PAL-XFEL CAVITY BPM PROTOTYPE BEAM TEST AT ITF

Sojeong Lee, Young Jung Park, Changbum Kim, Seung Hwan Kim, D.C. Shin
Heung-Sik Kang, Jang Hui Han, In Soo Ko
Pohang Accelerator Laboratory, Pohang University of Science and Technology, Pohang 790-784

Abstract

To achieve sub-micrometer resolution, The Pohang Accelerator Laboratory X-ray Free electron Laser (PAL-XFEL) undulator section will use X-band Cavity beam position monitor (BPM) systems. Prototype cavity BPM pick-up was designed and fabricated to test performance of cavity BPM system. Fabricated prototype cavity BPM pick-up was installed at the beam line of Injector Test Facility (ITF) at PAL for beam test. Under 200 pC beam charge condition, the signal properties of cavity BPM pick-up were measured. Also, the dynamic range of cavity BPM was measured by using the corrector magnet. In this paper, the design and beam test results of prototype cavity BPM pick-up will be introduced.

PAL-XFEL Cavity Beam Position Monitor

PAL-XFEL will provide X-rays in ranges of 0.1 to 0.06 nm for hard X-ray line and 3.0 nm to 1.0 nm for soft X-ray line by using the self-amplified spontaneous emission (SASE) Schematic [1, 2, 3]. To generate X-ray FEL radiation, the PAL-XFEL undulator section requires high resolution beam position monitoring systems with <1 μm resolution for single bunch. To achieve high resolution requirement, the PAL-XFEL undulator section will use the cavity BPM. Total 49 units of cavity BPM system will be installed in between each undulators with other diagnostics tools.

Design of PAL-XFEL Cavity BPM pick-up

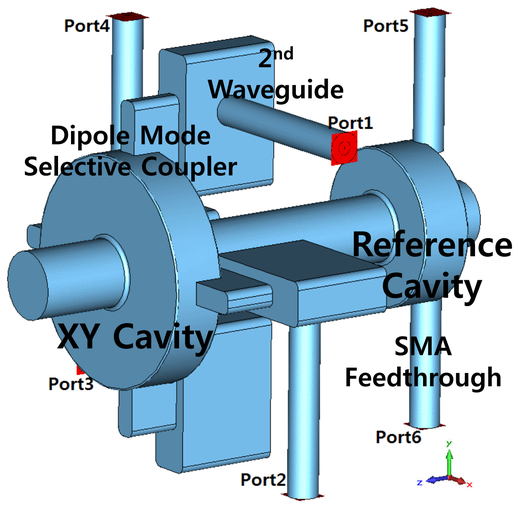

Figure 1. Modeling of PAL-XFEL cavity BPM pick-up vacuum part.

1. Design Feature of PAL-XFEL Cavity BPM pick-up

- **X-band Operating Frequency**

The operation frequency of PAL-XFEL cavity BPM system was set as 11.424 GHz, X-band frequency.

: Due to the limitation of installation space, the compact cavity BPM pick-up was required.

: To achieve high resolution and compact pick-up size, the X-band operation frequency was chosen for PAL-XFEL cavity BPM system.

- **SMA Feedthrough**

For easy installation and maintenance, the PAL-XFEL cavity BPM pick-ups adopt the SMA feed through as output signal port.

2. Component of PAL-XFEL Cavity BPM pick-up

- **Reference Cavity**

This cavity uses TM_{010} mode, monopole mode, of pill box cavity.

→ Measuring the bunch charge to normalize the amplitude of XY cavity signal.

Reference cavity was designed as simple structure, for easy fabrication.

- **XY Cavity**

The XY cavity uses TM_{110} mode, dipole mode, of pill box cavity.

→ Measuring beam position by using excited dipole mode of XY cavity and reference cavity signal.

The dipole mode selective coupler for suppressing the monopole mode signal of XY cavity [4, 5].

Second waveguide was adopted to minimize the brazing effect on the pill box part of XY cavity.

3. Simulation Results of PAL-XFEL Cavity BPM pick-up

	Reference Cavity	XY Cavity
Frequency [GHz]	11.424	11.424
Q_L	2290	2544
Q_{ext}	3470	3882
β	1.94	1.90
R/Q	114.13 Ω	3.77 Ω/mm^2

Table 1. Simulation Results of each cavity RF parameters. CST microwave studio module was used to calculate the RF parameters of monopole and dipole mode of each cavity.

Fabricated Prototype PAL-XFEL CBPM

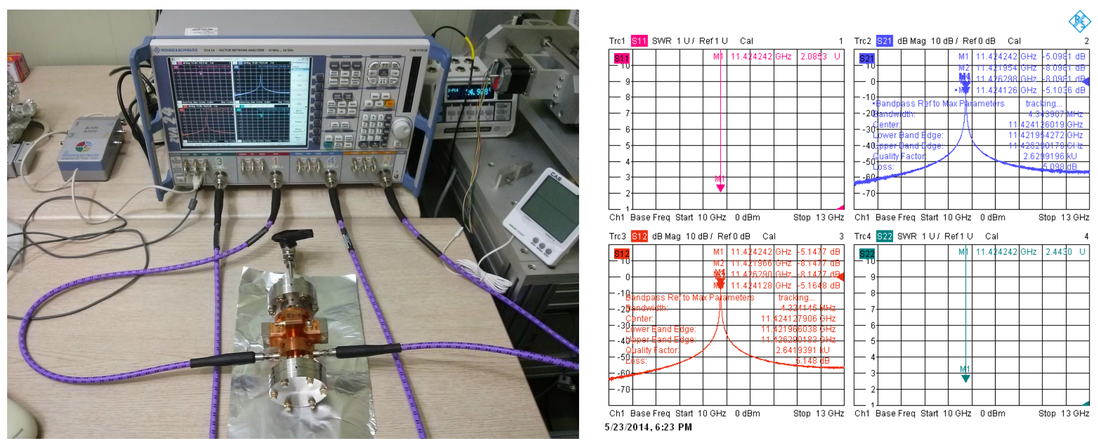

Figure 2. Fabricated PAL-XFEL cavity BPM pick-up and Reference Cavity of CBPM#02-06 Measurement Result

CBPM #02-06		Frequency [GHz]	β	Q_L	Q_{ext}
Reference Cavity	Port1	11.424	2.241	2876.61	4160.52
	Port2	11.424	2.534	2887.96	4027.74
XY Cavity	Port1	11.4242	2.394	2534.01	3592.54
	Port2	11.4242	2.020	2532.51	3786.17
	Port3	11.4242	1.934	2525.06	3830.41
	Port4	11.4242	2.291	2526.84	3629.78

Table 2. CBPM#02-06 RF parameter Measurement Result

Beam Test of cavity BPM pick-up at ITF

1. Installing Cavity BPM at ITF beam line

The prototype cavity BPM pick-up was installed in the beam line of Injector Test Facility (ITF) at PAL. ITF can provide 200 pC electron beam [6] to the prototype cavity BPM pick-up. Three coaxial cables, RF signal amplifier and oscilloscope were used for monitoring response of cavity BPM pick-up.

Figure 3. Installed Cavity BPM pick-up at ITF dump section and down converted raw signal of XY cavity *y*-direction port (200 MHz). Measured decaying time was ~ 30 ns.

2. Dynamic Range Measurement of Cavity BPM pick-up

By using Cor6 corrector magnet and two stripline BPMs, dynamic range of cavity BPM pick-up was measured.

For measurement, the power detector, down converting frequency mixer and oscilloscope was used.

- Ratio of beam offset change at cavity BPM to 1A change of Cor6 = 4.594mm / A
- the cavity BPM pick-up response to Cor6 current change is similar to the monopole and dipole mode electric field distribution.
- The measured dynamic range of cavity BPM pick-up was ~4 mm.

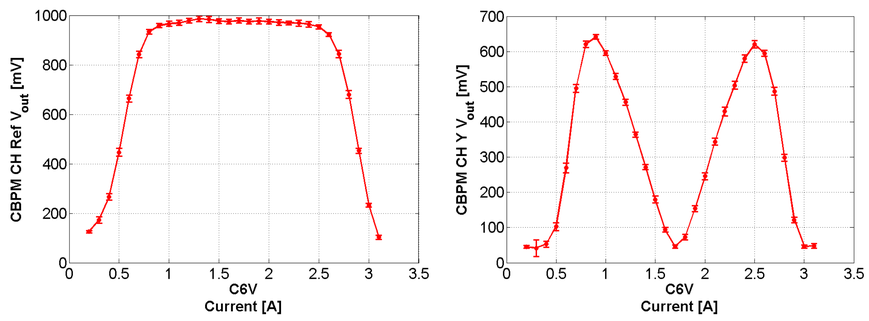

Figure 4. Cavity BPM pick-up response to the corrector MPS current(C6V, vertical direction corrector) change

Reference

[1] I. S. Ko and J.-H. Han, "Current status of PAL-XFEL project." in *Proceedings of 27th Linear Accelerator Conf.*, MOIOB03, Geneva (2014).
[2] J.-H. Han et al., "Status of the PAL-XFEL project." in *Proceedings of 3rd Int. Particle Accelerator Conf.*, IPAC12 (2012).
[3] Kang, Heung-Sik, et al., "Current status of PAL-XFEL project.", in *Proceedings of 4th Int. Particle Accelerator Conf.*, Shanghai (2013).
[4] Li, Zenghai et al., "Cavity BPM with Dipole-Mode-Selective Coupler", in *Proceedings of the 2003 Particle Accelerator Conf.*, Portland, OR (2003).
[5] Waldschmidt, G. et al., "Electromagnetic design of the RF cavity beam position monitor for the LCLS." in *Proceedings of the 2007 Particle Accelerator Conf.*, Albuquerque, New Mexico (2007).
[6] Han, J. H., et al., "Beam operation of the PAL-XFEL Injector Test Facility.", in *Proceedings of 36th Int. Free Electron Laser Conf.* Basel (2014).