Preliminary Test of the KOMAC Linac BPM at the Test Bench for Upgrade

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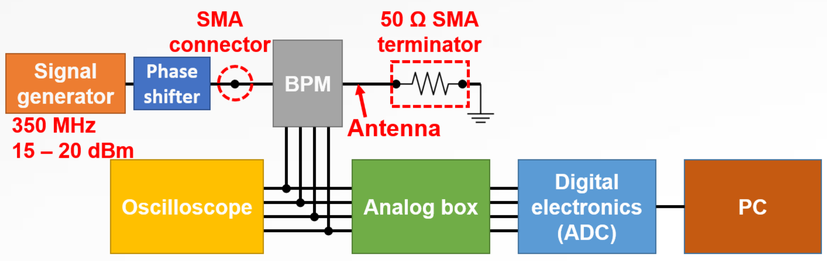
Introduction

- **7 Linac BPMs (Beam Position Monitor) are installed in KOMAC 100 MeV linear accelerator [1].**
- **Current role: To measure beam phase for RF tuning [2].**
- **Purpose of the upgrade: To measure the beam position, phase, and current simultaneously.**

Experimental Setup



Schematic diagram of the test setup

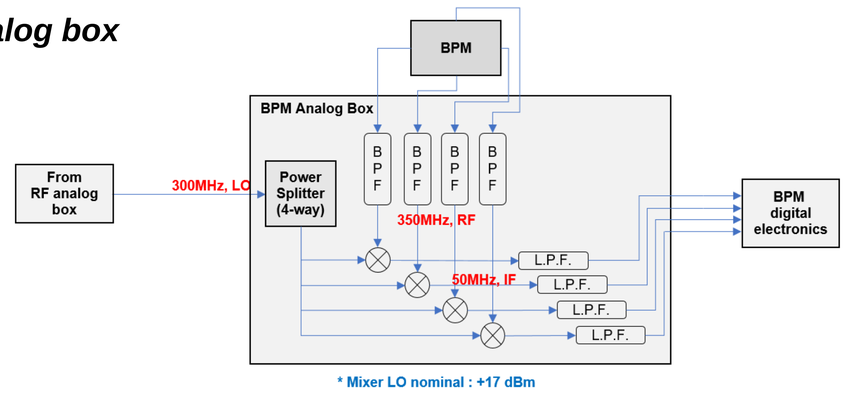
BPM Test Stand

(a) (b)

(a) total setup, (b) the BPM transducer and the antenna wire.

- 350 MHz RF proton beam is imitated by a straight metal wire to which 350 MHz RF signal is applied.
- A motion stage moves the wire and the imitated beam position is varied.

BPM Analog box



- 350 MHz beam signal is converted to 50 MHz sine wave signal to analyze the signal easily in the BPM analog box.

BPM Digital Electronics

- The 50 MHz IF signals from the BPM analog box are converted to the digital value by the ADC (analog to digital converter) of the BPM digital electronics.
- The BPM digital electronics consists of MVME3100 baseboard, PENTEK7142 FPGA board which includes 4 channel 14 bits ADC, and vxWorks 6.8 operating system. By EPICS, the digital values are connected to the computer.
- The 50 MHz IF signals from the BPM analog box are processed by using digital IQ demodulation [3]. The acquired IQ values are transferred to the computer and the beam characteristic values are calculated.

Result and Discussion

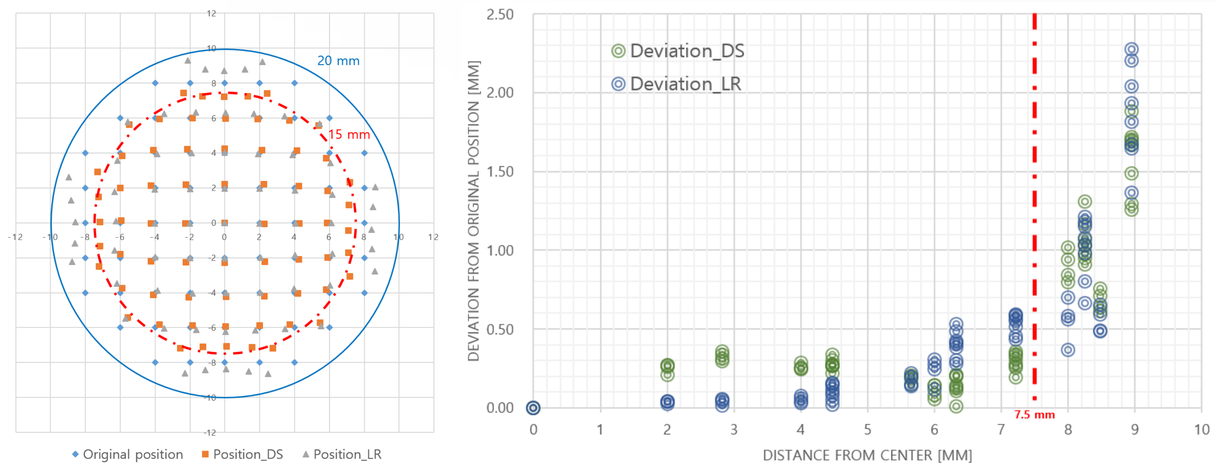
Beam Position

- The beam aperture diameter of the BPM is 20 mm. Within the 15 mm diameter, the calculated beam position is generally correct.
- To acquire more accurate position results, various fitting methods like the polynomial fitting can be tried.

$$V_i = \sqrt{I_i^2 + Q_i^2}\ , \qquad i = x_+, x_-, y_+, y_-$$

$$(x, y) = \left(R_{DS} \cdot \frac{V_{x_+} - V_{x_-}}{V_{x_+} + V_{x_-}},\ R_{DS} \cdot \frac{V_{y_+} - V_{y_-}}{V_{y_+} + V_{y_-}} \right), \qquad \text{difference over sum}$$

$$(x, y) = \left(R_{LR} \cdot 20 \log \frac{V_{x_+}}{V_{x_-}},\ R_{LR} \cdot 20 \log \frac{V_{y_+}}{V_{y_-}} \right), \qquad \text{log ratio}$$

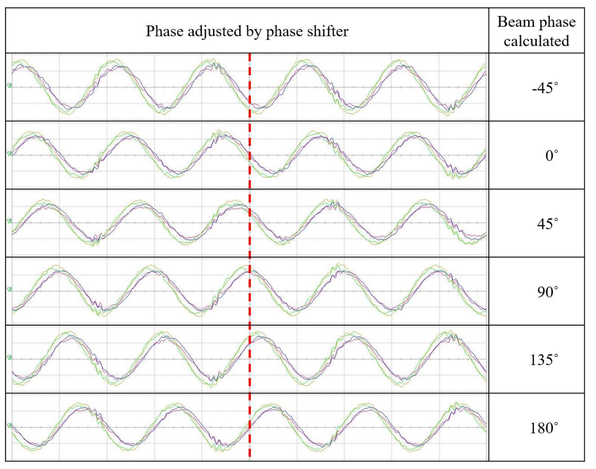


Beam position difference between the original position and the measured position

Beam Phase

$$\phi\ (\text{Beam phase}) = \arctan\left(\frac{Q}{I}\right)$$

- beam phase ← arc tangent of Q and I ratio
- phase adjustment ← phase shifter
- Well agreement between the input signal and the measure value can be seen.

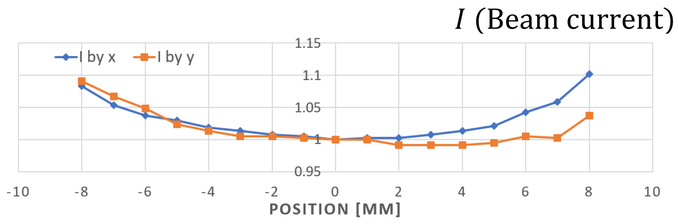


Beam Current

- Generally, BPM measures beam position and phase. However, the beam current can be decided from the amplitude of BPM signal.
- When the coefficient K is set constant, beam current value changes by the beam position. The delicate decision of the K value is required.

$$I\ (\text{Beam current}) \propto \sum_{i=1_4}^{4} |V_i| = \sum_{i=1}^{4} \sqrt{I_i^2 + Q_i^2}$$

$$= \mathrm{K} \sum_{i=1} \sqrt{I_i^2 + Q_i^2}\ , \qquad i = x_+, x_-, y_+, y_-$$



Summary

- **The signal processing system works well, and it can be used for the real accelerator system.**
- **The measurement by the BPM: the beam position, the beam phase, and the beam current → it also works well, but more data and data manipulation are needed to acquire more precise and accurate result.**
- **The upgrade is in progress. After more test and system improvement, the upgraded system will be applied to the accelerator operation.**

References

[1] H. J. Kwon, H. S. Kim, K. T. Seol, J. Y. Ryu, J. H. Jang, and Y. S. Cho, Design and Fabrication of the Beam Position Monitor for the PEFP Linac, Nuclear Engineering and Technology, Vol.45, No.4, p. 523, 2013.

[2] H. S. Kim, H. J. Kwon, J. Y. Ryu, K. T. Seol, Y. G. Song, J. H. Jang, and Y. S. Cho, Beam Phase Measurement for PEFP Linear Accelerator, Proceedings of LINAC2012, p.894, 2012.

[3] T. Schilcher, RF Applications in Digital Signal Processing, Proceedings of CERN Accelerator School, p.249, 31st May – 9th June, 2007, Sigtuna, Sweden.