor can adjust the motor speed to beam conditions, iv) position and current measurement with a dedicated 14 bit ADC for improved resolution and further off-line processing.

Overview of the new system

Fig.1 gives a conceptual overview of the system. It is made up of 3 subsystems: i) a CAMAC based WIPAM (**WI**re **P**rofilemonitor **A**cquisition **M**odule) including the DASH (**D**ata **A**cquisition module with Hitachi **SH**2 microcontroller) back-end, ii) up to 4 **M**otor **D**rive **M**odules (MDM), iii) up to 8 profile monitors.

Control signals are generated from the CAMAC based electronics (WIPAM). They are then decoded and conditioned for driving the motor in the power stage electronics (MDM). Measurement signals from the profile monitor are first conditioned at the MDM then further processed in the WIPAM. The following sections provide a more detailed explanation of the subsystems.

WIPAM

The DASH back-end has been developed as a standardised universal controller, which can support various front ends. The firmware is responsible for controlling the motors, processing and storing the raw data, calculating the current profile and checking interlock conditions.

The microcontroller 10 bit ADC is used for sampling the DC motor voltage and current. A control program uses these data to drive the DC motor at the required speed. In addition, the scanning wire position is also used to initiate the braking sequence early enough to avoid overshoots. The actual motor speed ranges from 1000 to 5000 rpm. With a 20 gear ratio factor and taking into account the acceleration and deceleration phases, typical time for a run ranges from 0.3 sec to 2 seconds.

The status of the different rest position switches are continuously monitored to make sure that all profile monitors are in their rest position when not in use. The program will otherwise attempt to bring a faulty monitor back into its rest position. If unsuccessful, the program will generate an interlock to avoid any possible damage.

The analogue front-end (AFE) provides correctly conditioned signals for the MDM. In addition, scanning wire current and position signals are filtered and sampled at 10 kHz using a MAXIM 14 bit ADC.

Parameter limits such as beam width or position can be defined so that interlocks may be generated in case the measured parameters go over these limits.

MDM

The MDMs decode the information from the WIPAM, in particular the profile monitor to be activated and the rotation direction of the motor. They provide the necessary power for driving the DC motors, as well as the 10 V reference signal for the position potentiometer measurements. The logarithmic conversion of the current from the scanning wire is also performed in the MDM: 800 mV correspond to a decade with a 0 V output voltage corresponding to 1 μA. Almost 8 decades can be measured this way.

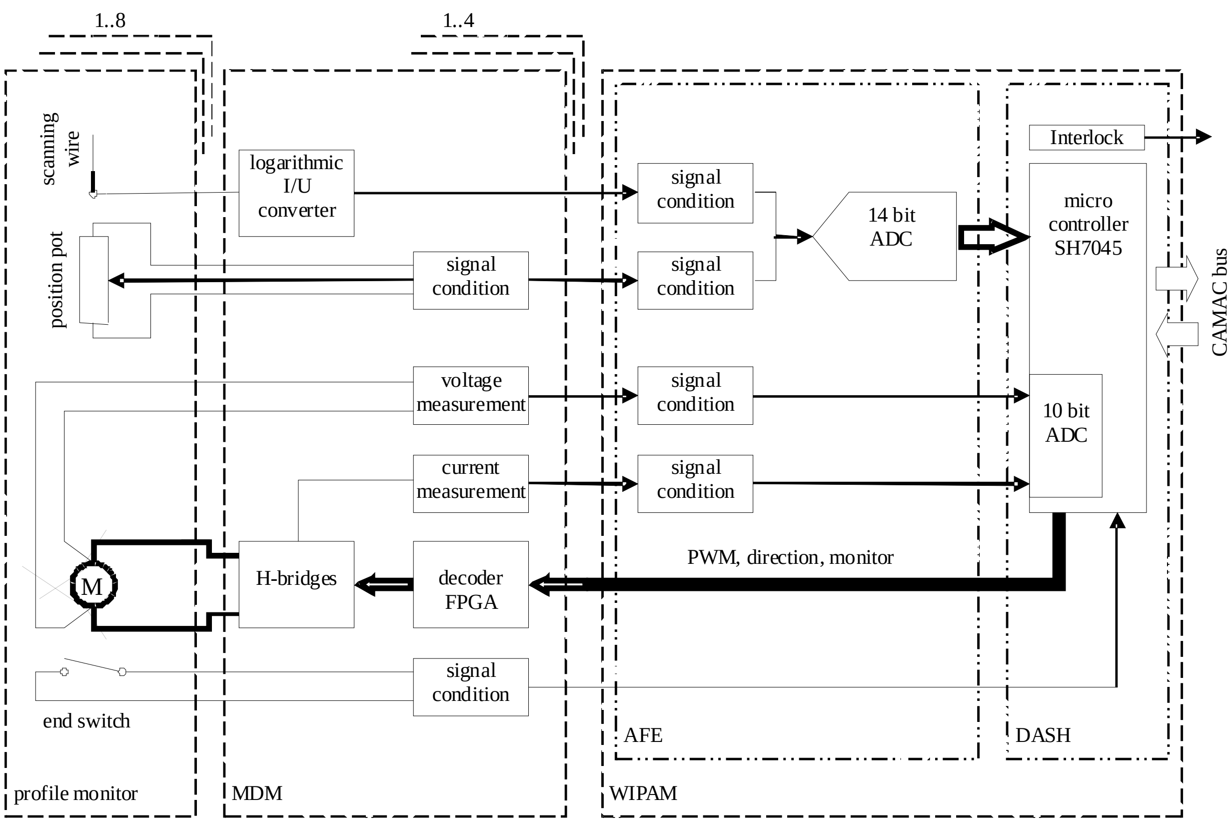

Figure 1: Conceptual overview of the system showing the main system elements.

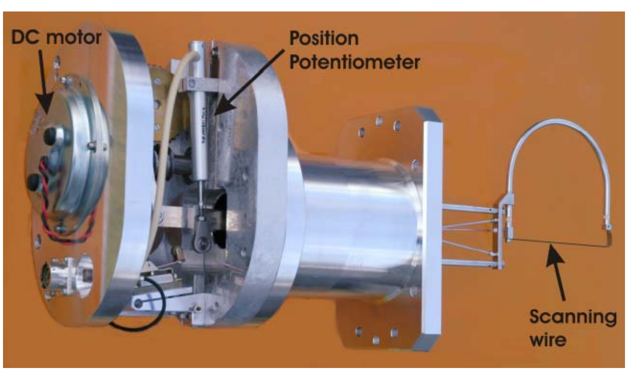

Figure 2: Profile monitor controlled by the system.

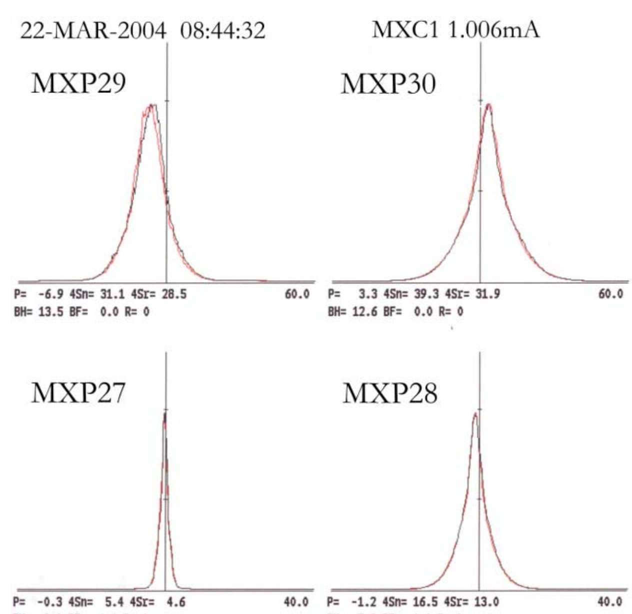

Figure 3: Beam profile measurements with the new electronics showing the beam broadening in the horizontal (MXP29) and vertical direction (MXP30) before the BX2 beam dump

NEWLY INSTALLED CURRENT MONITOR

A current monitor has been built to replace an early prototype installed a few years ago.

Main features

The current monitor consists of a TM01-mode coaxial resonator (reentrant cavity, quality factor Q ~2000). The cavity is tuned at 101.26 MHz, the 2nd harmonic of the proton beam pulse frequency. This frequency is used because of the better signal-to-noise ratio, the RF disturbance components being mainly at the odd harmonics (fundamental, 3rd, …). No significant shape dependency of the 2nd harmonic amplitude for relatively small beam pulses is expected [2]. The magnetic field in the resonator thus provides a direct measurement of the beam current. The monitor is made of aluminium, with a 10μm coating layer of silver to improve the electrical conductivity.

Currents from 0.5μA to 2.5mA can be measured using ~10 kHz analogue output bandwidth electronics. Drifts related to various thermal effects (resonator, cables, electronics) limit the measurement accuracy to ~5%, making almost weekly calibration necessary. The measurement precision is better than 0.5%. With this latest version a test signal can be fed into the cavity to check the integrity of the measurements.

Resonance condition and temperature dependence

For a given resonant frequency, using an external capacitor shunt reduces the actual length of the resonator. The corresponding resonance condition is given by:

$$\tan\left(\frac{2\pi L}{\lambda_m}\right) = \frac{\lambda_m}{2\pi c C_{total} Z_o} \qquad (1)$$

with L. the resonator length, C the capacitor shunt, Z_o the characteristic impedance of the transmission line, and λ_m the resonant wavelength.

Effect of temperature changes on the resonant frequency has been measured. The corresponding frequency drift is 106 kHz for a temperature change of 50°C (25 → 75°C). These measurements are in accordance with what can be theoretically expected using (1). Indeed, taking into account the thermal expansion coefficient (2.4 × 10^{-5} /°C), the changes in the resonator length and in the capacitor shunt, the drift was expected to be 105 kHz.

REFERENCES

[1] P.A. Duperrex, U. Frei, L. Rezzonico, "New distributed remote control fort he profile monitors", PSI Scientific and Technical Report 2004, Volume VI, p.18-20.

[2] R. Reimann & M. Rüede, "Strommonitor für die Messung eines gepulsten Ionenstrahls", Nuclear Instruments and Methods 129 (1975) 53.

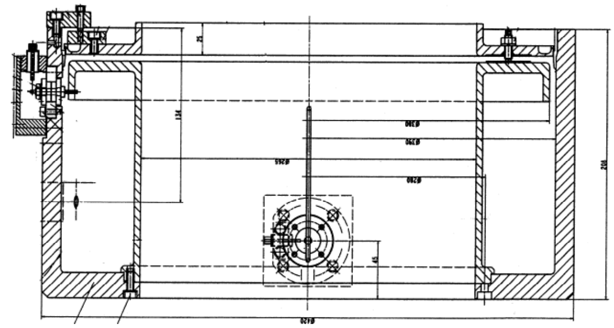

Figure 4: Drawing of the current monitor

Figure 5: Monitor during laboratory tests preceding the installation on the machine

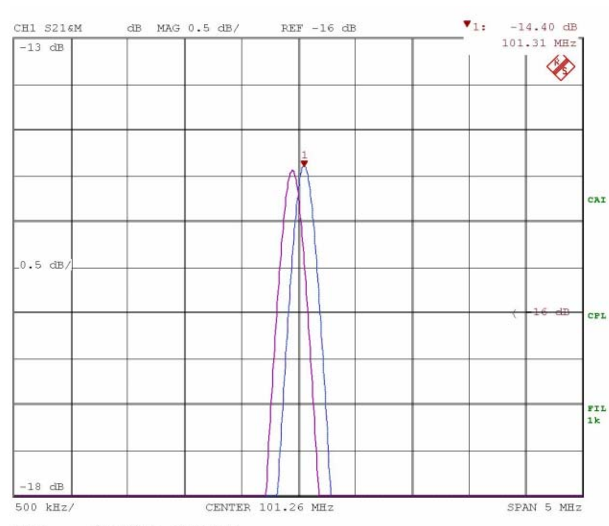

Figure 6: Resonance measurements at two different temperatures (25 → 75°C) showing a negative frequency shift for increasing temperature.