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Mapping of Stripline Beam Position Monitor for the PEFP Beam Line

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1. Introduction

The Proton Engineering Frontier Project (PEFP) has developed the stripline beam position monitor (BPM) to measure transverse beam position in the 20-MeV and 100-MeV beam lines. The prototype of stripline BPM was designed and fabricated. To test characterization of BPM and calibrate it, we performed mapping, set of electrode responses to the moving wire signal induced by RF signal input. From this mapping position sensitivity and offset of BPM were obtained.

2. Position Sensitivity and Offset Calibration

2.1 Prototype of Stripline BPM Characterization

Stripline type beam position was selected to measure beam position in the PEFP 20-MeV and 100-MeV beam lines because it has large signal strength and enough sensitivity, compared with other type of BPM, to measure long bunches at the end of the beam lines [1]. The electrode length was determined as 70mm to make BPM have optimized output signal strength. Detailed characterization of prototype stripline BPM is described in the Table I.

Table I: Characterization of Prototype Stripline BPM

Distance between electrode = inner diameter of beam pipe	100mm
Electrode length	70mm
electrodes angular width	π/4
Electrode end	Short end
Theoretical Sensitivity from dimension	0.339dB/mm

2.2 Mapping System and Mapping Description

Calibration of the Beam Position Monitor is performed to obtain position sensitivity for conversion output voltage signal of BPM into position and offset, difference between mechanical center and electrical center of BPM [2]. It is also performed to verify the position linearity and resolution.

We calibrated the Prototype of stripline BPM by wire method which uses moving wire which is input RF signal as simulated beam using test stand, RF signal generator and oscilloscope.

Test Stand for wire method calibration was composed of 1.2mm diameter tungsten wire, manual stage to make the wire move vertically and horizontally, as it is shown in the Fig. 1. Manual stage can travel up to 13mm and has 10um resolution. For better shielding from outside electromagnetic interference and low line loss, RG214 with N-type connector in the transmission RF signal to the wire and Heliax cables in the transmission from BPM electrode to oscilloscope were used. BPM was fixed by ISO single wall clamp.

Fig. 1. Test Stand to calibrate stripline BPM

The coupling between wire and BPM electrode was approximately -38dBm for 350 MHz RF signal when the wire is at the center. 15dBm, 350MHz RF signal was placed on the wire during the mapping and BPM electrode responses were measured to the wire signal for centered beam, -6mm and 7mm displaced beam from the center.

2.3 Mapping Result

Log-ratio processing which shows better linearity results than sigma-del processing and AM/PM method was used to calculate position sensitivity and offset. [3], [4]. The results of obtained position sensitivity and offset are described in the Table II and Table III.

Table II: Horizontal Position Sensitivity and Offset

Vertical Displacement(mm)	Horizontal Position Sensitivity (dB/mm)	Offset(mm)
-6	0.4647	-1.3273
0	0.4612	-1.2196
7	0.4520	-1.3212

Table III: Vertical Position Sensitivity and Offset

Vertical Displacement(mm)	Horizontal Position Sensitivity (dB/mm)	Offset(mm)
-6	0.4645	-2.4762
0	0.4661	-2.5134
7	0.4585	-2.4606

Position sensitivity which was obtained in the mapping has differences more than 30% from the theoretical results. It comes from the disregard of higher order terms in the theoretical sensitivity formula, the fabrication error like block location error and the reason that theoretical sensitivity was calculated under the assumption BPM is 2-dimensional.

The offset, difference mechanical center and electrical center of BPM electrode, denotes the accuracy of BPM. The requirement of PEFP beam line BPM accuracy is 1.5mm, 3% of beam pipe radius. The accuracy of horizontal direction results is within the requirement, but the accuracy of vertical direction result does not satisfy the above requirement.

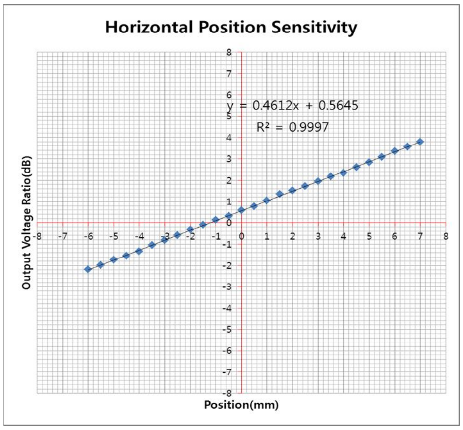

Fig. 2. Horizontal Position Sensitivity measured on the axis for centered beam

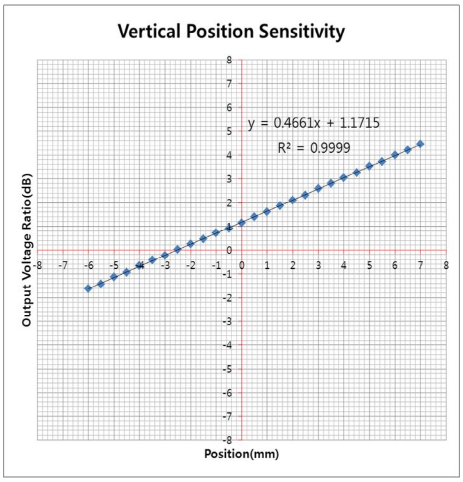

Fig. 3. Vertical Position Sensitivity measured on the axis for the centered beam

Horizontal and vertical position sensitivities for the centered beam are described in the Fig. 2. and Fig. 3. It shows mapping results have good linearity in the mapped range. Comparison between sensitivity for centered beam and sensitivity for displaced beam is described in the Fig. 4.

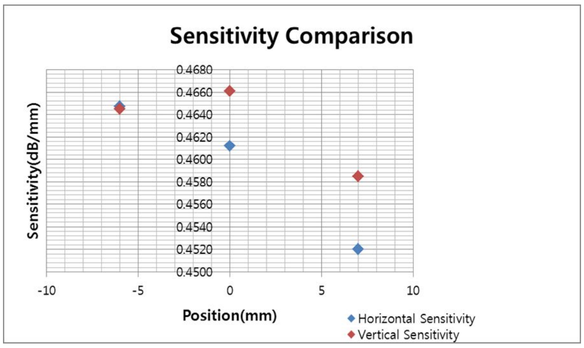

Fig. 4. Sensitivity Tendency in the Position Variation

3. Conclusions

We obtained position sensitivity and offset from the wire method mapping. In the range of mapping, the results show good linearity enough to satisfy the beam line beam position monitoring requirement. However, the aperture is much larger than the range which mapping was done and higher accuracy for vertical direction moving is required than current results in the PEFP beam line BPM. Therefore, we have a plan to fabricate another test stand which has a better accuracy to satisfy the requirement of beam line BPM and perform additional calibration to cover full range of stripline BPM.

Acknowledgement

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