Initial Beam Test of the Prototype Strip Line BPM

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1. Introduction

A beam position monitor (BPM) was developed which would be used for the Proton Engineering Frontier Project (PEFP) beam line. It is a strip line BPM which is commonly used one for the proton beam. The BPM cross section was designed with the SUPERFISH code and the matching section to the feed through was designed by the MWS code. The design parameters of the BPM are shown in Table 1 [1]. The designed BPM was fabricated to verify the manufacturing process and check its electrical performance. After the low power test at the test stand, the BPM was installed at the 20-MeV proton accelerator beam line as shown in Fig. 1

Table 1: Design Parameters

BPM type	Strip line
Flange size	6” CF
Electrode inner diameter	100 mm
Electrode thickness	2 mm
Electrode width	45 degree
Electrode length	70 mm
Electrode gap	15 mm
Feed through	SMA type

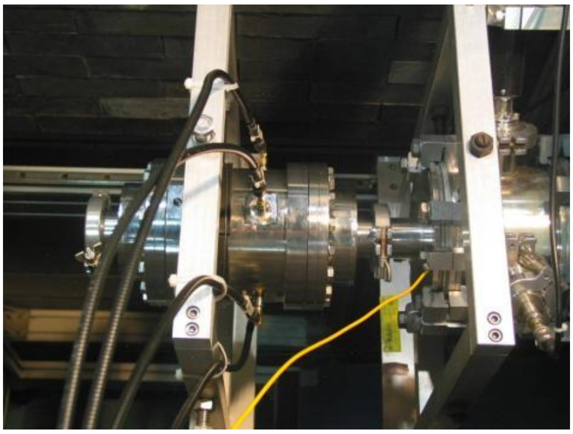

Fig. 1: Strip line BPM installed at the 20-MeV beam line

2. Beam Test of the BPM

The beam test was done with the 20-MeV proton beam for various beam conditions. To check the BPM performance, the measured results were compared with the calculation results with analytic formula.

2.1 Signal Amplitude Calculation

The output signal amplitude was estimated with the well know formula for the strip line type BPM [2]. The parameters used for the calculation are summarized in Table 2. The beam bunch rms length was calculated by using the PARMILA code. During the calculation, the high frequency effects such as transit time factor and Bessel factor were considered. The calculated signal amplitude was 8.8mV/mA in rms value (12.6mV/mA in peak to peak value) by using 350MHz beam bunching frequency.

Table 2: Beam Parameters

Beam energy	20 MeV
Beta	0.2032
Charge in bunch (20mA)	5.71E-11 C
Beam bunch rms length	0.0332 ns
Beam bunch frequency	350 MHz
Transit time factor (15mm gap)	0.988
Bessel factor	0.514

2.2 Signal Measurement

The output signals from 4 ports were measured by using the oscilloscope (Tektronix, DPO7104). The 1/4” heliax cables were used for the transmission line. During the test, the quadrupole triplets in the beam line were set to transport the proton beam without loss. The current setting values were such that 107.0A for the 1^{st} one, -75.0A for 2^{nd} one and 71.4A for the 3^{rd} one.

First, the beam signal was measured by using the low pass filter option (500MHz) imbedded in the oscilloscope. The test currents were 2mA and 4.2mA respectively. The line loss was measured by using a network analyzer (Agilent, E5071C) and the result was -1dB. The output signals from each port are shown in Fig. 2. The measured signal amplitudes in peak to peak value were summarized in Table 3. The signal amplitude from +y port was not reliable because the port was treated with the vacuum sealant to prevent the vacuum leakage.

Second, the beam signal was measured by using the band pass filter installed before the oscilloscope. The losses including both the line and band pass filter were -3.3dB and – 4.5dB in +x and –x port respectively. The measured signal amplitudes for 1mA~4mA beam current range are also summarized in Table 4.

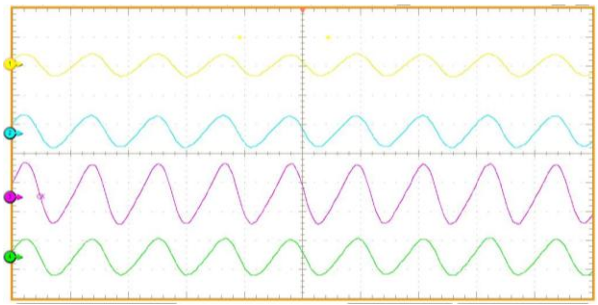

Fig. 2: Measured signal from the BPM (Ch1: +x, Ch2: +y, Ch3: -x, Ch4: -y, horizontal: 2.5ns/div., vertical: 20mV/div., 500MHz bandwidth)

Table 3: Measured signal with 500MHz bandwidth option

Current	Port	Signal (pk-pk)	Ratio
2.0mA	+x	10.0 mV	79.9%
	+y	14.0 mV	
	-x	26.0 mV	
	-y	15.0 mV	
4.2mA	+x	21.5 mV	79.3%
	+y	29.6 mV	
	-x	53.5 mV	
	-y	34.0 mV	

Table 4: Measured signal with 350MHz bandpass filter

Current	Port	Signal (pk-pk)	Ratio
1.5mA	+x	2.6 mV	28.7%
	-x	4.4 mV	
2.8mA	+x	4.2 mV	30.0%
	-x	8.9 mV	
4.6mA	+x	11.7 mV	50.5%
	-x	24.7 mV	

3. Results and Discussion

The ratios between the measured signal amplitude and calculation were also summarized in Table 3 and Table 4 respectively. The ratio was calculated with only signals from the x direction because the signal from the +y port was not reliable due to the treatment of the vacuum sealant. The ratios were 80% when the 500MHz bandwidth option was used regardless of the beam current, but the ratios in the case of the 350MHz band pass filter were less than those measured by 500MHz bandwidth case. Moreover the values were not constant.

There are possibilities to induce this kind of differences. First, the beam pulse length was 50μs and the beam current was the average value over the pulse, whereas the bunch signal was measured with very specific point for 25ns that was 1/2000 interval of the beam pulse width. Therefore, we could not specify the appropriate current value that represented the bunch signal we measured. Second, the +y port signal was not reliable. Therefore, we could use only two port signals. To properly compare the signal values, it is good way to use entire 4 port signals.

In future, we will repair the +y port and do the low power test more carefully. After that, we try to do the beam test again with entire 4 port signals.

Acknowledgement

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REFERENCES

[1] J. H. Jang, et al., Design and Fabrication of a Prototype Stripline BPM for PEFP Beam Lines, Transactions of the Korean Nuclear Society Spring Meeting, Taeback, May, 2011.
[2] E. R. Beadle, et al., Accelerator Instrumentation, AIP Conference Proceedings 212, AIP, New York, 1989.