Electronics sensitivity measurement of Beam Position Monitoring system for PEFP Linac and Beam-line

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1. Introduction

The proton engineering frontier project (PEFP) is developing a 20-mA, 100-MeV proton linac and 10 beam lines for 20MeV and 100MeV proton beams. We selected the strip line type BPM for the proton linac and beam-line. The layout of the BPMs for the PEFP 100-MeV linac and beam-line is given in Fig. 1. After fabrication of to the BPMs, we checked their electrical performance in the RF test and Beam test. And then, we measured electronics sensitivity of the BPM's modules. This paper summarized electronics signal processing of the BPM and results of the measurement.

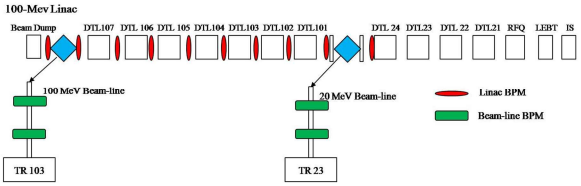

Fig. 1. Layout of the BPMs in PEFP 100-MeV linac and beam-line.

2. Test of the prototype BPM

The performance of the prototype BPM was tested in a test beam line of the 20-MeV proton linac which was installed in KAERI. In the first step, we compared the experimental results of the RF properties of the BPM with the calculation. After performing the offset calibration of the BPM at a test stand by using a wire method, the BPM was installed in the test beam line, and it was checked with the position sensitivity and the offset calibration values.

2.1 offset calibration of the BPM

For the offset calibration of the BPM, we made a test stand and used a 350 MHz RF signal running through a copper wire as an artificial beam signal in the calibration process. We obtained the beam line sensitivity of 0.802 dB/mm and linac sensitivity of 3.32 dB/mm.

2.2 Beam test of the BPM

We performed the real beam test of the BPM in the 20MeV proton beam line in KAERI site. The raw signals were filtered with 350-MHz band pass filters to get the fundamental frequency response. The beam center position was shifted about +8.5 mm in the horizontal direction and -0.005 mm in vertical direction. The beam center position of -0.005 mm means that beam center is located on the physical center.

3. Electronics signal processing of the BPM

We are under the test to use the Log-ratio BPM electronics module of the Bergoz Instrumentation for direct beam position derivation from the pickup signals. The layout of the BPM electronics system is given in Fig. 2. The signal from the BPM is through the 350 MHz band pass filter and signal divider for measured beam phase, after then we got the x-axis and y-axis position signals from electronics modules.

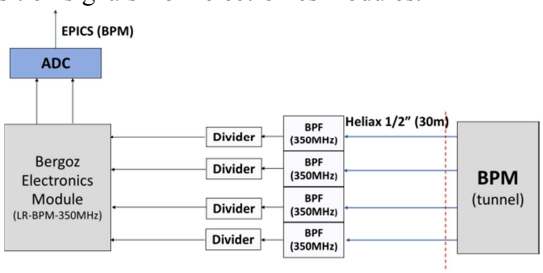

Fig. 2. Layout of the BPM electronics system

3.1 Measurement of pick-up sensitivity

The BPM electronics boards have pick-up sensitivity x-axis and y axis separately. We measured sensitivity in the test was consist of RF signal generator, pulse delay generator and oscilloscope. Photo of the set-up the test is shown in Fig. 3.

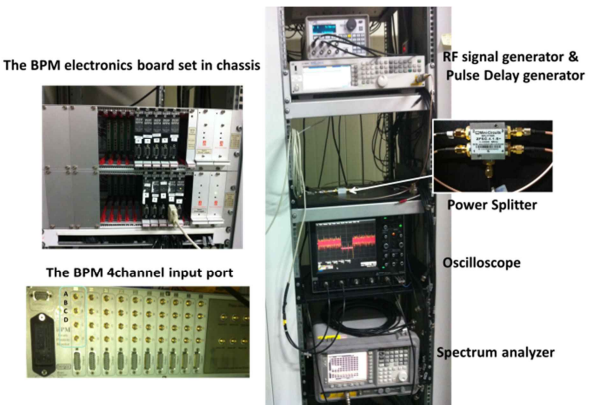

Fig. 3. Photo of the set-up the test

14 BPM electronics boards set in 3 chassis. The signal from the signal generator to the power splitter then 4 signals to board it was converted x-axis and y-axis signal values. We check that signal from the oscilloscope. Using the oscilloscope measurement condition are 100 ㎲ and 2 Hz in pulse mode, used boards LR-BPM-PEFP-350 MHz # 1 to # 14. Measured sensitivity average of the x-axis is 46.7 mV per dB and x-axis is 46.3 mV per dB in 14 boards.

$$S_x = \frac{160}{Ln\,10}\ \frac{\sin\left(\frac{\varphi}{2}\right)}{\varphi}\ \frac{x}{b} \qquad (1)$$

From the eq (1) [1] calculated position sensitivity is 3.3 dB per mm in linac BPM and 0.8 dB per mm. When we multiply two values, got the average sensitivity 140 mV per mm (x-axis), 145 mV per mm (y-axis) in linac BPM, 36 mV per mm(x-axis), 37 mV per mm(y-axis).

3.2 Measurement of the specifics electronics modules

We check 14 LR-BPM boards in this test and confirm the actual dynamic range in use. The layout of the BPM electronics module test is given in Fig. 4.

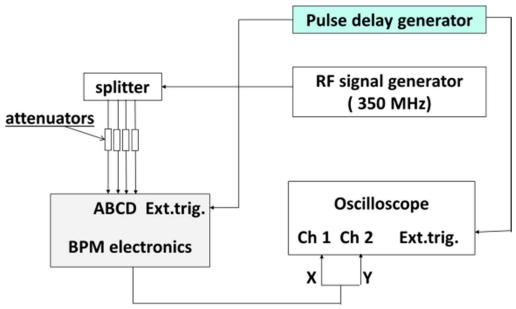

Fig. 4. The layout of the BPM electronics module test

The measured minimum available value is about -60 dBm. The parameters of Specifications of the LR-BPM electronics board are summarized in Table Ⅰ.

Table Ⅰ: Specifications of the LR-BPM electronics board

Parameter	Value
Operation frequency	350 MHz
Operation mode	CW or Pulsed
Accuracy	<50 ㎛
Bandwidth of output signal	>5 MHz
Dynamic range	-60 dBm ~ 5 dBm

4. Conclusions

A strip line type BPM for the PEFP beam lines was designed and fabricated. We measured RF properties of the BPM at the test stand and tested the BPM by using 20-MeV proton beam in the test beam line. After then we checked the sensitivity of 14 BPM's electronics modules. We also found that the signal level is consistent with the calculation when the beam center is located on the physical center and available dynamic range using the electronics. We finished the check all of the BPM's electronics module for the signal processing system. The BPM will be used in beam commissioning and operation of the PEFP 20-MeV and the 100-MeV beam lines.

ACKNOWLEDGMENTS

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REFERENCES

[1] R. E. Shafer, Beam Position Monitoring, AIP Conference Proceedings, Upton, NY, 1989, pp. 26 - 58.