OBSERVATION OF BEAM DISTURBANCE CAUSED BY ID GAP VARIATION AT TLS STORAGE RING

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Abstract

Insertion device is controlled by user for specific experimental condition on user beam time. It operates with user defined gap and phase.Three different undulators are installed in TLS (Taiwan Light Source), including one elliptically polarized undulator.Interactions between these undulators were studied to demonstrate the impact on beam performance.How to get more stable beam under undulators' interaction is discussed in this study.

INTRODUCTION

Taiwan Light Source (TLS), the first third-generation synchrotron accelerator in Asia, began construction in 1986 and was completed in 1993. The TLS has an electronic energy of 1.5 GeV and a perimeter of 120 m; it uses an e-gun to generate electrons, which are then accelerated by the linac and sent into the booster, after which the full energy is injected into the storage ring through the transport line. Multiple insertion devices are installed at the junction of the long straight section; thus, it is a third-generation synchrotron with a relatively high insertion device density [1]. This study focused on the three undulators U5, U9, and EPU, which have adjustable gaps, and investigated the interference effects of magnetic field interactions on electron beams caused by the movements of the undulators (dynamic and static) during their gap adjustments. The orbit, stability, tune, injection efficiency, size, and lifetime of the beam were considered.

RESEARCH METHOD

The magnetic fields of undulators U50, U90, and EPU are strongest when their gaps are adjusted to a minimum (min gap), resulting in the severest relative interference, which affects the quality of the produced electron beam. Therefore, under safety conditions that did not lead to beam loss, the three undulators were adjusted to their minimum possible gaps, after which the gap of one of the undulators was changed individually to determine its effect on the electron beam (Figure 1).

Test mode	U5 gap (mm)	U9 gap (mm)	EPU gap (mm)	EPU phase (mm)
1	50 → 32 → 50	21	21	0
2	21	50 → 34 → 50	21	0
3	21	34	50 → 24 → 50	0
4	21	21	24	0 → 9.9 → 20 → 28 → 0 → -9.9 → -20 → -28

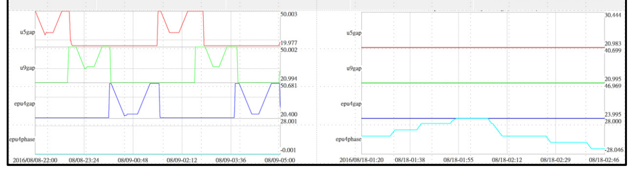

Figure 1: ID test mode.

RESEARCH RESULT

This section discusses the interference in the electron beam caused by magnetic field interactions due to the movements of the undulators U5, U9, and EPU (dynamic and static) during their adjustments. The orbit, stability, tune, injection efficiency, size, and lifetime of the electron beams are analyzed. The results are as follows:

ID Variation-orbit

Adjusting the U9 gap resulted in the greatest interference effect on the electron beams, with a 0.1 mm variation in beam orbit discovered. U5 and EPU gaps did not have any significant effect (Figure 2).

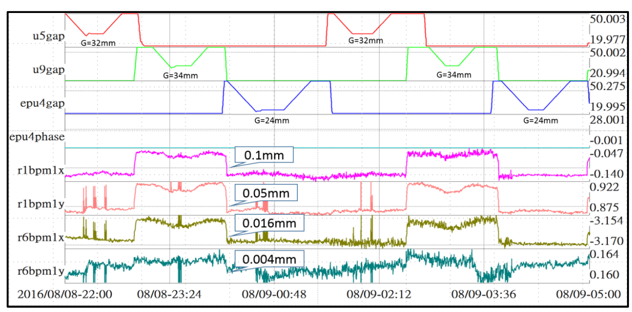

Figure 2: ID variation- orbit.

ID Variation-stability

Dynamic adjustment of the U9 gap resulted in a maximum change in beam stability of approximately 0.4%, whereas no effect was observed when the undulator was static. U5 and EPU gap adjustment again had no significant effect (Figure 3).

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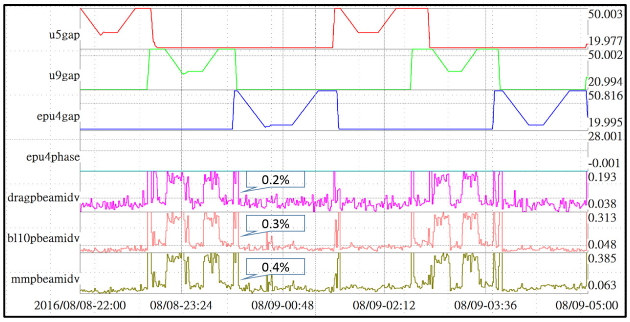

Figure 3: ID variation-stability.

ID Variation- tune

Adjusting the U9 gap resulted in the greatest change in the beam working tune, with fx and fy exhibiting a variation of approximately 30 kHz; adjustment of the U5 and EPU gaps also had an effect (Figure 4).

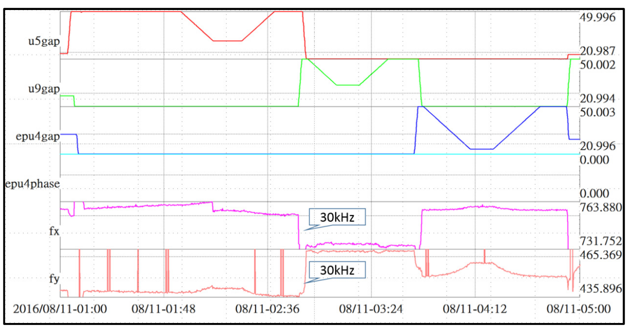

Figure 4: ID variation-tune- (fx,fy).

ID Variation- injection Efficiency

Adjusting the U5 gap toward the minimal gap value resulted in deterioration in beam injection efficiency, whereas adjusting the U9 and EPU gaps did not have a significant effect (Figure 5).

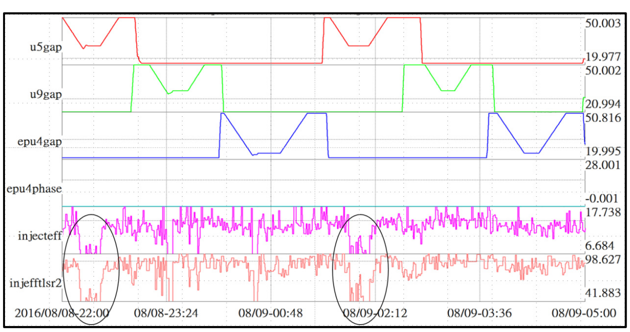

Figure 5: ID variation-t injection efficiency.

ID Variation- beamsize, Beam Lifetime

An adjustment of the U9 and EPU gaps caused a greater variation in beam size y and beam lifetime, whereas adjusting the U5 gap did not have a significant effect (Figure 6).

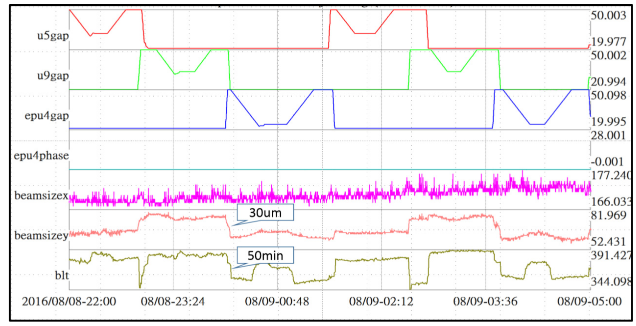

Figure 6: ID variation- beamsize, beam lifetime.

ID EPU Phase Variation- tune

Only EPU phase adjustment resulted in a relatively significant variation in the beam working tune, with fx and fy changing by approximately 16 and 4 kHz, respectively (Figure 7).

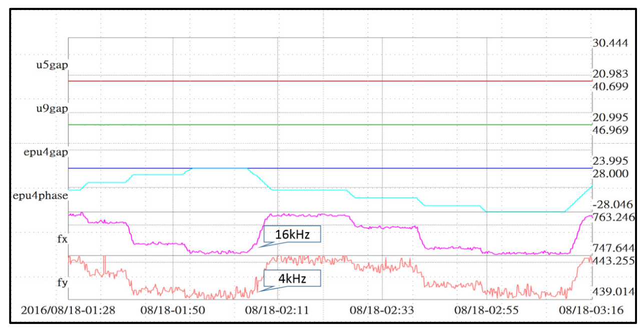

Figure 7: ID EPU phase variation- tune- (fx,fy).

CONCLUSIONS

Undulators shorten the space period of magnetic field alternation, reduce the electron oscillation amplitude, and cause the superimposed synchrotron radiation to form constructive interference over a particular spectrum, which greatly enhances the brightness[2]. This study investigated interference in the electron beam caused by magnetic field interactions due to the movements of the undulators U5, U9, and EPU (dynamic and static) during their gap adjustments, with the orbit, stability, tune, injection efficiency, size, and lifetime of the beam considered. U9 gap adjustment had the most significant effect on the electron beams, and the results of this study can serve as a reference for the operation of the TLS accelerator (Figure 8).

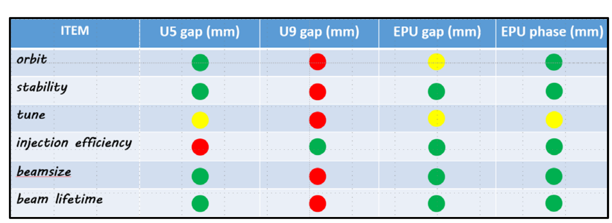

Figure 8: ID variation-Influence.

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