OPTIMIZATION OF SMALL APERTURE BEAM POSITION MONITORS FOR NSLS-II PROJECT*

I. Pinayev[#], A. Blednykh, B. Kosciuk, O. Singh, BNL, Upton, NY 11973, U.S.A.

Abstract

The NSLS-II Light Source is being built at Brookhaven National Laboratory. It will provide users with ultimate brightness beam and full realization of its capabilities requires corresponding stability of the beam orbit. The small aperture beam position monitors (BPMs) will provide better sensitivity to the beam position but also requires thorough design. In this paper we present the results of the optimization including signal power levels and button heating.

INTRODUCTION

The standard beam position monitors for the NSLS-II storage ring is be mounted on an aluminum multipole vacuum chamber [1, 2]. The vertical gap is 25 mm and the distance between the button centers is 16 mm.

Small aperture BPMs will be installed in the straights around the insertion devices (ID). The ID beamlines are the most demanding for the beam stability, therefore, most of the small aperture BPMs will be installed on the special supports providing high mechanical stability [3]. The vertical gap is expected to be around 15 mm. Therefore the design of the small aperture BPMs will differ from the regular assemblies.

GEOMETRY OPTIMIZATION

The MATLAB script similar to [4] was used for optimization of the distance between centers of the buttons.

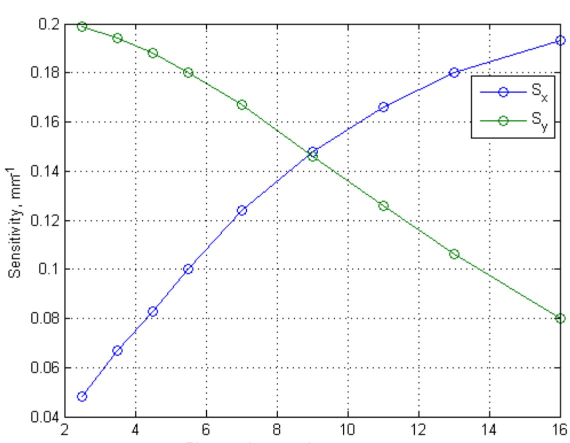
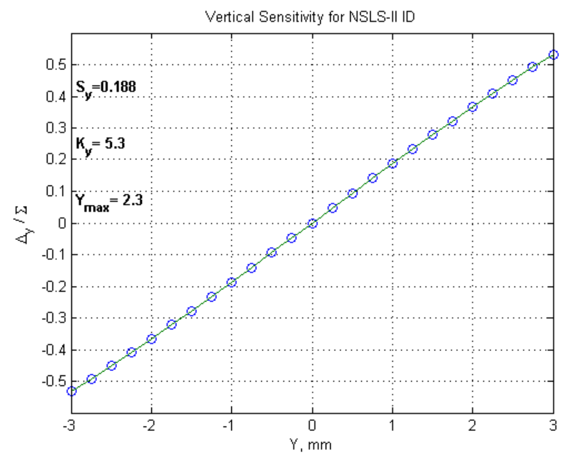
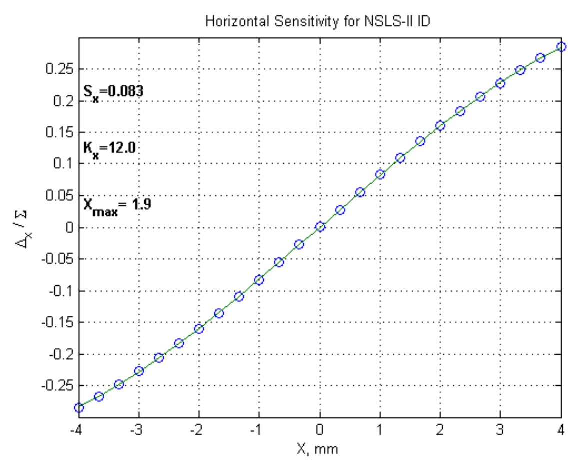


Figure 1: Dependence of sensitivity coefficients on the distance between the centers of the 4.5 mm buttons.

The results of the simulations are shown in Fig. 1. Based on the numerical the calculations we specified 4.5 mm separation between the button centers. In this case sensitivity to the vertical motion doubles in comparison with the standard BPMs when horizontal is not changed. The rational for such choice is that the vertical beam size is much smaller and requirement for beam stability in the vertical plane are stricter. The dependence of difference over the sum signal for the chosen button separation is shown in Fig.2.



a)



b)

Figure 2: Dependencies of difference over sum signal for the geometry with 4.5 mm distance between button centers: a) for the vertical plane, b) for the horizontal plane.

The standard BPMs has separation of 16 mm and it is possible to reduce the distance down to the 9.6 mm. Further reduction is limited by the size of the SMA connector. However, it is possible to reduce the effective

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[#]pinayev@bnl.gov

distance by rotation of the BPM assembly as it was done at APS [5].

SIGNAL LEVEL ESTIMATION

The MATLAB script, has been used for a geometry optimization, also performs the evaluation of signal power for the on axis beam. With 500 mA circulating current will induce -8.2 dBm signal (at the RF frequency of 499.68 MHz) on the 4.5 mm diameter buttons installed on a vacuum chamber with 15 mm vertical gap. For a vacuum chamber with a 10 mm gap the power rises to -6.8 dBm. These signal levels are in line with standard BPMs. The trace of the BPM signal is shown in Fig. 3.

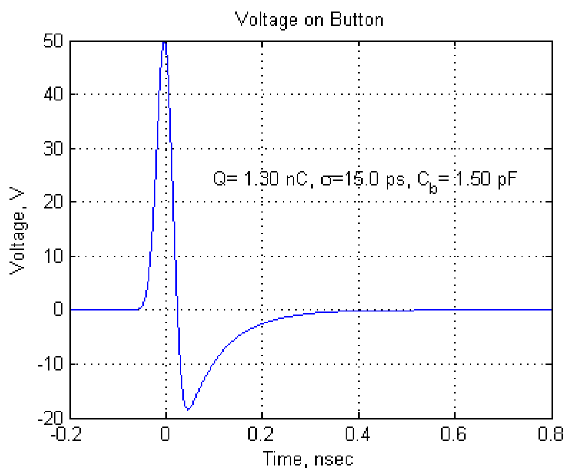

Figure 3: Trace of the signal from the button with 500 mA circulating beam.

IMPEDANCE OF THE BPM ASSEMBLY

Since the small aperture BPM buttons are closer to the beam than the standard ones there is a concern of heating due to wakefields induced by the travelling bunch. As it was proposed in [6] figure-of-merit has been uses to estimate power dissipated in a button. Its value depends on vacuum chamber vertical gap, button diameter, bunch length, circulating current, number of bunches and the revolution frequency. The regular BPMs have FOM=809 with nominal beam (500 mA in 1000 bunches). The small aperture BPM with 4.5 mm diameter buttons has FOM=204 (460 for a 10 mm vacuum chamber) for the same conditions. So, the SA BPMs are operating in milder conditions mostly due to the smaller button diameter.

The final design will be performed according to the rules described in [7]. The button diameter was set to 4.47 mm. With 0.25 mm annular gap the frequency of the trapped mode will be between harmonics of RF frequency. The longitudinal impedance has been simulated using GdfidL code [8] and the results are shown in Fig. 4. The loss factor simulated for a 4.5 mm bunch length is 3 mV/pC and the expected power loss is 1.5 W.

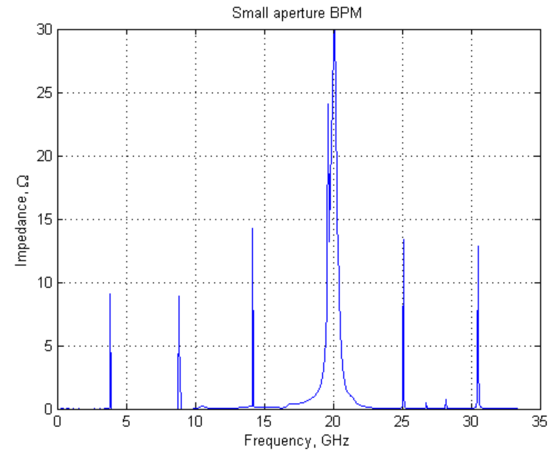

Figure 4: Real part of the longitudinal impedance of the small aperture BPM. The trapped mode resonance frequency is at 20.24 GHz. The small narrow peaks are due to the reflections from the unmatched ports.

CONCLUSIONS

The optimized small aperture beam position monitors provide required sensitivity to the beam motion with signal level as regular BPMs.

REFERENCES

[1] I. Pinayev, O. Singh, R. Alforque, A. Blednykh, P. Cameron, V. Ravindranath, and S. Sharma, “Research and Development Program on Beam Position Monitors for NSLS-II Project,” EPAC’08, Genoa, June 2008, TUPCC082, p. 1245 (2008); http://www.JACoW.org.

[2] O. Singh et al., “NSLS-II Beam Diagnostics Overview”, PAC’09, Vancouver, May 2009, TU3GRI03.

[3] B. Kosciuk et al., “Development of High Stability Supports for NSLS-II RF BPMs”, PAC’09, Vancouver, May 2009, TH5RFP012.

[4] A. Olmos, F. Perez, G. Rehm, “MATLAB Code for BPM Button Geometry Computation”, DIPAC’07, Venice, May 2007, TUPC19, p. 186 (2007); http://www.JACoW.org.

[5] G. Decker, “Beam Stability in Synchrotron Light Sources”, DIPAC’05, Lyon, June 2005, ITWM01, p.233 (2005); http://www.JACoW.org.

[6] P. Cameron and O. Singh, “Comparative Study of Button BPM Trapped Mode Heating” PAC’09, Vancouver, May 2009, TH5PFP081.

[7] P. Cameron, A. Blednykh, B. Kosciuk, I. Pinayev, V. Ravindranath, and O. Singh, “BPM Button Optimization To Minimize Distortion Due To Trapped Mode Heating”, PAC’09, Vancouver, May 2009, TH5RFP011.

[8] W. Bruns, GdfidL code; http://www.gdfidl.de