BEAM DIAGNOSTIC INSTRUMENTATION FOR TIFR-BARC LINAC

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Abstract

A large number of locally developed Faraday Cups (FC) and Beam Profile Monitors (BPM) have been installed in the beam lines at TIFR-BARC superconducting LINAC booster. The microcontroller based control electronics for these beam diagnostic devices have been developed, installed and successfully commissioned for all the diagnostic stations in the accelerator and user beam lines.

Each control station with an unique station address can control up to eight diagnostic devices. Signal multiplexing, Analog to Digital conversion with a 12 bit ADC and auto gain selection are main features of the faraday cup controller. A BPM controller can simultaneously control and monitor any two BPMs out of eight connected devices. Signal multiplexing, pre-amplifier gain selection, and a 3-phase DC motor drive with speed ramping are some of the basic features of the BPM controller. These control systems communicate with the control room PC on a RS232 communication line through a Serial to Ethernet switch.

INTRODUCTION

A superconducting linear accelerator, indigenously developed to boost the energy of heavy ion beams delivered by the Pelletron accelerator at Mumbai, has been operational since July, 2007. The heavy ion beam needs to be transported to various user stations over a large distance of 20 to 50 m. A periodic array of beam diagnostic devices monitoring beam intensity and profile is essential for optimal beam transport. More than twenty diagnostic boxes are mounted in LINAC accelerator and user beam lines for this purpose. A diagnostic box consists of a Faraday Cup, BPM and adjustable pair of X-Y slits. The remote control and monitoring of FCs and BPMs is necessary for optimization of beam on the target. Several of earlier instrumentation developments have been reported previously. The instrumentation control is continuously upgraded for better performance.

FARADAY CUP CONTROLLER

An eight channel microcontroller based addressable local control station (LCS) has been developed for control and readout of the Faraday Cups (FC). This enables the FC movement (in/out), status read-back and the preamplifier gain selection. Commercially available Danfysik make preamplifiers are used to measure the beam current. The preamplifier gives 0-5 V output for the selected range. The preamplifier output signals are multiplexed in the LCS so that only the selected FC information is sent to the control room. An analog signal is converted into digital signal using 12 bit ADC. If the range selection is necessary, then controller changes the range relay of Danfysik preamplifier. Available beam current measurement range in LINAC is 0.1nA to 1uA. The Faraday cup in/out operation is done by a local power relay. The local relay control is done through an open collector transistor IC in the LCS unit. The LCS can be used in two modes, local and remote. In the local mode, 4*20 LCD display and 4*4 matrix keyboard are provided for monitoring and control. In the remote mode the LCS can be controlled and monitored from the master control station (MCS) in the control room, via RS-232 serial line through MOXA make serial to Ethernet switch [1]. Two identical LCS for faraday cups have been installed in LINAC and are fully functional.

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BPM CONTROLLER

As mentioned earlier, several (20 no.s) locally developed BPMs have been installed in beam lines at the Pelletron Linac Facility, Mumbai [2]. A local BPM utilizes a 3 phase DC motor and magnetic coupling. Due to the magnetic coupling, the rotating torque requirement is higher than that of the commercial BPMs. The BPM driver design has been done taking into account the higher torque requirement. Further, speed ramping is also incorporated in the design. The BPM controller (LCS) is a combination of A) the BPM selection and control unit and B) the BPM driver unit.

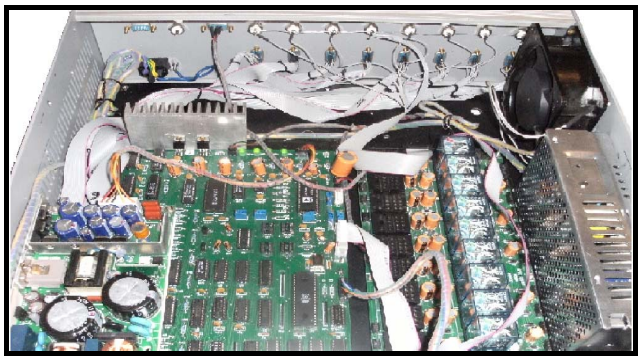

Figure 1: A picture of Faraday cup controller Board

A. BPM selection and control unit

An addressable 8051 microcontroller based control unit can simultaneously select and control any two of connected BPM's. Selection of a BPM involves assigning

of the particular BPM to the driving channel (CH1 or CH2), the BPM signal selection through an analog multiplexer and the BPM preamplifier selection for gain change. Preamplifier gain range selection varies from 1nA to 1μA. The control unit communicates with the driver unit on hard wires and with the control room PC on RS232 communication line through MOXA. In local mode, 4*20 LCD display and 4*4 matrix keyboard are provided for monitoring and control. The multiplexed BPM signal is made available for viewing in the control room.

B. BPM driver unit

The BPM motor requires 24 volt, 3 phase signal for driving. An independent microcontroller is used here for the 3 phase sequence generation. The speed ramping is achieved with a slowly increasing driver frequency. The motor takes about 3 seconds to achieve full speed, starting from the rest position. The driver signal is amplified using transistors before connecting to a high current MOSFET stage. For compact design we have used SMPS power supplies.

The main challenge in this design was to drive two BPMs simultaneously with high current MOSFET switching. The problem was overcome using two separate SMPS power supplies with proper isolation between two channels. The EMI filters are used in AC as well as in DC lines for spike suppression. It should be mentioned that use of EMI filters in DC line is highly effective spike suppression, particularly with SMPS.

Two such control stations have been developed and installed in the beam lines. Monitoring and control of any two BPMs is very convenient for beam tuning. For example, it enables simultaneous beam profile viewing before and after any of the active elements.

CONCLUSION

Beam diagnostic instrumentation (FC and BPM) with computer control is successfully commissioned for all the diagnostic stations in the accelerator and user beam lines. We propose to develop the microcontroller based remote access slit control and readout, in a similar manner.

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