NEW DISTRIBUTED REMOTE CONTROL FOR THE PROFILE MONITORS

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A new remote control system has been designed for the numerous profile monitors of the proton accelerator facility. It is now in the implementation phase, the old control system being gradually phased out. The structure of the system, improvements compared to the old system and profile measurements are reported here.

INTRODUCTION

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

SHORTCOMINGS OF THE OLD SYSTEM

The existing profile monitor controlling system has been in operation for 20 years. It consists of 3 multiplexed systems controlling altogether 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. All the profile monitors of a beam line may be disabled due to a minor problem at the multiplexing level such as the current measurement board.

The wire current measurement of the old system relies on a linear circuit. In most cases, several profile measurements are required to get the correct amplifier gain setting. 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 analysis or time based filtering of the data is therefore hindered by the old system.

IMPROVEMENTS

The goals of the new remote control system were to remove these shortcomings, to provide a better control of the DC motor and at the same time to provide a more powerful diagnostic tool.

On the other hand, the profile monitor boxes and the cabling was to remain unchanged. The performance of the electromechanical devices is still satisfactory and their design has been improved over the years. The cost of replacement of hundreds of cables would have been prohibitive.

Improvements addressing these shortcomings are:

- A distributed system structure based on internally developed CAMAC boards, each controlling up to 8 profile monitors. The exact attribution of the monitors to a board depends on the beam line interlock distribution structure. Note that it would have been prohibitive (costs and space) to allocate one control system to a single profile monitor.
- A logarithmic current to voltage converter is used for the wire current measurement covering the whole operational range. With it a single scan is enough for a beam profile measurement and thereby possible damages to the scanning wire are minimized.
- The new control of the DC motor can adjust the motor speed to beam conditions: lower speed for low intensity beam or broad beam profile, higher speed for high intensity or narrow beam profile.
- Position and current measurement is performed with a dedicated 14 bit ADC for improved resolution and further off-line processing.

THE NEW SYSTEM

Overview of the system

Fig. 1 gives a conceptual overview of the system. It is made up of 3 subsystems:

- a CAMAC based WIPAM (**WI**re **P**rofile monitor **A**cquisition **M**odule) including the DASH **(D**ata **A**cquisition module with Hitachi **SH**2 microcontroller) back-end.
- up to 4 **M**otor **D**rive **M**odules (MDM)
- 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 this 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 gear ratio factor of 20 and taking into account the acceleration and deceleration phases, typical time for a scan ranges from 0.3 sec to 2 seconds.

The status of the rest position switch is continuously monitored for all the profile monitors to make sure that the 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. Based on this locally stored raw data, profiles with reduced resolution (only 400 points) are calculated for direct interpretation using the existing profile measurement programs. With the raw data it is also possible to perform some detailed analysis of profile structures and, for example, suppress possible 50 Hz line perturbations.

Parameter limits such as beam width or required position can be defined, if desired, 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. Currents from 100 pA to 1 mA corresponding to the range from -3.2 V until +2.4 V can be measured this way. One scan is then enough to obtain a meaningful measurement. This wouldn’t have been the case with linear amplifiers. The voltage and current signals from the motor are conditioned for further processing at the WIPAM stage.

The profile monitors

Fig. 2 shows a profile monitor before installation on the beam line. The DC motor, the potentiometer giving the wire position and the scanning wire are visible.

CALIBRATION

Before a profile monitor can be operated with the new electronics, some calibrations must be performed. Indeed, DC motor parameters such as internal resistance and effective counter emf per rpm vary from one motor to another. For instance, the internal resistance ranges from 1.5 to 2.5 Ohm for the X beam line. Since these parameters are used for the motor speed control, they have to be individually measured and taken into account in the WIPAM firmware. The procedure is performed with a dedicated CAMAC board locally driven by a LabVIEW program. During the calibration procedure the impedance of the cables between the monitor box and the MDM electronics is also measured. Depending of the cable length it ranges between 0.7 and 1.4 Ohm.

IMPLEMENTATION

The new system is being progressively implemented. It was important to gain experience with a limited number of profile monitors for which it was still possible to rapidly switch back to the old configuration in case of severe malfunction. For that reason, the beam lines X, Y and then W have progressively received the new electronics in 2004. It provided the necessary concept validation before the implementation could take place where changes are practically irreversible. Following the successful X, Y and W implementation, the beam lines H and B are receiving the new electronics during the next shutdown (SD05). The Inj.1 profile monitor electronics may then be replaced during the SD06.

Improved and proactive maintenance can be implemented with the new system. By measuring and keeping track of the electric power required to drive the DC motors, problems related to any anomalous electric power consumption could be detected as, for instance, with insufficient lubrication. Last year, the calibration phase also helped identifying monitors needing extra maintenance; for instance the MYP20 DC motor had to be replaced.

EXAMPLE OF RESULTS

Fig. 3 shows beam profile measurements performed with the new electronic control system in the horizontal direction (MXP27 & 29) as well in the vertical direction (MXP 28 & 30). These monitors are located before the BX2 beam dump. The relatively larg beam cross-section (MXP29 & 30) is indicative of the beam broadening before it reaches BX2.

ACKNOWLEDGMENT

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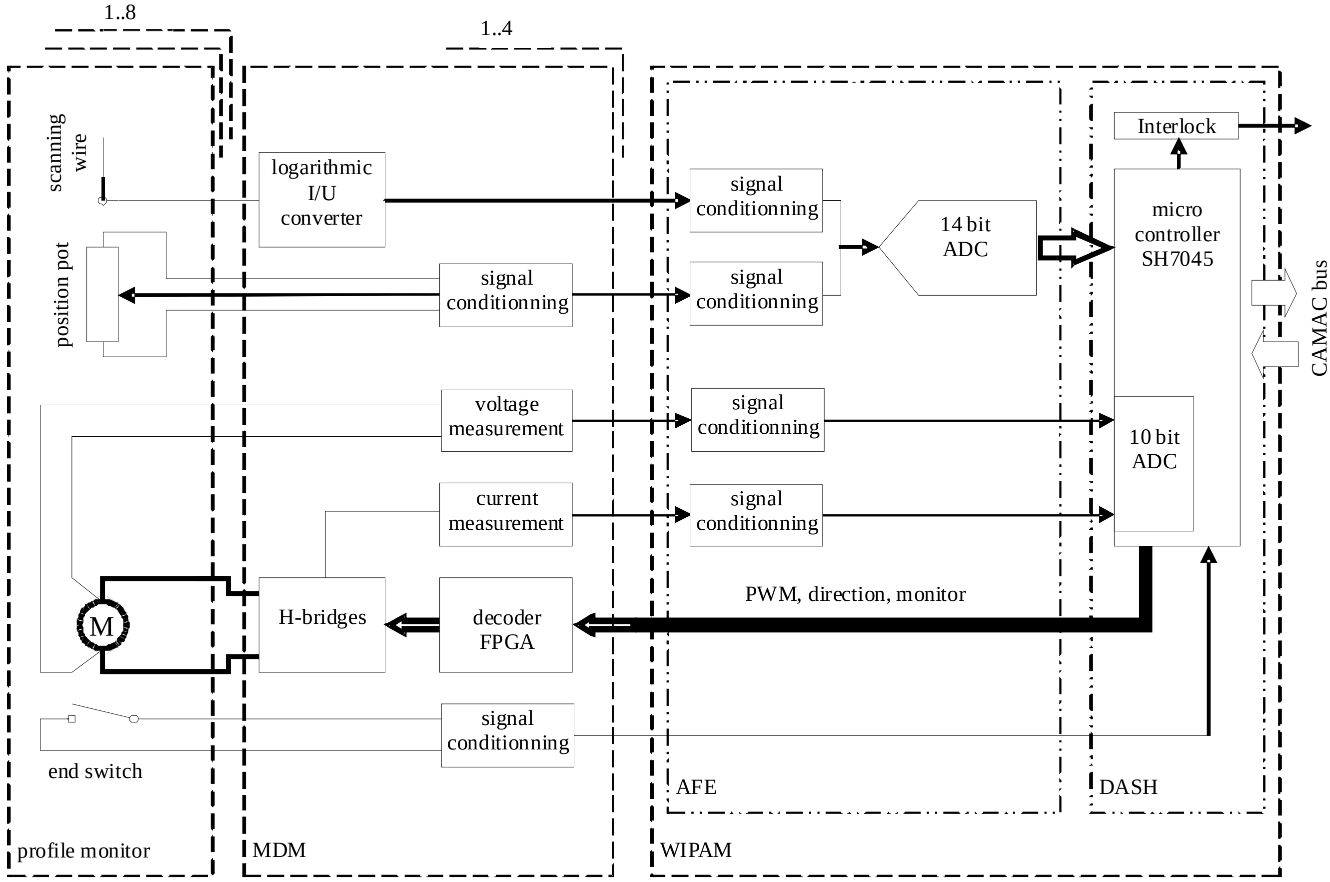

Fig. 1: Conceptual overview of the system showing the main system elements.

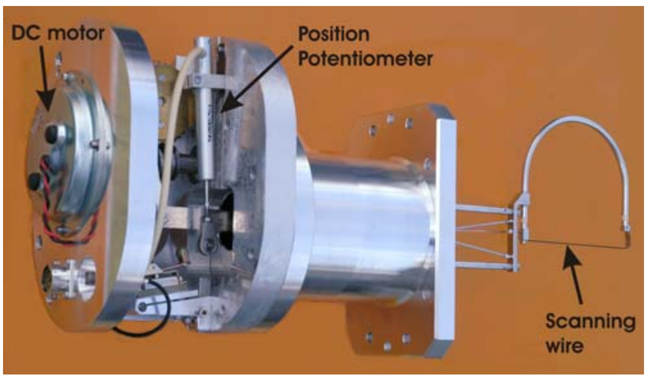

Fig. 2: Profile monitor controlled by the developed system.

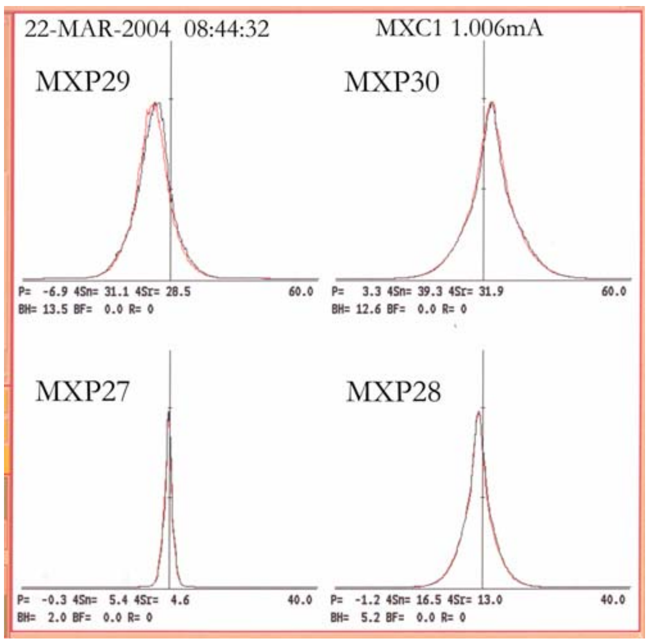

Fig. 3: Beam profile measurements with the new electronics showing the beam broadening in the horizontal (MXP29) and vertical direction (MXP30) before the BX2 beam dump.