TAPER SHAPE EFFECTS ON THE HOM DAMPING OF THE PLS-II SRF CAVITIES*

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Abstract

PLS-II storage ring employs three cryomodules to accelerate an electron beam. Two commercial cryomodules will be installed in a long-straight section during the upgrade phase; one will be in a short-straight section in the future. The available length of a long straight section is not enough to install two commercial cryomodules with its supplementary parts. In order to install two cryomodules in the section, we need to modify the tapers for reducing their total length. The main concern for this modification is the effects on the beam instability due to the HOM damping efficiency change. In this paper, the HOM damping effects of different taper shapes has been studied.

INTRODUCTION

The Pohang Light Source (PLS) of the Pohang Accelerator Laboratory (PAL) is under upgrade. A superconducting RF (SRF) system has been chosen for the PLS-II [1-3]. Three cryomodules will be use in the PLS-II storage ring. Two commercial cryomodules will be installed into one long-straight section during upgrade stage, and one will be in a short-straight section of PLS-II storage ring in the future. The available length for the cryomodules of the long-straight section is 6.28 m. In this space, two beam-pipe transitions from elliptical section of vacuum valves to circle cross section of cryomodules, two commercial cryomodules, three bellows, three or four vacuum valves need to be installed. Two commercial cryomodules, either of CESR-type cryomodules by RI or KEKB-type cryomodules by Mitsubishi Electric Corporation, are too long to be installed into this section.

In order to install two cryomodules in this section, we need to reduce the total length of the two cryomodules. The most simple and economic method is to shorten the cryomodules warm tapers or replace two adjacent warm tapers by a beam-pipes with bellows. The main concern for this modification is the beam instability, which is evaluated by higher-order mode (HOM) damping effects. Both CSER-type and KEKB-type cryomodules use the coaxial ferrite HOM dampers to absorb the HOM-induced power [4, 5]. Here we only shorten the tapers, but two HOM damper positions are not changed. Shorting cavity length could induce the HOM standing wave point position movement. The movement will lead the variation of the HOM power absorbability on ferrite HOM absorbers, that means that the Q_{ext} or Q_{load} of the HOM or HOM damping effects are changed.

In this paper, 3 plans to install the two cryomodules in a long-straight section of PLS-II storage ring have been presented, and the HOM spectrum and impedance have been calculated by using SuperLans [7]. After evaluating the HOM damping effects for different taper shapes, the reasonable plans are presented.

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TAPER ANGLE EFFECTS ON THE HOM DAMPING OF THE CSER-TYPE CRYOMODULE

A CESR-type cryomodule, such as used in SSRF, if we change its taper angle to 11.31°, two cryomodules can be installed in a long-straight section (see Fig. 1).

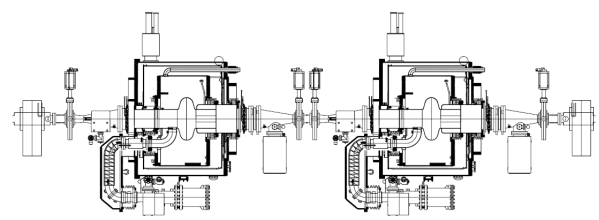

Figure 1: Two-cryomodule installation in a long-straight section of the PLS-II storage ring.

Figure 2 shows the PLS-II storage ring's longitudinal impedance thresholds [4, 7] and impedance of the CESR-type cryomodules with different taper angle. We find that there are no monopoles with sharp impedance change for different taper angle from original angle to 11.31°; and no monopoles, whose impedance is over the impedance threshold. This means the beam is stable in longitudinal direction.

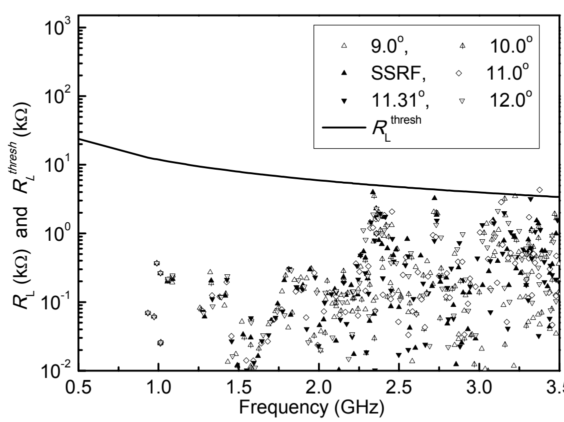

Figure 2: Longitudinal shunt impedance R_L of CESR-type cryomodules with different taper angles and the beam impedance threshold R_L^{thresh} of the PLS-II storage ring.

The transverse shunt impedance's variation show that there are no significant change of the transverse impedance, and no dipoles, whose shunt impedance can threaten the beam stability strongly (See Fig. 3).

From above calculations, we found that increase of the taper angle of the CESR-type cryomodules from about 9.43° of SSRF cryomodules to 11.31° does not change the HOMs' impedance both in longitudinal direction and transverse direction. This modification plan can be used for PLS-II case.

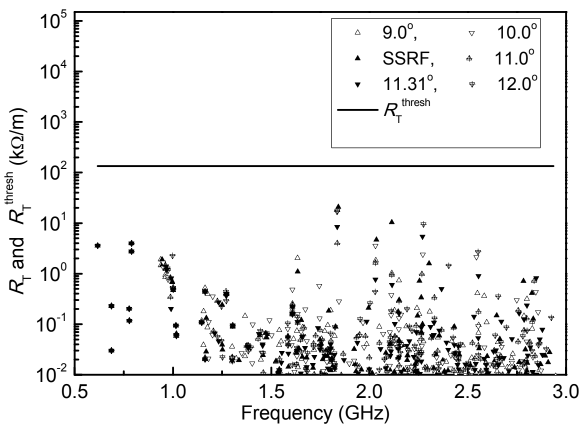

Figure 3: Transverse shunt impedance R_T for different taper angles and the beam impedance threshold R_T^{thresh} of the PLS-II storage ring.

TAPER ANGLE EFFECTS ON THE HOM DAMPING OF THE KEKB-TYPE CRYO-MODULE

The original taper angles of a KEKB-type cryomodule, such as used in BEPCII is a bout 9.46°. If the angle is increased to be 18.46° of the PLS-II cavity, two KEKB-type cryomodules can be installed in a long-straight section, as shown in Fig. 4.

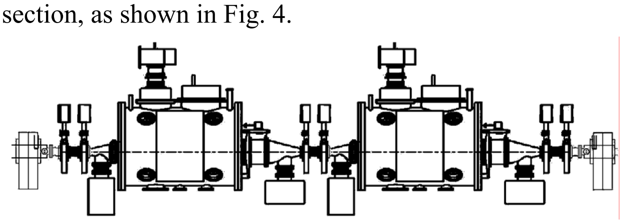

Figure 4: Two KEKB-type cryomodules in a long-straight section of the PLS-II storage ring.

Figure 5 and 6 shows the PLS-II storage ring's longitudinal and transverse impedance thresholds and impedance of the BEPCII and PLS-II cavities. From Fig. 5 and 6 show that there are no HOMs, whose impedance is over the impedance threshold. This means the beam is stable in longitudinal and transverse direction.

HOM DAMPING EFFECTS OF THE TWO-COMBINED KEKB-TYPE CRYOMODULE

For the KEKB-tape cryomodule, another choice is to replace two small-pipe tapers by a beam-pipe, as shown in Fig. 7.

Figure 8 shows the PLS-II two-combined cryomodule's and BEPCII cavity's longitudinal impedance R_L and the PLS-II storage ring's longitudinal shunt impedance threshold R_L^{thresh}. We found the average longitudinal R_L of KEKB-type two-combined cryomodule is lower or almost the same as that of BEPCII cavity. The reason is that the beam-pipe modes transfer into warm-connected pipe between two cavities, and are absorbed by it, as shown in Fig. 9.

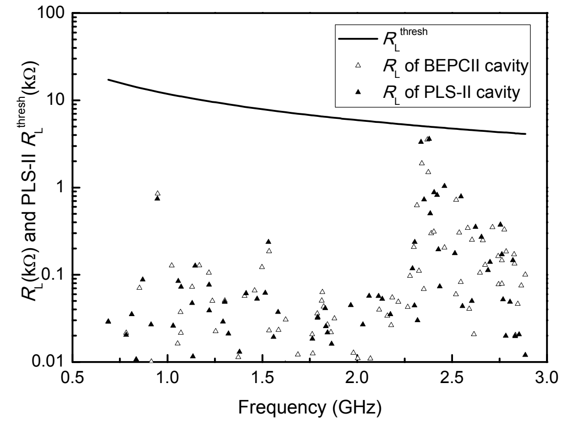

Figure 5: Longitudinal shunt impedance R_L of the BEPCII and that of PLS-II cavities, and the longitudinal impedance threshold R_L^{thresh} of the PLS-II storage ring.

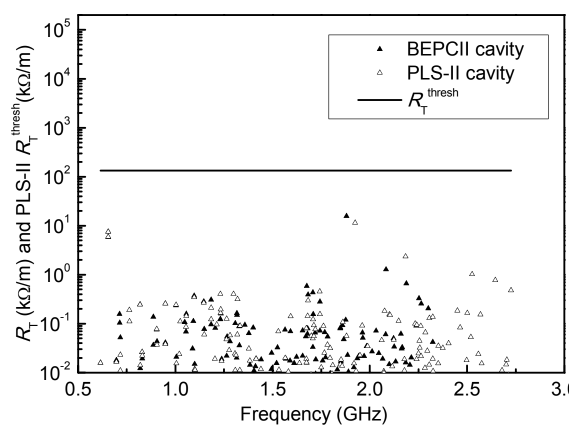

Figure 6: Cavity transverse shunt impedance R_T and the transverse impedance thresholds R_T^{thresh} of the PLS-II storage ring.

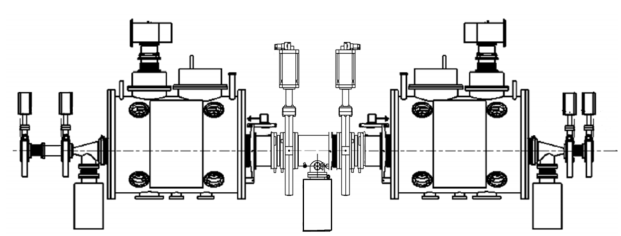

Figure 7: Two KEKB-type combined cryomodule in a long-straight section of PLS-II storage ring.

Figure 10 shows the transverse shunt impedance R_T of the BEPCII cavity and two-combined KEKB-type cryomodule, and the PLS-II storage ring's transverse impedance threshold R_T^{thresh}. The HOM calculation results show that some modes' R/Q increase, but due to their low Q_L, as shown in Fig. 10, these modes are no threat for PLS-II storage ring beam stability.

The calculation results show that both plans either to increase taper angle or replace two adjacent tapers with a beam-pipe for the KEKB-type cryomodules can meet PLS-II requirements, but later one has low shunt impedance in both of longitudinal and transverse directions. We would suggest using later one for PLS-II storage ring, if PLS-II employees KEKB-type cryomodules.

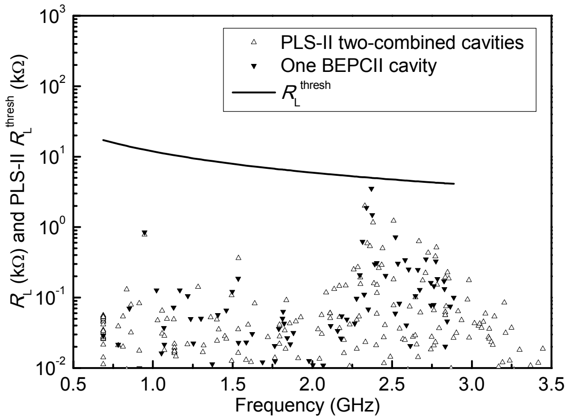

Figure 8: Longitudinal R_L of the BEPCII cavity and PLS-II two-combined cavities, and the longitudinal impedance threshold R_L^{thresh} of the PLS-II storage ring.

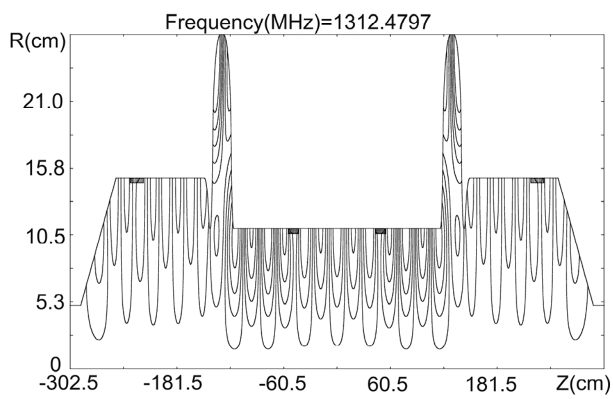

Figure 9: Electric field profile of a beam-pipe mode in the PLS-II two-combined cavity.

CONCLUSIONS

Three modification plans for the commercial cryomodules have been evaluated. Two CESR-tape cryomodules fabricated by RI can be used in PLS-II storage ring after shortening the cavity by increasing the taper angles. Two KEKB-type cryomodules fabricated by Mitsubishi Electric Corporation can be used in the PLS-II storage ring after shortening the total length of two cryomodules by either increasing the taper angles or replacing two adjacent tapers with a beam-pipe. The KEKB-type two-combined cavity has more benefits in HOM shunt impedance than PLS-II cavity with high taper angle. After considering the cost and construction period, two CSER-type cryomodules have been chosen for PLS-II finally.

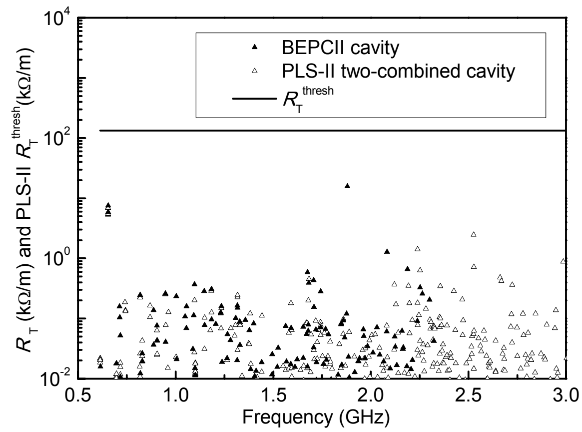

Figure 10: Transverse shunt impedance R_T of the BEPCII cavity and PLS-II two-combined cavities, and the transverse impedance threshold R_T^{thresh} of the PLS-II storage ring.

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