ISBN: 978-3-95450-214-1 ISSN: 2673-5490 doi:10.18429/JACoW-IPAC2021-THPAB309

NEW WORKING TUNE FEEDBACK SYSTEM FOR TLS

S. J. Huang†, Y. C. Lin, Y. K. Lin
National Synchrotron Radiation Research Center (NSRRC), Hsinchu, Taiwan

Abstract

TLS storage ring has two sets of working tuning feedback systems: one is used to correct the working tune deviation caused by insertion device U90; another system uses a local trim coil to correct the working tune deviation caused by all insertion devices. This article describes a new working tune feedback system in TLS that can correct the working tune effectively back to the required conditions for operation; the two existing feedback systems do not cause problems. We can both avoid increasing the local radiation dose and decreasing the injection efficiency.

MOTIVATION

Taiwan Light Source of National Synchrotron Radiation Research Center (NSRRC) is a third-generation synchrotron radiation accelerator with nine insertion devices, five of which are superconducting magnets and four are traditional magnets. The three traditional magnet insertion devices are U50, U90 and EPU56, which can adjust the gap to vary the synchrotron radiation energy required for the experiment. When a user adjusts the gap of the insertion device to vary the energy, the working tune of the storage ring alters because of an altered distribution of the local magnetic field. A corresponding tune feedback system is thus needed to correct the corresponding working tune offset.

There are currently two systems for feedback in the storage ring. The first is for U90, which has the strongest magnetic-field strength inserted into the device. U90 is used for dynamic tuning (U9DT) to adjust the current setting of the quadrupole magnet to improve the working tune shift caused by U90 gap adjustment, but the problem with U9DT is the quadrupole magnet. The hysteresis characteristic of the quadrupole magnet causes an error of the magnetic-field distribution. When the current setting alters significantly, the working tune of the storage ring has an offset error 25 kHz (Fig. 1).

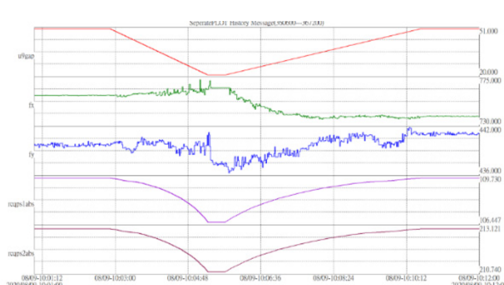

Figure 1: Working tune shift due to the influence of hysteresis characteristics.

† huang.szujung@nsrrc.org.tw

The other two insertion devices U50 and EPU56 should have the working tuning offset error attributed to the gap adjustment. For a current working tune feedback system, we can adjust the current value of the trim coil on the local quadrupole magnet to correct the offset error.

For a current working tune feedback system, we use an asymmetric magnet current setting to correct the working tune [1]. If the current setting is greater than 1.5 A, there is a risk, however, of increasing the radiation dose and decreasing the injection efficiency, as shown in Fig. 2. There is thus an urgent need to redevelop a new working tune feedback system.

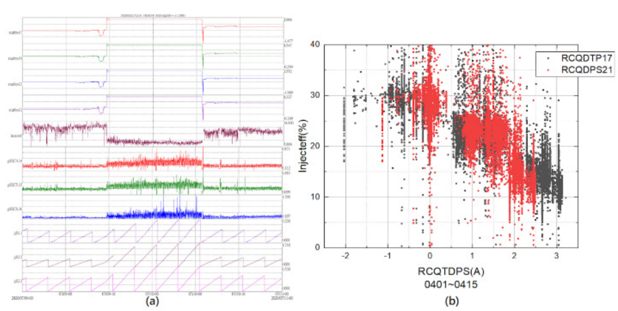

Figure 2: Setting current of trim coil; (a) relation between electron orbit and background radiation dose; (b) relation with injection efficiency.

DATA ANALYSIS AND PROGRAMMING

The quadrupole magnet is composed of electromagnets, so we must first understand how the current setting of the quadrupole magnet responds to a variation of the working tune. The corresponding relation between the working tune measured in various current setting areas is shown in Fig. 3.

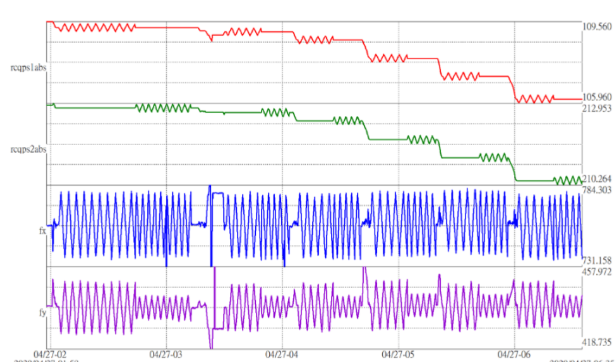

Figure 3: Relation between the current setting of the quadrupole magnet and the shift of the working tune.

ISBN: 978-3-95450-214-1 ISSN: 2673-5490 doi:10.18429/JACoW-IPAC2021-THPAB309

The purpose of this process is to understand the variation of the hysteresis characteristics for varied current setting intervals; we make at least three repeated measurements in each section to decrease the statistical measurement errors.

The measurement of the working tune is based on the result measured by the bunch-by-bunch feedback system [2]. To confirm the accuracy of the measurement, we wait 3 s after the quadrupole magnet current is settled to obtain stable data from that feedback system. After confirming that the measurement mechanism is stable, we acquire reliable data, and proceed to the next setting step to alter the current setting of the quadrupole magnet.

The statistical measurement results yield a response of the working tune to the quadrupole magnet current setting as follows.

$$R = \begin{bmatrix} \frac{dfx}{dQ1} & \frac{dfy}{dQ1} \\ \frac{dfx}{dQ2} & \frac{dfy}{dQ2} \end{bmatrix} = \begin{bmatrix} -121.432 & 66.978 \\ 157.172 & -41.442 \end{bmatrix}$$

The deviation of the real-time working tune from an ideal value is measured as follows.

$$T = [\Delta fx \quad \Delta fy]$$

The amount of correction required for a quadrupole magnet of the first pair of quadrupole magnets ($\Delta Q1$) and the second pair of quadrupole magnets ($\Delta Q2$) is

$$Q = [\Delta Q1 \quad \Delta Q2]$$

We use a Matlab program to compile the matrix calculation formula as follows.

$$T = \mathrm{Q}R \Rightarrow Q = TR^{-1}$$

After calculating the formula, we can obtain the required difference Q of the quadrupole magnet current.

The goal of program operation is mainly to correct the working tune deviation caused by the magnetic field effect during the mobilization of insertion devices. It is thus necessary to add several restrictions such as judging the state of the insertion devices to avoid a beam trip caused by misjudgement.

PROGRAM EXECUTION RESULTS

The program test is divided into three parts (Fig. 4). (I) The U90 is mobilized. After the U90 gap changes below 30 mm, the situation cannot be corrected in time. (II) Mobilization of any two insertion devices begins. When the U90 begins at the minimum gap, the working tune has a large offset, so the working tune cannot be locked. (III) Three insertion devices are simultaneously mobilized. When the gap of all insertion devices is smaller than 30 mm at the same time, the working tune might not be corrected in time. The working tune cannot then be corrected in real time when the magnetic field fluctuates greatly, but these situations are not normal during a user time. For the variation of the working tune under most conditions, it can thus be corrected to a steady state ±2 kHz.

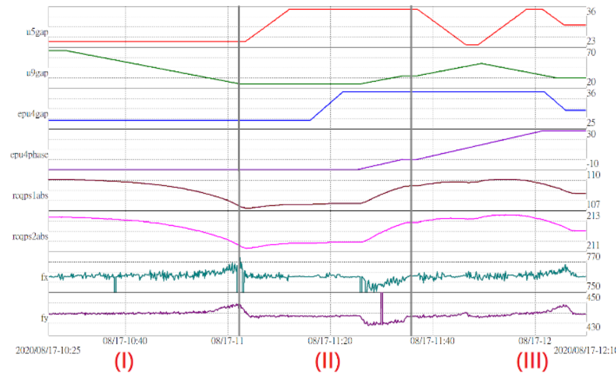

Figure 4: Random change of the gap of insertion devices to observe the result of system operation of the tune feedback system.

CONCLUSION

This article discusses that the newly developed tune feedback system is an effective help in the compensation and correction of the working tune. In the future, we shall continue to observe the effects of the radiation dose and stability during user time. The new tune feedback system can not only decrease the local radiation dose but also increase the injection efficiency.

REFERENCES

[1] C. H. Kuo *et al.*, “Commissioning Tune Feedback in the Taiwan Light Source”, in *Proc. 2nd Int. Particle Accelerator Conf. (IPAC'11)*, San Sebastian, Spain, Sep. 2011, paper MOPO016, pp. 517-519.

[2] C. H. Kuo, Y.-S. Cheng, P. C. Chiu, K. T. Hsu, K. H. Hu, and C.-Y. Liao, “Operation Status of Bunch-by-bunch Feedback System in the TLS”, in *Proc. 2nd Int. Particle Accelerator Conf. (IPAC'11)*, San Sebastian, Spain, Sep. 2011, paper MOPO015, pp. 514-516.