STUDY OF THE WHITE CIRCUIT TRACKING PERFORMANCE IN THE BOOSTER SYNCHROTRON OF SRRC

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Abstract

Tracking performance of the White circuit is very important for the operation of booster synchrotron. An intensive White circuit tracking performance study in upgraded SRRC booster synchrotron was performed. Tune is the most sensitive parameter that relative to the White circuit tracking. Tune variation during energy ramping reflects the tracking condition. We investigate tracking performance by observed tune variation and to perform tune correction. Study result about the tracking performance and its improvement will summarize in this report.

1 INTRODUCTION

In the Taiwan Light Source (TLS) booster synchrotron, the electrons was emitted from an electron gun and accelerated to 50 MeV through a rf linac. Before the beam was extracted to the storage ring, The 50 MeV electrons beam in the booster synchrotron were raised up to 1.5 GeV energy. Tune information was obtained by an exit measurement system; it provides the ν_x and ν_y during the energy ramping cycle from 50 MeV to 1.5 GeV. The tune variation in the energy ramping can be correlated to the tracking error among the three families White circuit in the booster synchrotron. Three families White circuit tracking performance were important parameter for the booster synchrotron operation. With the tune monitoring and measurement system help, we can create an optimized lattice for the booster synchrotron to get a better working tune and a more efficient operation. An application program will be developed to automatic measurement and correction the tune variation. This tool is a very useful to monitor and understand the beam behavior in the booster synchrotron. In this experiment, we use it to estimate the performance of the tracking among these three families White circuit in the booster synchrotron.

2 THE CONFIGURATION OF TUNE MEASUREMENT AND CORRECTION SYSTEM

In figure 1, it shows the booster betatron tune monitoring and measurement system. In order to get tune variation information during ramping, the betatron tune was measured along the ramping cycle that the electron beam was injected at 50 MeV and ramp up to 1.5 GeV. While the stored electron beam in the booster synchrotron was excited by a magnetic pulse from the booster extraction kicker, the electron beam executed the betatron oscillation motion. The signal of the beam motion was picked up by the stripline and a log ratio amplifier[1]. A transient digitizer at VME crate records these associated signals. Application programs also on the VME crate get the raw data tune by tune and perform data analysis.

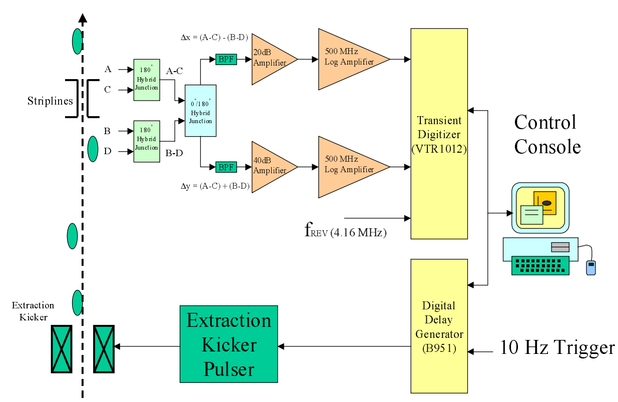

Figure 1. A function block diagram of betatron tune measurement system

A several programs on VME crate management these operations of the data acquisition system. Another Client programs running on the control console which were invoked by a Matlab scripts file to provide the analysis tool. Data analysis including Fourier analysis, peak identification and tune variation presentation also done by the Matlab scripts files.

Figure 2 presents the configuration of the tune variation correction system. In the tune measurement and correction procedure, the first step is that the magnet current of dipole, focusing and defocusing quadrupole was monitored in the ramping cycle. We change the ratio of focusing quadrupole magnet current to dipole magnet current or defocusing quadrupole magnet current to dipole magnet current. We can clearly observe the behavior of the tune variation in energy ramping cycle from 50 MeV to 1.5 GeV. The second step is after a fine tuning that a correction waveform was carried out to apply to the defocusing and focusing trim magnet power supply by this way. A waveform generator was installed in one of the VME crate in booster synchrotron control system. An automatic procedure will be developed and installed to the booster synchrotron normal operation. While the booster synchrotron tune measurement was enable, the tune correction waveform was applied to quadrupole trim power supply after a few minutes automatically.

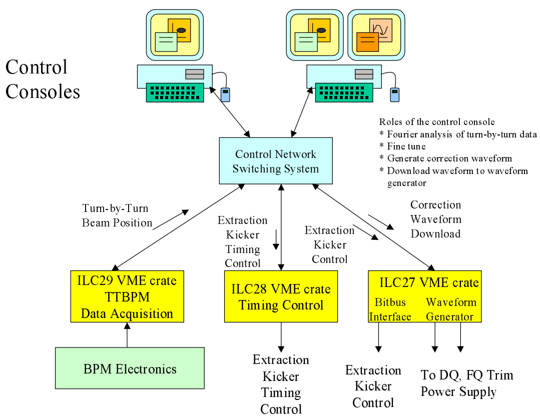

Figure 2. The betatron tune variation correction system

3 THE BETATRON TUNE SIGNAL ANALYSIS

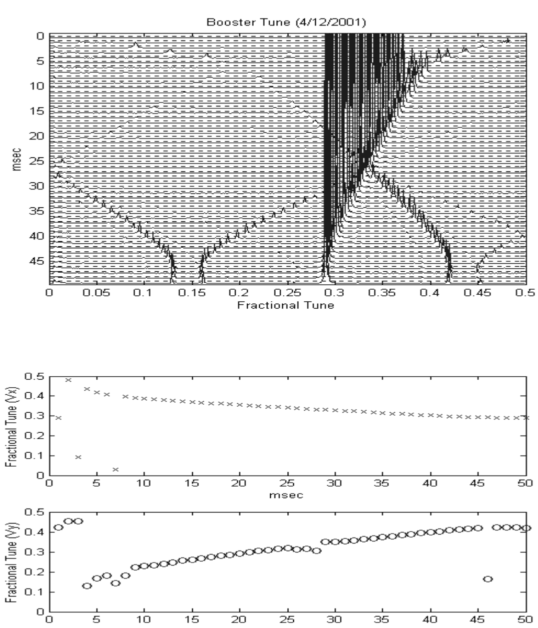

Figure 3. The betatron tune variation measurement result before the fine tune

An experiment result was shown in the figure 3. In this experiment, application programs analysis these associated data and perform peak identification and show the fractional tune step by step from 50 MeV to 1.5 GeV. The total ramping duration is 50 ms. A sinusoidal like function was implemented for the kicker strength to excite the electron beam. Amplitude and timing of the kicker excited strength were tunable for another experiment need. This tool is very useful to understand and monitor the booster ramping behavior. Specially, we estimated the tracking performance among three families White Circuit by this information help.

4 THE IMPROVEMENT OF TUNE VARIATION

The figure 4 presents the experiment result that an optimization setting of these families power supplies and a quadrupole correction trim power supply was made for a proper working point of the booster. A better improvement in tune variation behavior has been observed and carried out. From the measurement result, the tune variation behavior has big change after a fine-tuning.

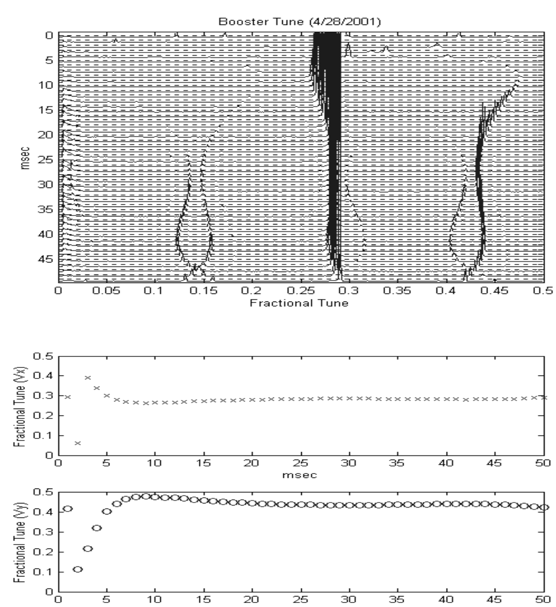

Figure 4. The betatron tune variation measurement result after fine tuning

In the booster synchrotron normal operation, the extraction kicker was installed to deflection the electrical beam in horizontal movement[2]. The ν_x signal is more significant than ν_y signal, so the ν_y signal is not big enough to provide useful information in this case. In the beginning 10 ms of the energy ramping cycle, the data were not clear enough. It almost happens in the low energy region. These regions are unclear at this moment. Improvement of this problem is under way. After the 10 ms energy ramping cycle, the tune variation is small and smooth change. It implies two important notices, that first, the working point, and the second, the tracking performance among the three families White circuit, are good.

5 THE PERFORMANCE OF TRACKING

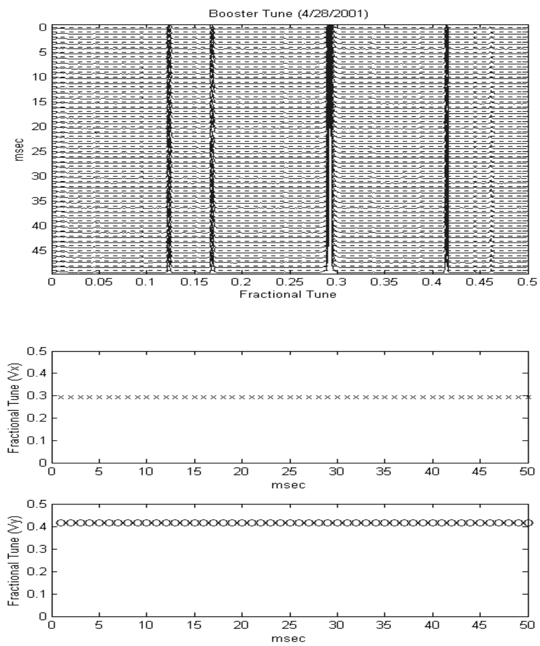

Figure 5. The betatron tune measurement by a fix kicker strength and timing setting

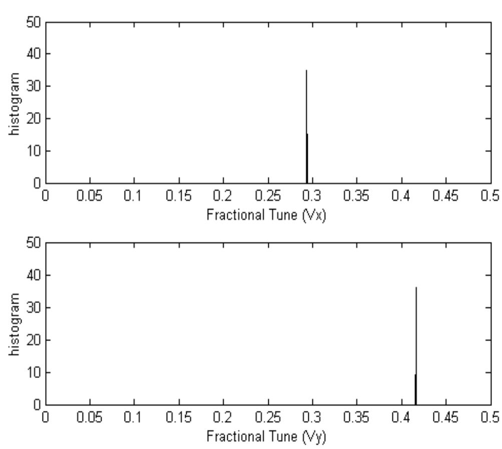

Figure 6. The histogram of betatron tune variation by a fix setting of kicker strength and timing

Another functions of the betatron tune measurement Matlab scripts were installed to monitor the tune variation in a fix setting value of kicker strength and timing. An experiment result is shown in the figure 5. The tune variation is very small. Figure 6 presents the tune variation histogram. The tune variation range is smaller then 0.002. For the booster overall stability, a great phase tracking among these three families White circuit was demanded. A proper control algorithm was implemented to perform the phase regulation. In a long time monitoring and measurement, less than 1 us phase shift is observed[3].

Another important parameter about the tracking performance of booster three families White circuit is the betatron tune variation behavior. In this experiment setup and result, booster extraction kicker strength and timing setting are fixed and simulated to the booster synchrotron normal operation. The synchrotron tune almost keeps constant in the duration of tune measurement procedure. This provides an information about booster three families White circuit have very great tracking performance.

6 SUMMARY AND IMPROVEMENT

An optimized ratio setting of these three families power supplies were easily achieved for normal operation of the booster synchrotron in TLS by the help of tune measurement system. The experiment result not only shows the reduce in tune variation and the performance in tracking among the three families White circuit but also indicates that this tune measurement and correction system is a very useful tool in understanding the tracking behavior during the ramping cycle.

The extraction kicker only kicks the electron beam in horizontal direction. The vertical tune signal is not easy to monitor and identify. In order to provide another experiment need and improve the vertical tune signal strength. Another component will be installed into the booster synchrotron in a few months.

7 ACKNOWLEDGMENTS

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8 REFERENCES

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[3]. C. S. Chen, et al., “Performance of The New White Circuit in Upgraded 1.5 GeV Booster Synchrotron” Proceedings of the 7th European Particle Accelerator Conference, Vienna, 26-30 June 2000, p.1829.