A WIRE SCANNER SYSTEM FOR CHARACTERIZING THE BNL ENERGY RECOVERY LINAC BEAM POSITION MONITOR SYSTEM *

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Abstract

A stepper motor controlled wire scanner system has recently been modified to support testing of the Brookhaven National Laboratory (BNL) Collider-Accelerator department's Energy Recovery Linac (ERL) beam position monitor (BPM) system. The ERL BPM consists of four 9.33 mm diameter buttons mounted at 90 degree spacing in a cube with 1.875 inch inside diameter. The buttons were designed by BNL and fabricated by Times Microwave Systems. Libera brilliance single pass BPM electronic modules with 700 MHz bandpass filter, manufactured by Instrumentation Technologies, will be used to measure the transverse beam positions at 14 locations around the ERL [1]. The wire scanner assembly provides the ability to measure the BPM button response to a pulsed wire, and evaluate and calibrate the Libera position measurement electronics. A description of the wire scanner system and test result data will be presented.

INTRODUCTION

Many test stands have been fabricated to characterize BPMs in accelerators around the world [2, 3, 4].

During construction of the BNL Relativistic Heavy Ion Collider (RHIC), a wire scanner system was developed to characterize the stripline BPMs [5]. This system was recently modified to support characterization of the ERL button BPMs and associated electronics.

While a 10 ns wide pulse was sufficient for simulation of an ion beam and detection by the RHIC stripline BPM, a very narrow pulse of <1 ns is required to simulate an electron pulse for detection by the ERL button BPM.

Initially, the ERL BPM was simply placed in the existing assembly and driven with a 150 ps pulse from the Hyperlab Inc. HL9200 triggerable impulse generator. Two major problems were found. First, the narrow pulse did not pass through the transformer used in the impedance matching circuit of the existing wire assembly; and second, the length of the pulsed wire through the BPM was too long, creating a very noisy system. Touching cables or waving a hand near the assembly drastically changed the position measurements.

The major modifications to the assembly included removing the impedance matching circuit, minimizing the length of the pulsed wire through the BPM, and minimizing gaps in the pipe assembly enclosing the wire.

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WIRE SCANNER SYSTEM DESCRIPTION

A hardware block diagram of the wire scanner system is provided in figure 1 and photographs of the assembly are shown in figures 2 and 3.

A 0.01 inch dia. steel music wire is routed through the BPM under test and connected to x-y stepper motor assemblies at the top and bottom. A copper component with a V at one end is soldered to an N-connector for electrical connections to the wire at both ends (fig. 4).

The BPM sits stationary on a plate and the wire is moved via the top and bottom stepper motor assemblies with one micron position step accuracy. Function/pulse generators and a digital delay generator are used to synchronously trigger the Libera BPM electronics and generate simulated beam pulse trains. The pulse trains trigger an impulse generator to create short pulses (~150 ps) that are amplified via a 10 Watt power amplifier and applied to the wire.

The pulses on the wire send a charge to the BPM button pickups, and the Libera BPM electronic module is used to convert the normalized difference between two buttons to position for each plane.

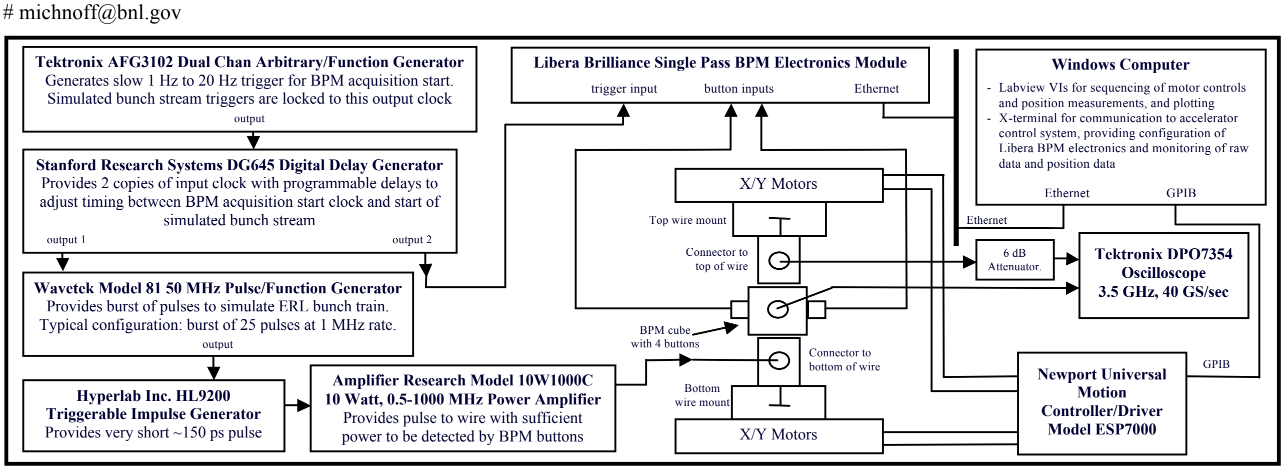

Figure 1: Block diagram of BPM wire scanner system.

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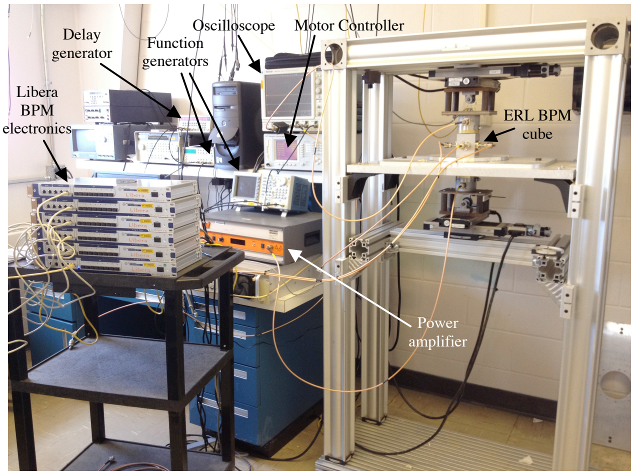

Figure 2: Wire scanner assembly with Libera BPM electronics and associated test equipment.

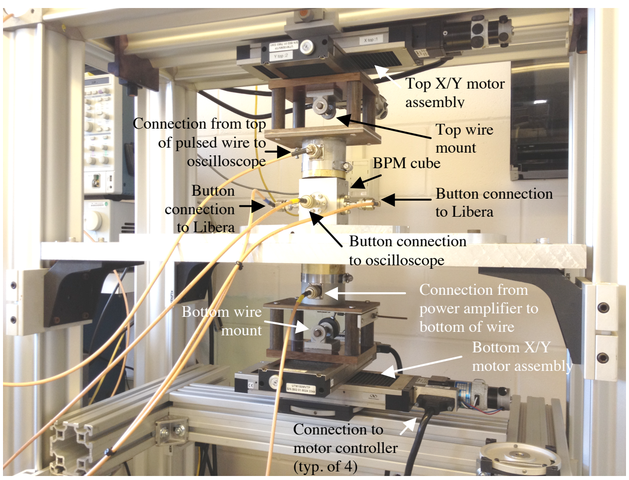

Figure 3: Wire scanner assembly.

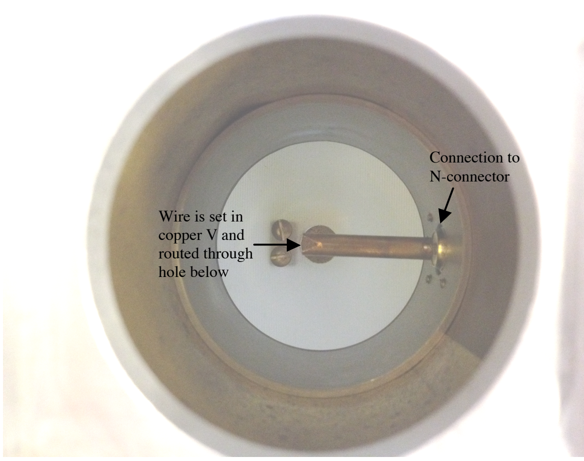

Figure 4: View of inside of wire assembly. Wire is set in the copper V that connects to the N-connector.

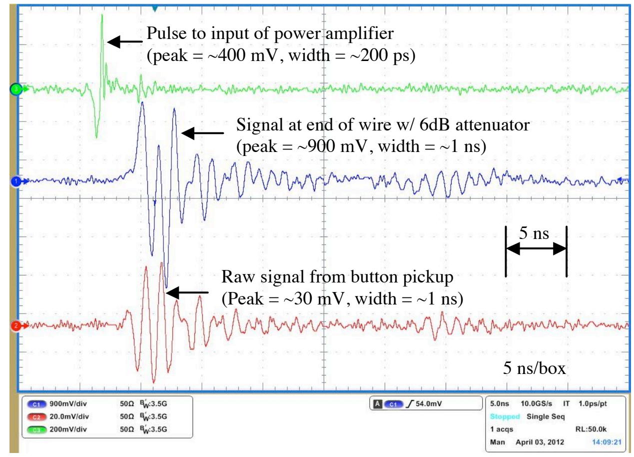

Figure 5: Plot of pulse applied to wire and button response.

A plot of the pulse from the impulse generator, the signal at the end of the pulsed wire after amplification, and the signal detected by one of the BPM buttons is shown in figure 5. Note that the signal at the end of the wire, which is very similar to the button response, has quite a bit of ringing. Although this configuration provides a decent signal for calibrating the electronics and mapping the BPM, the ringing signal does not adequately reflect a pulse that is generated by electrons. A single sharp pulse would be more desirable.

Figure 6 shows that ringing is also noted directly on the output of the power amplifier. This is likely due to driving the power amplifier with a very short pulse that has a frequency greater than the 1 GHz amplifier rating.

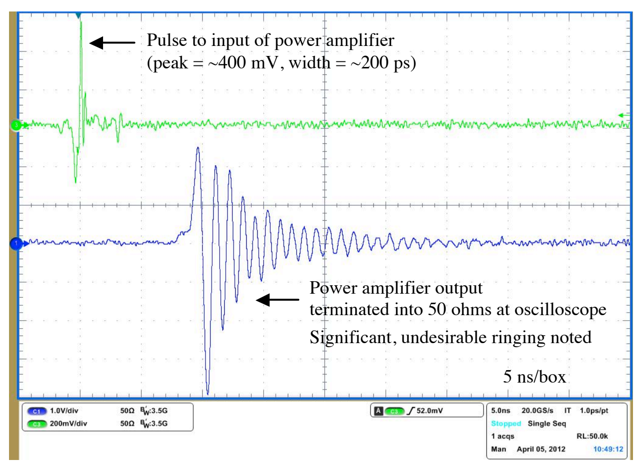

Figure 6: Plot of pulse into power amplifier and power amplifier output, with amplifier output bypassing wire setup and going directly to oscilloscope input.

A software module that resides on the Linux-based Libera electronic module was developed to allow communication via the standard RHIC control system software [6]. A Labview VI was developed to control the wire position, acquire position measurements from the Libera module and plot the scan data.

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TEST RESULTS

Figure 7 shows results of a wire scan from -10 mm to +10 mm. Prior to the measurement, the Libera module was calibrated by first moving the wire until the position read 0mm, then moving the wire to -10 mm and adjusting the Libera coefficient to produce a -10 mm measurement. The wire was then moved to +10 mm to confirm that the reading was +10 mm. Perfect calibration could not be achieved. A coefficient was selected that produced a value to within about 20 microns of the expected value.

Note from the plot that the response is nonlinear. At a wire position of about 5.5 mm from the center, the position reading is 650 microns away from the expected value.

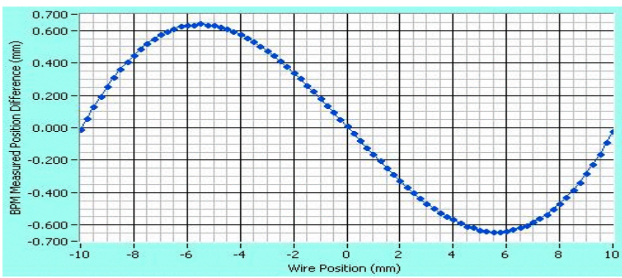

Figure 7: Difference between BPM measurement and wire position vs. wire position. For this scan the BPM electronics were calibrated to +10 mm and -10 mm.

Figures 8 and 9 show results from another scan after calibrating the Libera module to +/-5 mm. Note that the response is now better in the -5 mm to +5 mm range, but produces greater than 1mm error when the wire position is at 10 mm from the center.

Since the reported position varies significantly depending on the calibration coefficients, the required operating range must be carefully considered in order to provide the best possible measurements for the specific application. A nonlinear term is not currently available but could be implemented in the Libera module to provide a more accurate response.

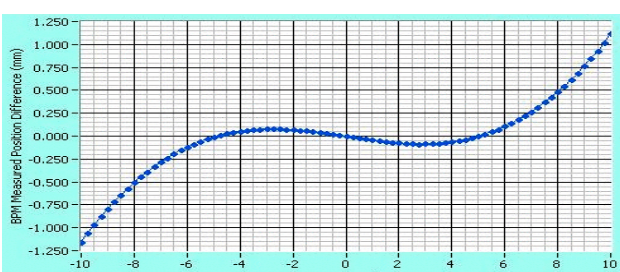

Figure 8: Difference between BPM measurement and wire position vs. wire position. For this scan the BPM electronics were calibrated to +5 mm and -5 mm.

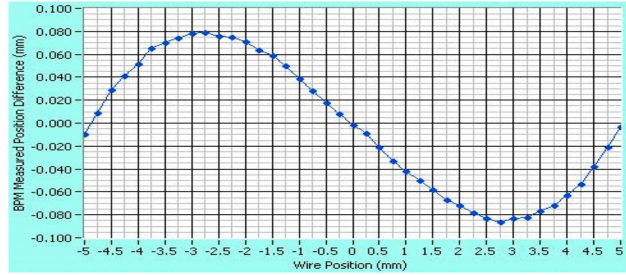

Figure 9: Zoom of figure 8 showing wire scan position error from -5 mm to +5 mm.

FUTURE ENHANCEMENTS

Several future enhancements are under consideration in order to improve the signal quality of the wire scanner system, including the following:

- Select a power amplifier that is better matched to the frequency generated by the 150 ps pulse. The Amplifier Research Model 10W1000C maximum frequency rating is only 1 GHz. This mismatch in equipment is likely the cause of the ringing power amplifier output.
- Design a system that properly matches the impedance between the 50 ohm power amplifier output and the BPM and wire assembly.
- Design a different method for mounting the wire to eliminate the wire stubs that currently exist above and below the connections to the N connectors.
- Add a second wire in the assembly to simulate multiple beams in the same BPM, a requirement for several projects at the BNL collider-accelerator facility, including the future eRHIC [7].

REFERENCES

[1] E. Pozdeyev, et al., “Diagnostics of BNL ERL,” Proc. PAC 2007, Albuquerque, New Mexico, USA.
[2] M. Cohen-Solal, “Design, test and calibration of an electrostatic beam position monitor,” Physical Review Special Topics – Accelerators and Beams, vol. 13, Issue 3, id. 03281
[3] G. Decker and Y. Chung, “Progress on the Development of APS Beam Position Monitoring System,” Proc. PAC 1991, San Francisco, CA, USA.
[4] Changbum Kim, “Test and Simulation for the Response of PLS-II Button-type Beam Position Monitor,” Journal of the Korean Physical Society, vol. 59, No. 2, August 2011, pp. 610-614.
[5] P.R. Cameron, et al., “RHIC Beam Position Monitor Assemblies,” Proc. PAC 1993, Washington, D.C.
[6] D.S. Barton, et al., “RHIC Control System,” Nuclear Instruments and Methods in Physics Research A 499 (2003) 356-371.
[7] V. Ptitsyn, et al., “High Luminosity Electron-Hadron Collider ERHIC,” Proc. IPAC 2011, San Sebastian, Spain.

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