Low Power Test of the PEFP Prototype Beam-line BPM and Linac BPM

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1. Introduction

The development of the beam position monitor (BPM) is in progress for the linac and beam lines of the proton engineering frontier project (PEFP). We selected the strip line type BPM for the proton linac and beam-line in the energy range between 20 MeV and 100 MeV. After fabrication of to the BPMs, we checked their electrical performance in the low power test at the test stand. This paper summarized calibration procedure and results of the measurement.

2. Low power test of the BPM

The BPM cross section was designed with the SUPERFISH code and the matching section to the feed through was designed by the MWS code [1]. The design parameters of the BPMs are shown in table 1, 2.

Table I: Design Parameters of Beam-line BPM

Electrode inner diameter	100 mm
Electrode thickness	2 mm
Electrode angle	45 degree
Electrode length	70 mm
Electrode gap	15 mm
Feed through	SMA type
Signal frequency	350 MHz

Table Ⅱ: Design Parameters of Linac BPM

Electrode inner diameter	20 mm
Electrode thickness	2 mm
Electrode angle	60 degree
Electrode length	25 mm
Electrode gap	3.5 mm
Feed through	SMA type
Signal frequency	350 MHz / 700 MHz

We performed the offset calibration and position sensitivity by measuring the electrode voltage signal in the low power test at the test stand as shown in Fig. 1 [2].

Fig. 1. Test stand for low power test

2.1 Test results of the beam-line BPM

First of all, we measured the inter-electrode coupling by putting the 350-MHz RF signal to the port4 and measuring the response signals at port 1, 2, 3. The same signal amplitude was measured at port 1 and port 3 because they are equally separated from port 4. The smallest signal was measured in the longest distance port 2. The inter-electrode coupling results are given in Table 3. We found that the measurement results are well agreed with the calculations.

We also measured electrode-center coupling in order to check whether the electrical center is located at the geometrical center. We used the 350 MHz RF signal radiated from a 3-mm-diameter copper instead of the beam. The copper wire located at the geometrical center of the BPM. The four electrodes of the pickup detect the radiated signal of the copper wire. The measurement of electrode-center coupling results are summarized in Table 4. It must be measured same value in symmetrical structure 4 ports of BPM. When compared to designed value -20 dB, port 2, 3, 4 signals measured little small due to the difference of electrical center and physical center.

Table Ⅲ. Measurement of Inter-electrode coupling of the beam-line BPM

Electrode	Measurement	Simulation
S_{14} [dB]	-32.3	-32.1
S_{24} [dB]	-41.1	-42.5
S_{34} [dB]	-32.2	-32.1

Table Ⅳ. Measurement of electrode-center coupling of the beam-line BPM

Electrode	Measurement [dB]	Simulation [dB]
Port 1 (+X)	-20.3	-20.8
Port 2 (+Y)	-18.9	-20.8
Port 3 (-X)	-18.2	-20.8
Port 4 (-Y)	-18.5	-20.8

Next we performed the calibration of the BPM by varying the wire position. We compared the physical position with the electrical point by the log ratio method as follows,

$$\frac{R-L}{R+L}=\frac{4\sin\left(\frac{\varphi}{2}\right)}{\varphi}\frac{x}{b}+\text{high order term}$$

where φ is the angular width, b is the electrode inner radius, R and L are the measured electrode voltages. This formula assumed the cylindrical geometry and neglected the difference between the beam pipe radius and the electrode inner radius. We neglected the high order terms in the following calculation. Fig. 2 is the 2-dimensional mapping result of the beam-line BPM.

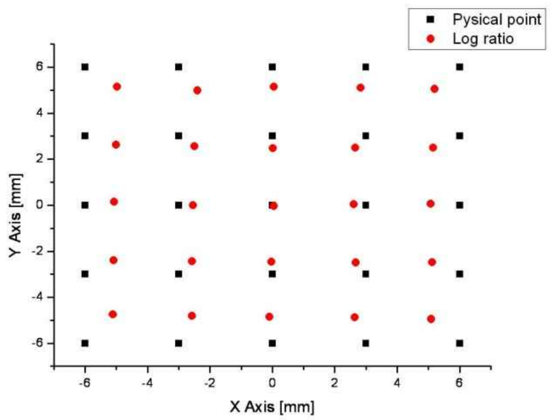

Fig. 2. 2-D Mapping of the beam-line BPM

The position sensitivity to convert the output voltage signal from the oscilloscope into the position is theoretically defined by [3]

$$S=\frac{160}{\ln 10}\frac{\sin\left(\frac{\emptyset}{2}\right)}{\emptyset}\frac{1}{b}+\text{high order term}$$

where ∅ is the angular width and b is the electrode inner radius. The beam line BPM theoretical position sensitivity is 33.91dB/mm.

2.2 Test results of the linac BPM

By using the same process as beam-line BPM, we measured inter-electrode coupling of linac BPM in 350 MHz and 700 MHz input signals. The results are summarized in Table 5. The measurement results are almost same as the simulation. The measurement results of electrode-center coupling for the Linac BPM is shown by Table 6. The 700 MHz signal amplitude was higher than that of 350MHz. Results of measured electrode-center coupling values in 4 ports are almost same because the difference error less than 3 %.

Table Ⅴ. Measurement of inter-electrode coupling of the Linac BPM

Electrode	Measurement (350/700 MHz)		Simulation (350/700 MHz)	
S_{14} [dB]	-27.9	-23.3	-28.2	-23.0
S_{24} [dB]	-37.0	-32.8	-37.0	-32.2
S_{34} [dB]	-28.1	-23.3	-28.2	-23.0

Table Ⅵ. Measurement of electrode-center coupling of the Linac BPM

Electrode	Measurement [dB] (350 MHz / 700 MHz)	
Port 1 (+X)	-30.2	-23.2
Port 2 (+Y)	-29.6	-23.7
Port 3 (-X)	-29	-23.1
Port 4 (-Y)	-29	-22.7

3. Conclusions

The commissioning process of the PEFP 100-MeV linac and beam lines will start from late 2012. The BPMs are important diagnostic equipments for beam commissioning. We studied the characteristics of the prototype BPMs for PEFP beam lines and linac. The measured inter-electrode couplings are almost same as the calculation result. We also obtained the calibration tables for beam line BPM.

Acknowledgement

This work was supported by the Ministry of Education, Science and Technology of Korea.

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