NEW WORKING TUNE FEEDBACK SYSTEM FOR TLS

S. J. Huang†, Y. C. Lin, Y. K. Lin
National Synchrotron Radiation Research Center (NSRRC), Hsinchu 30076, Taiwan, R.O.C.
E-Mail: huang.szujung@nsrrc.org.tw

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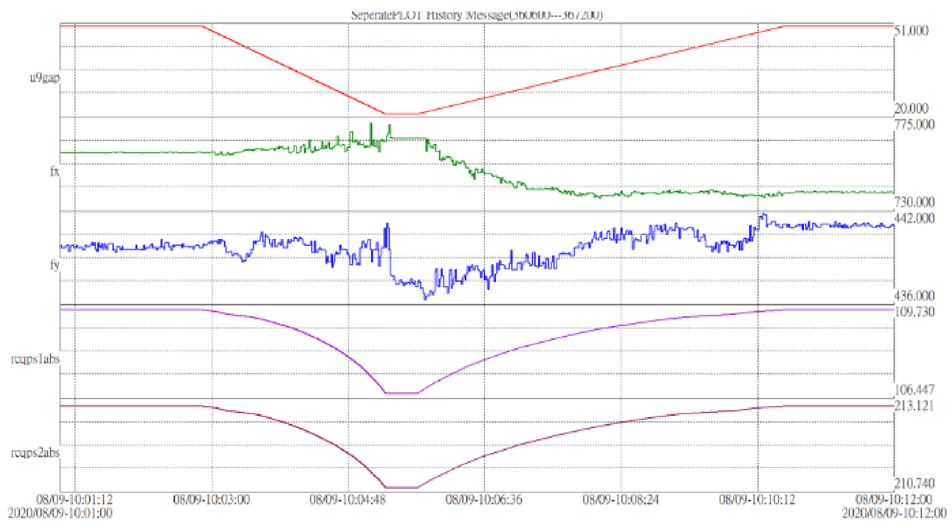
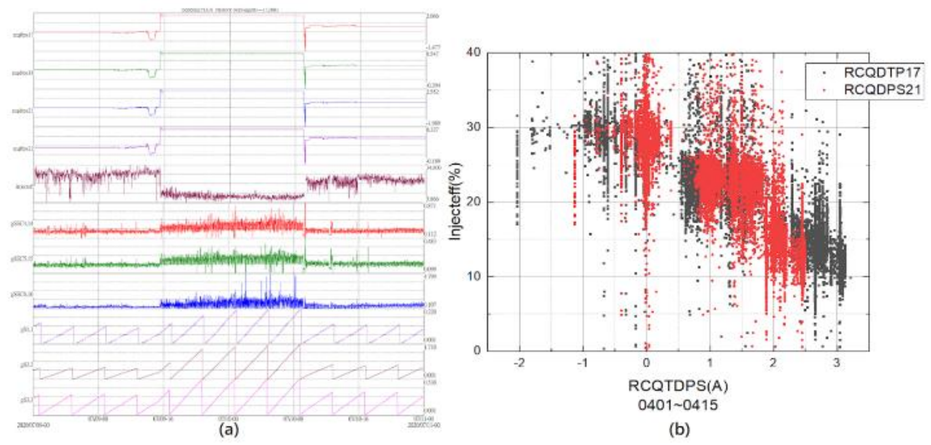
TLS storage ring has two sets of working tuning feedback systems: one is used to correct the working tune deviation caused by insertion device U90; another system uses a local trim coil to correct the working tune deviation caused by all insertion devices. This article describes a new working tune feedback 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

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.

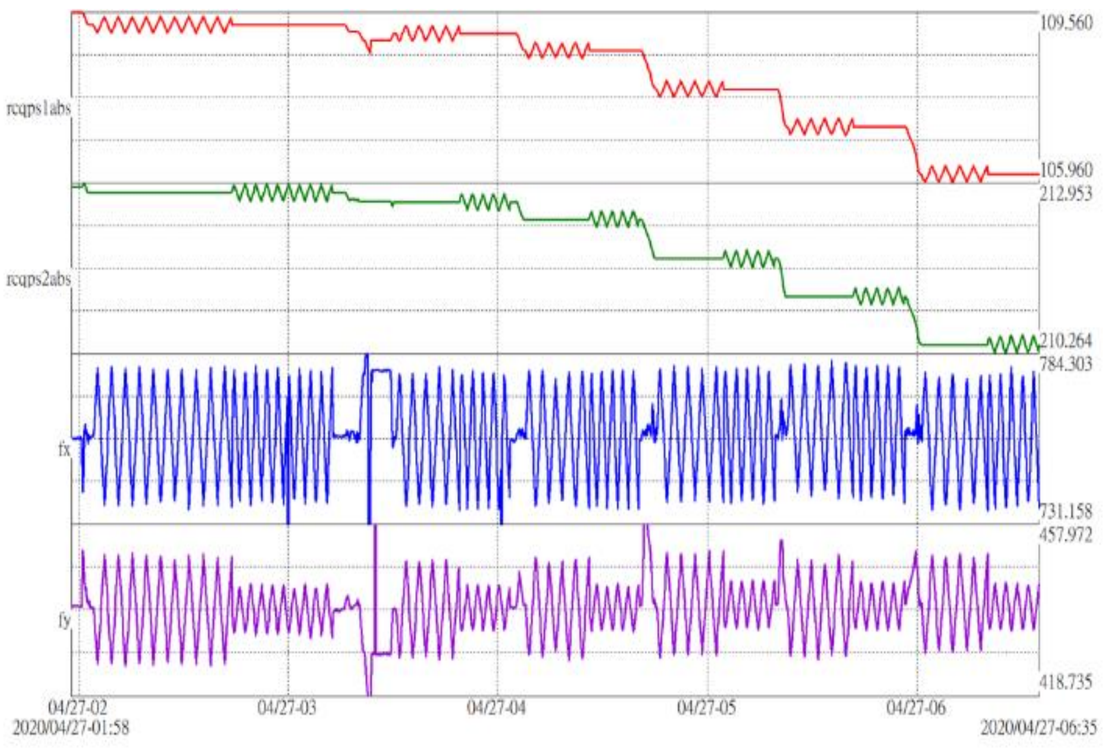


The hysteresis characteristic of the quadrupole magnet causes an error of the magnetic-field distribution. When the current setting alters significantly, the working tune of the storage ring has an offset error 25 kHz



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. We use an asymmetric magnet current setting to correct the working tune. 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.

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 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 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

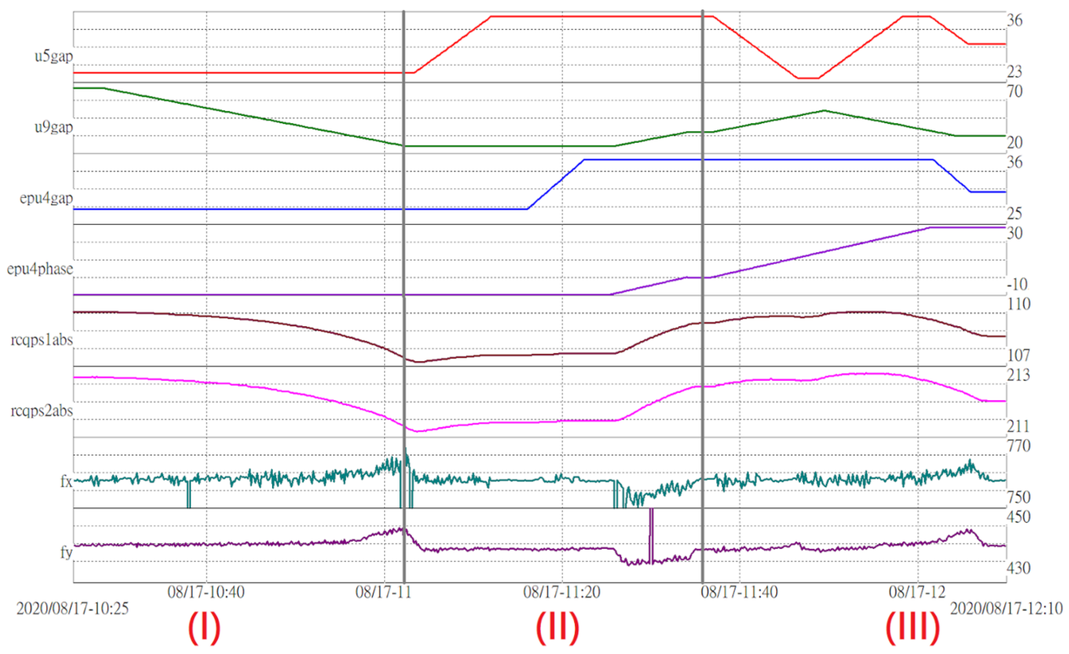
$$Q = [\Delta Q1 \quad \Delta Q2]$$

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

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

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



(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.

The operating point 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.

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.