Meeting Minutes

Linac and 400 MeV Beam Position Monitor Upgrade

The Huddle Meeting Room
Thursday, January 6, 2011
11:00 am to 12:00 am

I. In Attendance:

Bill Pellico,	AD/Proton Source Head
Fernanda Garcia,	AD/Proton Source/Linac Head
Manfred Wendt,	AD/Instrumentation Engineer
Peter Prieto,	AD/Instrumentation Engineer
Nathan Eddy,	AD/Instrumentation Engineer
Charlie Briegel,	AD/Controls Front-End Programmer
Sten Hansen,	PPD/EED Engineer
Terry Kiper,	PPD/EED Engineer Associate
Craig Drennan,	AD/Proton Source Engineer

II. Introduction

The meeting was called to discuss the specification and design of new beam position monitor (BPM) electronics for the Linac and the 400 MeV accelerator beam lines. At the request of Bill Pellico and Fernanda Garcia, AD/Instrumentation has taken responsibility for designing, installing and commissioning the new system. Previous to this meeting AD/Instrumentation had requested and obtained some preliminary specifications from AD/Proton Source department and made some further investigation into the requirements for a new BPM measurement and data acquisition system. AD/Instrumentation had decided that an effective and economical solution would employ a NIM module design recently installed and tested with BPM's in the MTA experimental beam line.

The goal of the meeting was to give the Proton Source Department and opportunity to review the specifications for the BPM readout system and provide additional requirements that may not have been previously communicated. It was also an opportunity for the Instrumentation Department to present their plans for implementing the new system and consider the new details that came up in the meeting.

III. Presentation and Discussion of Specifications and Requirements

III.1 BPM's Targeted for the Upgrade

Craig Drennan presented some initial slides indicating the location of the BPM's in the Linac, the 400 MeV line and the Booster Injection area are that need to be instrumented. Manfred Wendt indicated that a different set of electronics are being considered for the BPMs in the Booster injection area that see both the injected beam from the Linac and the Booster beam throughout the Booster acceleration cycle.

III.2 Motivation for an Upgrade

Craig presented some slides listing Linac and 400 MeV BPM system specifications and requirements. A plot of the BPM position readings down the Linac was shown indicating that there is some uncertainty in the calibration of the current readings. Though day to day tuning of the Linac typically relies more on beam current and beam loss measurements, having more confidence in the accuracy of the beam position readings would provide much benefit in diagnosing beam line variations and problems. Additionally, the new electronics will eliminate repair part obsolescence issues that exist with the current electronics and establish support through the AD/Instrumentation department going forward into the next 15 years.

It was noted that it is important that the new measurement electronics be linear over the beam intensity range of the Linac and 400 MeV. The Linac has an intensity range of 5 milli Amps to 60 milli Amps, and automated beam steering programs need to work reliably and predictably over this range.

III.3 Specifications and Requirements

It was mentioned that a more detailed document is currently being compiled to capture the system specifications, requirements and other calibration and installation details. A request was made for comments and contributions to this document. The Linac and 400 MeV specifications table presented is given below. Note that this table, in these minutes, will not be kept up to date.

Parameter	Minimum	Typical	Maximum
Beam Intensity Range	5 mA	34 mA +/- 1 mA	60 mA
Beam Pulse Duration	2 usec	25 usec	60 usec
BPM Signal Frequency (Note 1)		402.48 MHz	
BPM Signal Amplitude Range			
Position Measurement Range		+/- 25 mm	
Position Rise Time (within 2%)			200 nsec
Position Modulation BW	3 MHz		
Sample Rate		10 MHz	
Position Resolution (Note 2)	0.25 mm		
Position Accuracy (Note 3)			
Long Term Position Stability		0.25 mm	
Beam Phase w.r.t. RF, Resolution	0.1 deg		
Beam Phase Modulation BW			

III.3.1 Input Signal Amplitude Range

Craig noted that the BPM input Signal Amplitude Range was not known, but Sten Hansen stated that they believed that the input signals were typically +10 dBm. No one offered a maximum and minimum signal input level.

III.3.2 Position Measurement Rise Time

The issue of the position measurement rise time specification was raised. Bill Pellico confirmed that it will be important to measure a relatively accurate beam position in the early portion of the beam pulse. Nathan Eddy believed that the 200 nano second specification (see table above) could be met and that a plot, he would present later in the meeting, would show this. Manfred Wendt, Sten and Nathan discussed some of the electronics design details amongst themselves such as input bandwidths, IF frequencies, and polar coordinate calculations. The conversation seemed to indicate that there may be a problem achieving a 200 nano second rise time, but 300 nano second might be possible.

Craig requested that a bench measurement of this parameter be made. The input signals for this test would simulate the signals resulting from the arrival of the beam at a BPM at a known position.

III.3.3 Position Accuracy

It was noted that the Position Accuracy specification depends to a very large extent on the mechanical surveying of the BPM detector in the beam line. No one has indicated what would be done with regard to surveying and alignment of the detectors.

III.3.4 Beam Phase Measurement

The beam phase measurement was discussed. It was specified that the beam phase be measured with respect to an RF reference signal with a resolution of 0.1 degree. It was stated by Sten that this would be challenging but was confident that it could be achieved.

For reference in this note, a 200 MHz signal has a period of 5 nano seconds and 0.1 degree of phase corresponds to 1.4 pico seconds.

Bill Pellico agreed that this is a challenging specification and that measurement accuracy (as opposed to resolution) at 0.1 degree level would not be possible due to, among other things, cable length variation due to temperature changes.

III.3.5 BPM Response to Notched Beam

Bill Pellico asked whether the presence of a notch in the Linac beam would cause ringing or other errors in the BPM measurements. Manfred estimated that, due to bandwidth limits, the electronics would be unaffected by notches less than 150 nano seconds in width.

III.3.6 Data Acquisition Requirements

Craig's slides presented a simple list of requirements for the data acquisition and delivery of data to the ACNET control system and control system applications. The list presented is given below with comments from the meeting.

1. Data acquisition of the beam position and intensity begins after an operator adjustable delay from the selected TCLK event.

In the discussion Bill stated that a distributed trigger synchronized to the 400 MeV Chopper On trigger should be used for the 400 MeV BPMs and similarly a trigger synchronized to the 750 keV Chopper On could be used for triggering the Linac BPMs. Nathan Eddy believed that they had had good results using TCLK as a trigger in other applications, but stated that the proposed electronics could accommodate any trigger Proton Source wished to use.

2. One intensity and two positions (horizontal and vertical) are reported for each BPM at a 15 Hz rate.

3. Intensities and positions are averages of a settable number of samples over the beam pulse.

4. A settable offset, given as a number of samples into the data, determines which samples are not used in the averages.

5. Delivery of every position sample for two operator selected BPM positions could be delivered at a 15 Hz rate. (600 samples = 10E6 sample/sec * 60E-6 sec)

6. One beam pulse average phase measurement from each BPM location delivered at 15 Hz.

7. Delivery of every phase sample for two operator selected BPM locations could be delivered at a 15 Hz rate.

8. For BPM's in the 400 MeV line, the first Sample will be synchronous to the 400 MeV Chopper.

A detailed document for the Chopper / BPM timing is provided in Beams-doc-3696-v1 in the Accelerator Division docDB document database.

III.3.7 DAQ Summary

In summary, for each 15 Hz cycle, for each BPM detector instrumented, we will want to have the following data delivered to ACNET.

1 each, 2 byte vertical position average
1 each, 2 byte horizontal position average
1 each, 2 byte beam intensity average
1 each, 2 byte beam phase average

And for two operator selected BPM's,

600 each, 2 byte position samples from the first BPM
600 each, 2 byte position samples from the second BPM
OR
600 each, 2 byte phase samples from the first BPM
600 each, 2 byte phase samples from the second BPM

It was stated by Nathan Eddy that the MTA boards could deliver the full set of position samples from one BPM per cluster. A cluster is a set of 5 modules linked on a common LVDS data bus with one module providing Ethernet communications.

There is then a question as to whether enough data could be delivered if both of the BPM's, for which the full sample records are being requested, are in the same cluster. At this point requirements for data acquisition need to be clarified and some more information on what the new BPM measurement system can deliver is needed.

IV. Presentation of the New BPM Electronics

Nathan Eddy presented a few slides providing information about the new "MTA style" BPM electronics. Nathan explained that the BPM electronics for the Linac would differ in a few respects, but offered that the currently available MTA modules could be used for testing some aspects of the new system. Manfred, however, stated that he would prefer that man power be focused on making the Linac version of the module available so tests can be done using the Linac prototypes.

IV.1.1 Comparison of MTA electronics to the Linac Version

There are many similarities between the MTA version and the Linac version. Specifically, the signal processing and data communications are much the same, and a great deal of firmware and software has already been written and tested.

There are some significant differences between the two versions. The BPM signal input, initial down conversion will be design to work at 401 MHz as opposed to 200 MHz. Also the new version will have new circuitry to make the phase measurement that has been specified.

IV.1.2 Module Layout and Configuration

Nathan pointed out that the new Linac BPM electronics module can provide digital inputs, digital outputs, analog (DAC) outputs, and a USB interface as well as an Ethernet connection.

Nathan presented a slide showing the connection of 5 modules linked in a cluster. From module to module, data is transferred over an LVDS link to a single module that implements the Ethernet interface to the control system.

IV.1.3 Data Delivery Information

The slide also stated

Readout speeds for 8 (1Kbyte + header) UDP packets

Provides all RAW digitized I/Q data for 20usec @25MHz

2.4ms for master and 7ms from single slave

IV.1.4 Cost and Schedule

Nathan presented costs for the crates, cabling and circuit components. He anticipates having 3-5 prototypes assembled for testing by Spring 2011 and 75 production modules available by the end of 2011.

The meeting adjourned at 12:05 pm.

Recording Secretary was Craig Drennan