The Mechanical Stability of the Electron Beam Position Monitor at the Taiwan Light Source

C. K. Kuan, D. J. Wang, K. Y. Kuo, J. R. Chen*
Synchrotron Radiation Research Center, No. 1 R&D Road 6,
Hsinchu Science-Based Industrial Park, Hsinchu 30077,Taiwan
*also at the Institute of Nuclear Science, Nation Tsing Hua University, Taiwan.

Abstract

The mechanical stability of electron beam position monitor (BPM) is essential for accurately monitoring and controlling electron orbit stability. Many factors, such as storage ring floor movement, thermal expansion of support structure and the movement of BPM vacuum chamber will affect its accuracy. In this paper we report the measured results of storage ring floor motion, the motion of the BPM support structure and BPM vacuum chamber. We found the major factors contributing to BPM motion were the electron beam current power, air temperature and storage ring floor displacement.

1 INTRODUCTION

The Taiwan Light Source (TLS) in Synchrotron Radiation Research Center (SRRC) is a 1.5Gev third-generation synchrotron light source. Any electron beam orbit drift that leads to distortion in the closed orbit will result in a larger effective emittance and brightness reduction. To produce a stable and intense electron beam, 55 BPMs mounted in the storage ring vacuum chambers are used as reference points for the global orbit feedback system. If any BPM is moved, there will be a motion in the signal. Since the BPMs are assumed fixed in location, this effect will be considered as beam motion. To obtain the long term mechanical stability of BPM motion [1], the characteristics of ground motion [2,3], the motion of BPM support structure as well as BPM vacuum chamber have been measured.

2 STORAGE RING FLOOR MOTION

The motion of the storage ring floor was measured by using 6 hydrostatic leveling system (HLS) sensors with 0.1 μm resolution [4,5]. These 6 HLS sensors (HLS1-HLS6) are installed at the floor of the 200 m circumference storage ring; each is located at a corner of a hexagon as shown in Fig. 1. HLS3 sensor is adapted as the reference point. The relative displacement of all the other HLS sensor to HLS3 sensor is displayed in Fig. 2. They exhibit periodic modulations. After analyzing the data, we found that the periodic variation of relative displacement complies with local tidal movement. Moreover, The amplitude of the displacement of any HLS# sensor is approximately proportional to the projection of HLS#-HLS3 distance to the earth tidal distortion direction, which is roughly along the east-west direction.

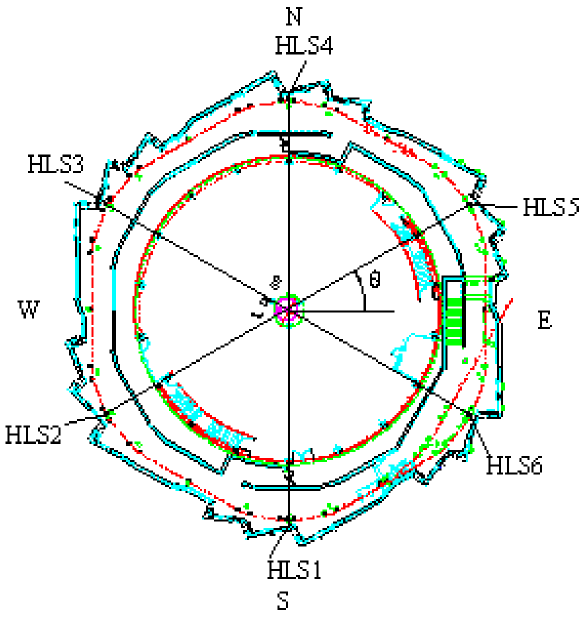

Figure 1: Layout of HLS

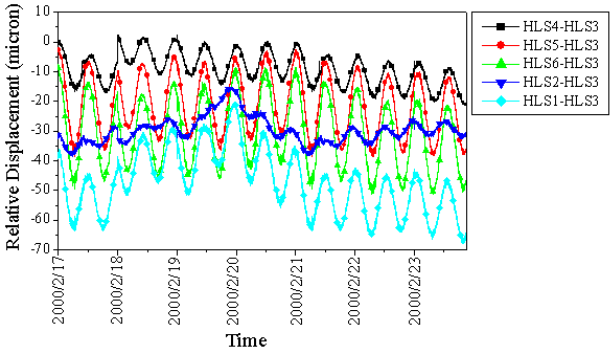

Figure 2: Relative displacement of storage ring floor

The relative displacement of various HLS sensor pairs is illustrated in Fig. 3a-3f. It is found that the amplitudes of relative displacement of those pairs, which make the same inclining angle with respect to the east-west direction, are proportional to the distance between them.

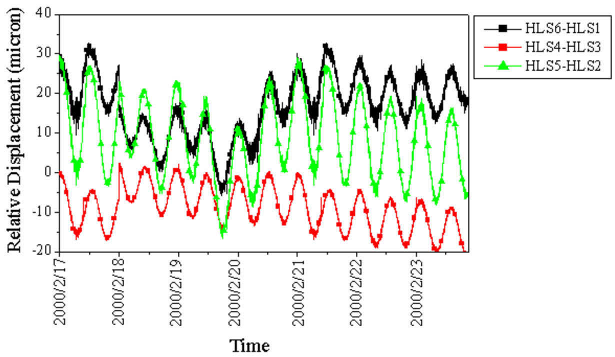

Figure 3a: Displacement between pairs of HLS of 30° direction

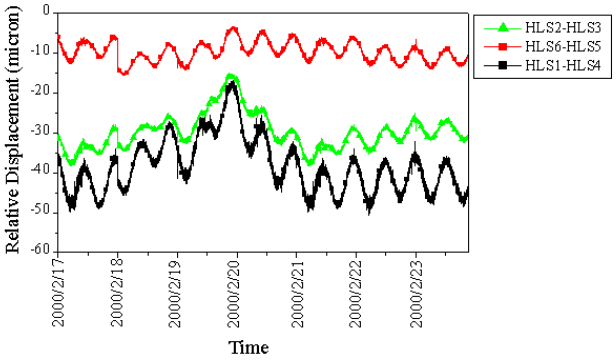

Figure 3b: Relative displacement of HLS pairs of 90° direction

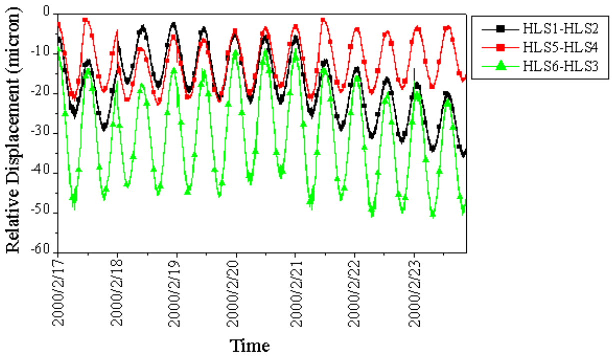

Figure 3c: Relative displacement of HLS pairs of 150° direction

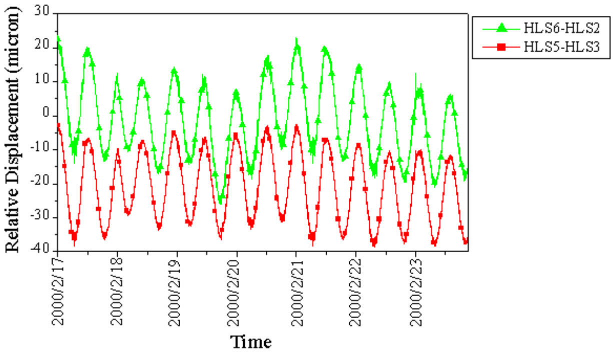

Figure 3d: Relative displacement of HLS pairs of 0° direction

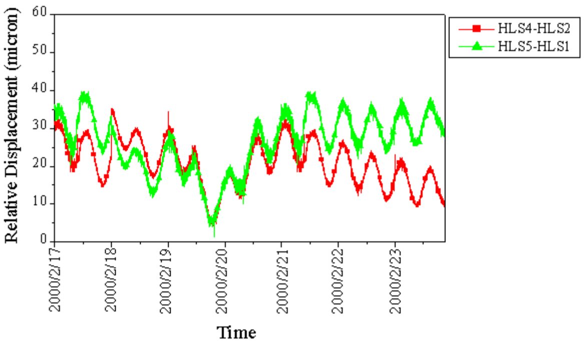

Figure 3e: Relative displacement of HLS pairs of 60° direction

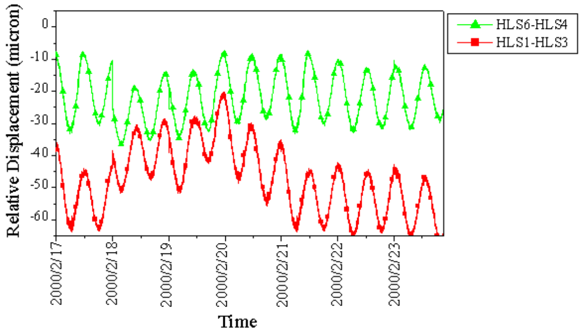

Figure 3f: Relative displacement of HLS pairs of 120° direction

These observations indicate that the movements of storage ring floor are significantly influenced by earth tide. The maximum amplitude of the displacement induced by tide effect is about 36 µm and most of it can be subtracted. After subtracting the tidal effect, the floor has a displacement of about maximum 20 µm during this 7-day observation period as shown in Fig. 4.

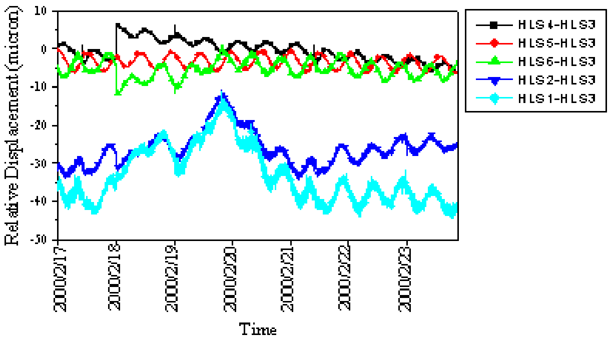

Figure 4: Relative displacement of HLS after subtracting the tidal effect

3 SUPPORT STRUCTURE MOTION

The motion of the BPM support structure was carried out by using 0.1 µm resolution linear potentiometer and 0.1 µm resolution Pt-100 thermal sensor. The electron beam orbit is 1.35 meter above the storage ring floor. The support structure is made of iron and stainless steel. The thermal expansion factor is about 11 µm/^{0}C/M. When temperature fluctuates, the height of BPM will change about 15µm/^{0}C. The temperature of the BPM support structure inside the storage ring tunnel is usually maintained within a variation of 0.25^{0}C during an 8-hour shift. Therefore, there is about 3.2 µm thermal expansion of the BPM support structure within a shift. This theoretical calculation is conformed to our measurement.

4 VACUUM CHAMBER MOTION

The movement of the BPM vacuum chamber relative to the BPM support structure is measured by using a 0.1 µm resolution linear potentiometer and 0.1 µm resolution Pt-100 thermal sensor. The measured displacement is showed in Fig. 5. This displacement is caused by thermal deformation of the vacuum chamber heated by synchrotron light. There is a strong correlation between beam current and the displacement of BPM. During the user beam time the maximum temperature variation of vacuum chamber is about 1.5^{0}C between the beam currents 200mA and 100mA. This will induce distortion of the vacuum chamber. The BPM is connected to a bellows. The BPM motion comes from the vacuum chamber outside the bellows and the BPM vacuum chamber itself. The outside vacuum chamber distortion will induce about 1/10 of the one to the BPM vacuum chamber in the horizontal direction. It is found the displacement of BPM changes quickly during the injection phase and drifts slowly during the user beam time. The displacement has a maximum 3 µm in the horizontal direction and 1 µm in the vertical direction. The displacement along the longitudinal direction has almost no change.

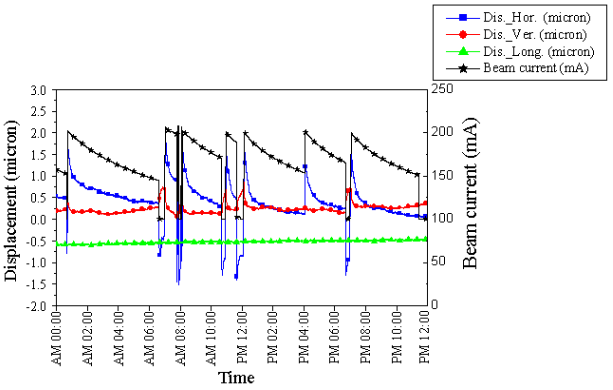

Figure 5: Displacement of BPM chamber relative to its support.

5 SUMMARY

The beam stability is affected by many factors. One of the factors is the mechanical stability of many mechanical parts like BPM, magnet and insertion device. The BPM is now continuously monitored at the TLS as described in this paper. The mechanical stability about the floor motion, temperature and structure distortion has been measured. The cooling water of the vacuum is improved now. The next step will focus on monitoring and improving the mechanical stability of magnet and insertion device.

ACKNOWLEDGEMENT

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