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A Beam Position Monitor Data Acquisition System for the New Fermilab 400 MeV Line

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Abstract

A VME based data acquisition system has been designed and installed for use in the new 400 Mev line connecting the Linac and Booster at Fermilab. Position information is digitized at rates up to 5 MHz during the entire beam pulse. Triggering can be accomplished by any of several mechanisms, including beam synchronized clock events, Tevatron clock events or an external trigger based on the chopper power supply trigger. Scaling and averaging are done locally. The results are returned to the ACNET control system via the Token Ring network.

I. INTRODUCTION

The Fermilab Linac is being upgraded to deliver 400 MeV beam to the Booster¹. This requires a redesign of the transfer line into the Booster. The new transfer line will include beam position monitors. This paper will describe the hardware and software included in the data acquisition system for the beam position detectors in the 400 MeV transfer line.

There are a total of 26 beam position detectors each of which have both horizontal and vertical pick-ups. Some of these are actually located in the Booster and are used in the Booster BPM system as well.

The position and intensities are digitized at a 5MHz rate during the beam pulse. The length of the beam pulse will vary depending on the number of turns injected into the Booster. A single turn of Booster beam requires a 2.8 microsecond pulse. Individual samples are available for display as well as the average position, position sigma and average intensity for each beam pulse.

Unlike the other beam position monitor systems at Fermilab, the scaling of the position signals as well as averaging is done locally in the microprocessor. Also, any offsets needed are applied at the microprocessor level.

II. HARDWARE

A. Overview

The digitization is accomplished in two VME crates each of which includes a processor board, system services module², memory board, Token Ring³ interface board, universal clock decoder board and several digitzer boards.

The system services module is a Fermilab designed board that includes a bank of dot matrix displays, led displays and switches for diagnostic purposes. The switches are also used to set the token ring address for the crate. The SSM board has a multi-function peripheral chip which is used to generate interrupts from external signals. The universal clock decoder is a Fermilab designed board that decodes Tevatron and Beam Sync clock events. The on board state machine is programmed to produce the proper VME bus interrupts in response to clock events. Process scheduling interrupts are also provided by the U.C.D. board.

B. Digitization

The digitizer boards are the four channel, 5 MHz quick digitizer boards⁴ designed at Fermilab which are now commercially available. The position signals are digitized with 12 bits of resolution and several intensity signals are also digitized. Each digitizer board has 512 Kbytes of memory available. Therefore, 64,000 position or intensity samples can be stored from each detector before the information is over-written..



Figure 1. Beam Position Monitor Crate

C. Timing

The digitizers are gated on with a pulse that is derived from the chopper power supply trigger and conditioned by intensity. In this way, the beam position is monitored for the entire length of the beam pulse no matter how many turns are injected into the Booster. On the falling edge of the gate signal, a VME interrupt is generated causing the digitized data to be read.

In the case of the detectors surrounding the Booster injection point the gate pulse is active during the first turn in Booster. We will also attempt to read the position information from the detectors in the circulating beam for as long as there is sufficient 200 MHz structure. These detectors are digitized on an additional channel with a different gate pulse. The additional gate pulse is delayed by one turn and the length of the gate is determined by a timer.

III. SOFTWARE

A. Microprocessor

In addition to a commercial operating system, there are several pieces of code written in house for these systems. These include Object Oriented Communications⁵, the $ACNET^{6}$ and Token Ring interfaces, as well as the code that

^{*} Operated by Universities Research Association under contract with the U.S. Department of Energy

reads the digitizers. Each of these tasks is written in C and runs under control of the operating system.



Figure 2. Beam Position Monitor Operation

The task that reads the digitizer boards is connected to the interrupt generated by the falling edge of the gate signal. The purpose of this task is to average and scale the positions, calculate the standard deviation of positions, average and scale the intensities, and record the date, time and memory location of the raw data.

A buffer including the date, time and memory location of the position data for the last 4000 Booster cycles is kept. This allows detection of beam position drifts over time.

In addition, position information is checked against variable limits. If the limits are exceeded, alarms are sent to the control system.

B. Application Program

The position information is transmitted to the accelerator controls system by way of Token Ring, and an application program will display the information in graphical form as well as numerically.

The positions are displayed in map form along with the respective magnets to facilitate tuning of beam position along the line as well as injecting properly into the Booster.

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