OPTIMIZATION FOR TAIWAN PHOTON SOURCE ELECTRON BEAM POSITION MONITORS THROUGH NUMERICAL SIMULATION

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Abstract

One of the key steps toward successfully building the newly proposed 3rd generation synchrotron radiation research facility, Taiwan Photon Source (TPS), is to optimize the design of the high resolution electron beam position monitors through numerical simulation. With more advanced electromagnetic simulation tool like MAFIA tailored specifically for particle accelerator, the design for the high resolution electron beam position monitors can be tested in such environment before actually fabricated and physically tested. The design goal of our high resolution electron beam position monitors is to achieve 0.1 micron resolution if allowed by engineering limitations. The design consideration to achieve this 0.1 micron resolution goal will also be discussed. The first design has been carried out and the correlated simulations were also carried out with MAFIA. The results are presented and discussed here. Sensitivity as high as 200 has been achieved at 500 MHz. Further study will also be described.

INTRODUCTIONS

Electron beam position monitor (EBPM) has been used as the major tool for electron beam track monitoring and also a feedback tool to correct beam track back to desired track. Hence it is one of the major steps to design EBPMs that can fit well to be used with the newly designed machine. With the newly proposed 3rd generation synchrotron radiation research facility, Taiwan Photon Source (TPS), thoroughly study on the design and numerical simulation for the high resolution electron beam position monitors is one of the key steps toward the success of building one such facility. With electromagnetic simulation tool like MAFIA, the design for the high resolution electron beam position monitors can be tested before actually doing any prototype experimental test. The design goal of our high resolution electron beam position monitors is to get the best resolution through sensitivity and signal optimization.

The paper is organized as follows. Since the mechanical design has been presented in another paper [1], it will not be described here. Also presented in the previous paper [1] is the definition and differences of resolution and sensitivity of electron beam position monitors. Here the simulation results will be presented and discussed. A summary will be given in the last section.

SIMULATIONS

Parameters Chosen to be Varied

The lattice design of TPS has been described in previous published paper [2]. To achieve the required emittance, a carefully designed and considered EBPM button has to be simulated first in MAFIA program. As described in the previous paper [1], SLAC designed button has been used the first model for this optimization [3]. The parameters chosen to be varied in this optimization are (1) the distance between the button centre and the vertical central plane, (2) the size of the gap between button and the surrounding shell, and (3) the size of the button.

The Distance Between the Button Centre and the Vertical Central Plane

The distance between the centre of the button and the vertical central plane has been varied from 6.5mm to 8.5mm in 0.5mm step. In the simulations, the test beam has been place on the centre, 0.5mm, 1.0mm, 1.5mm, and 2.0mm toward x and y directions of beam pipe. The gap size between the button and the shell was fixed at 0.5mm and the button size was fixed at 10mm in diameter. The results for button signal and sensitivity are shown in Figs. 1 (a) and (b).

The Size of the Gap Between Button and the Surrounding Shell

The gap size between the button and the surrounding shell has been varied from 0.25mm to 1.00mm in 0.25mm step. In the simulations, the test beam has been place on the centre, 0.5mm, 1.0mm, 1.5mm, and 2.0mm toward x and y directions of beam pipe. The distance between the button centre and the vertical central plane was fixed at 7.5mm and the button size was fixed at 10mm in diameter. The results for button signal and sensitivity are shown in Figs. 2 (a) and (b).

The Size of the Button

The size of the button been varied from 8mm in diameter to 12mm in diameter in 2mm step. In the simulations, the test beam has been place on the centre, 0.5mm, 1.0mm, 1.5mm, and 2.0mm toward x and y directions of beam pipe. The distance between the button centre and the vertical central plane was fixed at 7.5mm and the gap size between button and surrounding shell was fixed at 0.5mm. The results for button signal and sensitivity are shown in Figs. 3 (a) and (b).

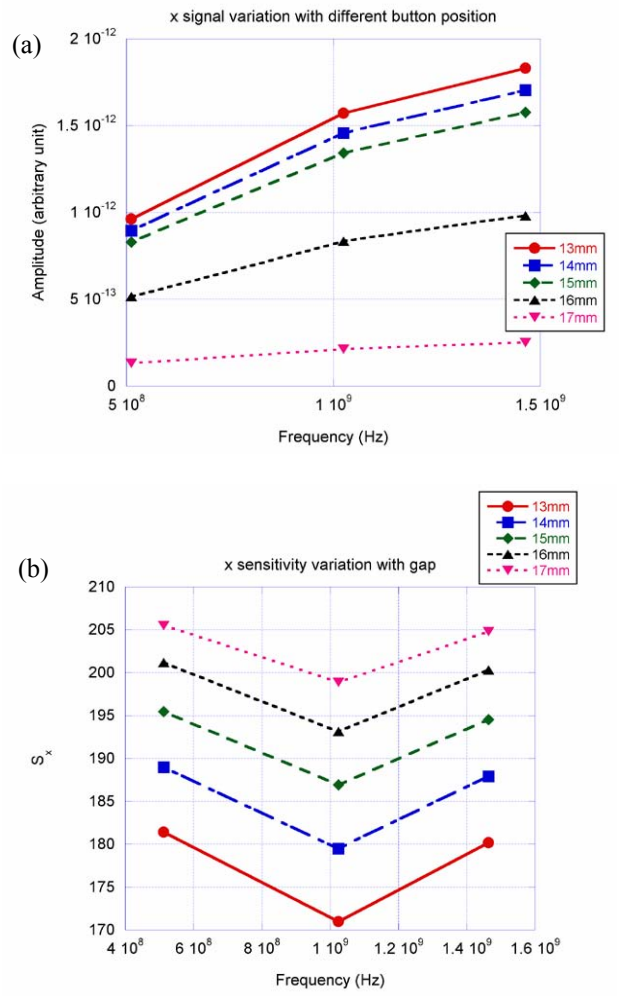

Figure 1: (a) Signal variation with different button positions at different frequencies when electron beam was located at 2.0mm in x-direction. (b) Sensitivity variation with the same conditions as in (a).

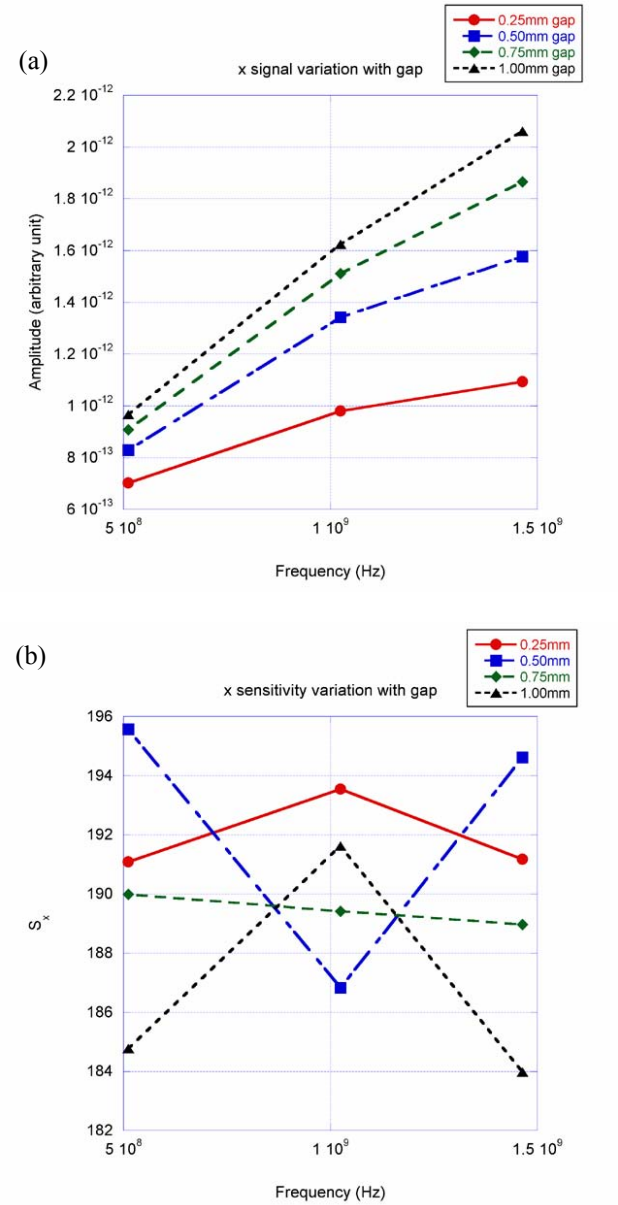

Figure 2: (a) Signal variation with different button gap size at different frequencies when electron beam was located at 2.0mm in x-direction. (b) Sensitivity variation with the same conditions as in (a).

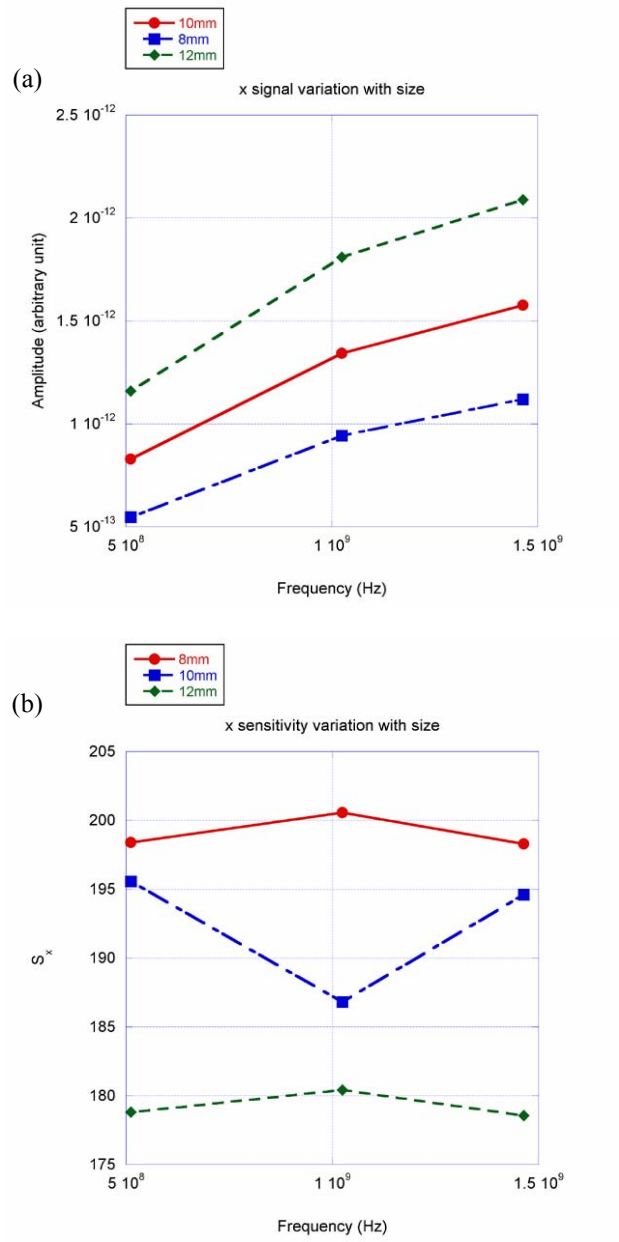

Figure 3: (a) Signal variation with different button size at different frequencies when electron beam was located at 2.0mm in x-direction. (b) Sensitivity variation with the same conditions as in (a).

DISCUSSIONS

From Fig. 1, it is easily to be seen that the button signal is higher as the button moved toward the center of the beam pipe. But the advantage is not so obvious with the distance goes below 7.5mm. With the consideration of welding technology in mind, it is wise to choose 7.5mm as the optimized distance.

From Fig. 2(a), the larger the gap is, the stronger the signal. It is also a choice between 0.5mm and 0.75mm gap size. We choose 0.5mm here.

From Fig. 3(a), the larger the button size is, the stronger the signal. But on the other hand, the sensitivity will become smaller as shown in Fig. 3(b). We choose 10mm in button diameter here.

CONCLUSIONS

From simulations with MAFIA software, we can understand how the signal and sensitivity change with button position, gap size between button and outer shell, and button size. According to our simulation, the TPS EBPM button will be located at 7.5mm from the centre plane with 0.5mm gap between button and outer shell and 10mm button size in diameter. It is also advised to use 1.5GHz electronics for signal processing.

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