PRELIMINARY TRANSVERSE AND LONGITUDINAL PHASE SPACE STUDY AT TLS

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Abstract

Turn-by-turn beam position monitors and phase detector have been implemented recently for Taiwan Light Source (TLS). Transverse as well as longitudinal phase space has been explored using turn-by-turn beam position and phase measurement in single bunch mode. Single bunch longitudinal beam transfer function measurement is also performed with various excitation amplitudes. Preliminary results of these experiments are summary in this report.

1. INTRODUCTION

Phase space portrait is useful tools in nonlinear beam dynamic study [1][2][3][4]. A six-dimensional phase space monitors is implemented to study turn-by-turn beam dynamics in Taiwan Light Source (TLS). This tools is also useful as an on-line diagnostic tool for TLS. Longitudinal beam transfer function (BTF) measurement is a standard diagnostic method and extensive study recently [5][6]. Experimental setup is implemented to measure longitudinal beam transfer function in TLS. Preliminary transverse phase space and longitudinal BTF measurement are performed. Systematic study will follow soon. These tools will use to study various issues of non-linear dynamics at TLS in near future.

2. TOOL DESCRIPTION

A six-dimensional phase space monitor includes two sets of BPMs to measure horizontal position and angle, two BPMs to measure vertical position and angle. One BPM located at dispersion region is used to extract momentum error, a phase detector to observe the energy oscillation. Log-ratio processors are implement to measure turn-by-turn beam position [7]. Beam phase is extracted by phase detector. The raw data is recorded by multi-channels 128 kW/256 kW transient digitizer located at VME crate. Functional block diagram is shown in Fig.1. The server software on VME crate is in charge of data acquisition. Client software running in control console is used to access raw data, to analysis and to display result. The data acquire is synchronize with revolution clock. Memory depth of transient digitizer limited record length.

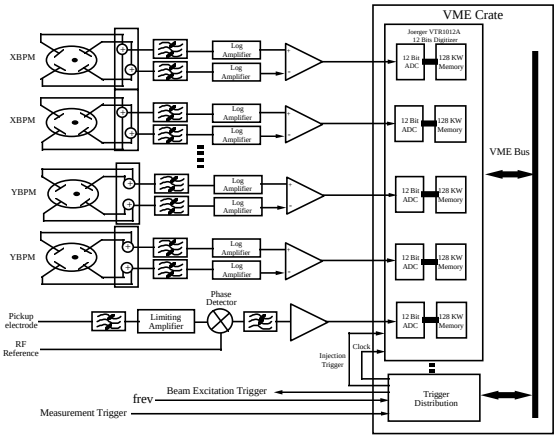


Figure 1. Block diagram of 6-dimensional phase space monitor.

Longitudinal BTF is measured by using phase detector and RF phase modulation. Dynamic signal analyzer (DSA) worked in swept-sine mode is used to acquire BTF directly. The DSA is connected to control system via GPIB to ethernet adapter. The data acquisition operates automatically. Experimental setup is shown in Fig. 2 for longitudinal BTF measurement.

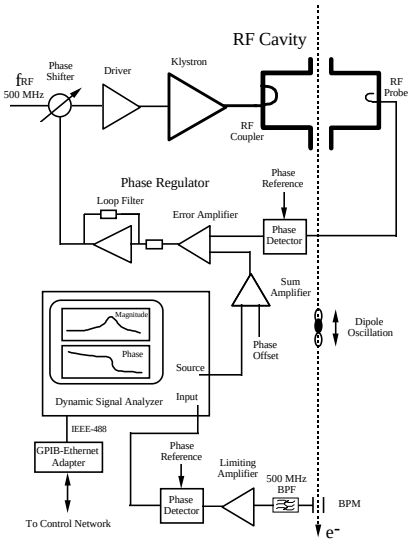


Figure 2. Experiment setup of longitudinal beam transfer function measurement.

3. TRANSVERSE PHASE SPACE EXPLORATION

Transverse turn-by-turn beam position was processed by newly installed log-ratio processors and digitized by digitizers. Only horizontal plane is presented in hear due to easily in beam excitation. One of an injection kicker is used to excite the stored beam. Preliminary study is done near $4\nu_x = 29$, $5\nu_x = 36$, $6\nu_x = 43$. Fig. 3 shown the stored beam is kick about 1 mrad, and tune close to 4th order resonance. The damping is strong. When tune closed to 5th order resonance, turn-by-turn beam position is shown in Fig. 4. Phase space plot of near 5th resonance with slightly difference in tune shown in Fig. 5,6,7. Phase space portrait near 6th order resonance shown in Fig. 8.

Since the injection kicker pulse is a 1.5 μsec half-sine, it will affect up to four turns of the stored beam. Effective kick strength is difficult to estimate if kicker fire asynchronous with the bucket address of the stored bunch. Synchronous kicker trigger with revolution clock will be added in next study. The storage ring does not have vertical kicker. Vertical excitation can be done by resonance excitation at this moment. Applied vertical betatron frequency burst to beam excitation system can excite vertical betatron oscillation. However, the experiment is inconvenient slightly.

Experiments report in here is still in its infancy. There are some inconvenience was found during the experiment. Various on-line tools will be development to provide a convenient environment for study. The tools will provide beam position versus turn display, shown tune immediately, record related machine parameters with the measured data, ... etc.

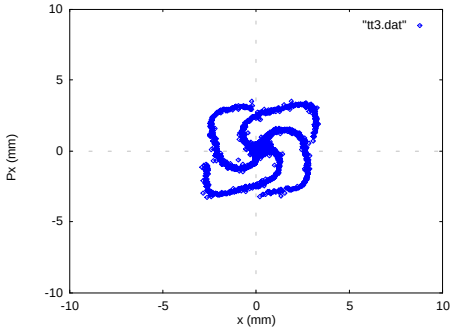


Figure 3: Horizontal phase space portrait near $4\nu_x = 29$ resonance.

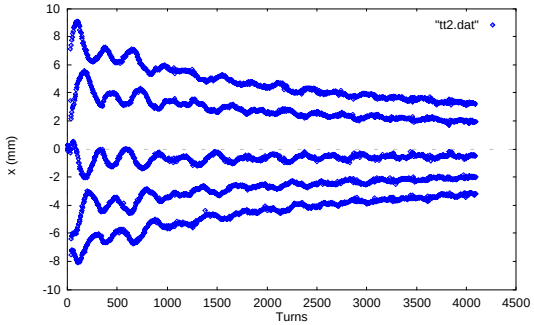


Figure 4: Horizontal beam position evolution near $5\nu_x = 36$ resonance.

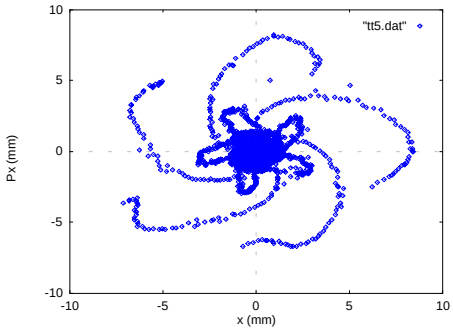


Figure 5: Horizontal phase space portrait near $5\nu_x = 36$ resonance.

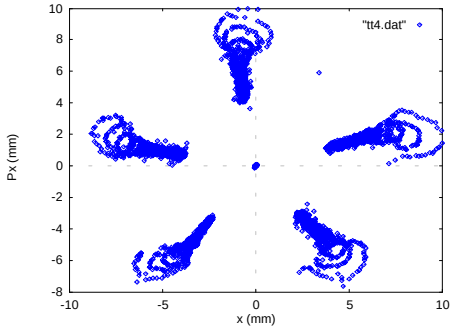


Figure 6: Horizontal phase space portrait near $5\nu_x = 36$ resonance.

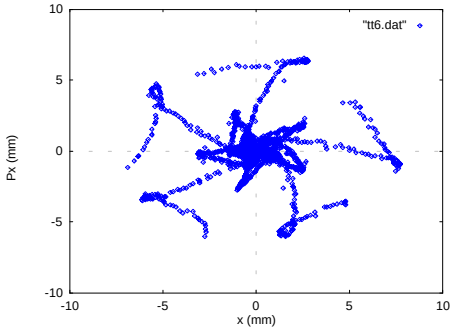


Figure 7: Horizontal phase space portrait near $5\nu_x = 36$ resonance.

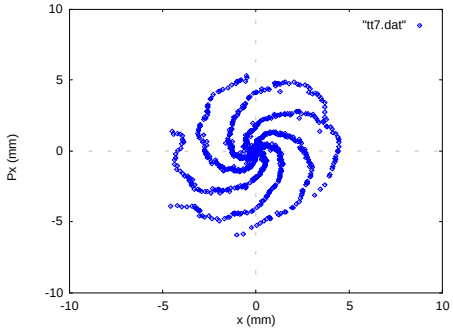


Figure 8: Horizontal phase space portrait near $6\nu_x = 43$ resonance.

4. LONGITUDINAL PHASE SPACE OBSERVATION

With the longitudinal phase-space monitor, both the phase oscillation and momentum deviation can be simultaneously observed. The measurement was done under the single-bunch operation with RF phase modulation. Longitudinal phase space is performed by using the phase detector and a BPM located at dispersion region. Turn-by-turn momentum error is extracted by deduce from relationship $\Delta p/p = \Delta x/\eta$. Preliminary measured results are shown in Fig. 9. The data is slightly noisy. Performance of the monitor should improve further.

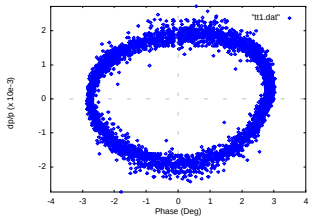
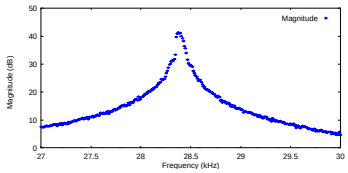


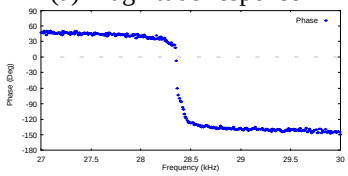
Figure 9: Longitudinal phase space portrait with RF phase modulation..

5. LONGITUDINAL BEAM TRANSFER FUNCTION MEASUREMENT

Preliminary longitudinal BTF is measured also. Fig. 10 is shown longitudinal BTF of a typical sweep in linear regime, resonance occurs at synchronous frequency and the phase shift 180 degrees at resonance.



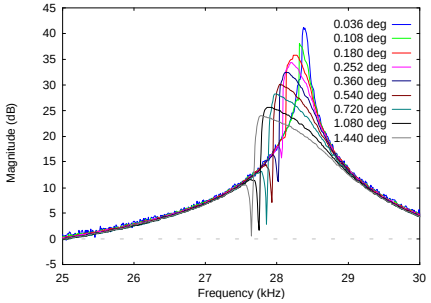
(a) Magnitude response



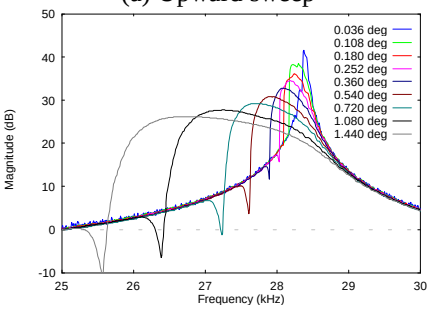
(b) Phase response

Figure 10: Typical longitudinal beam transfer function.

First experiment is performed on the topics of excitation amplitude dependent BTF. Longitudinal BTF have been studied intensively by J. Byrd [5][6] in ALS. However, further study is helpful to investigate the usage of longitudinal BTF. In this report we measure longitudinal BTF by vary excitation amplitude. BTF of upward and downward sweep is recorded. Preliminary experiment data is shown in Fig. 11. Hysteresis effect is prominence that is a typical behavior of nonlinear system. Notch occur at the low frequency side in the magnitude response of BTF is due to out of phase in inner and outer beamlet oscillation [5], and phase detector cannot detect the signal.



(a) Upward sweep



(b) Downward sweep

Figure 11: Longitudinal beam transfer function with various excitation level; (a) upward sweep, (b) downward sweep.

6. SUMMARY

A six-dimensional phase space monitor is implemented in SRRC recently. Preliminary nonlinear beam dynamic experiments is on going. We have been performed transverse phase space experiments near $4\nu_x = 29$, $5\nu_x = 36$, $6\nu_x = 43$ resonance. Third order resonance experiment is in study. Simulation, analysis measured data and improves the performance of the monitor is current efforts. Further study for amplitude dependent tune shift and phase space trajectories near nonlinear resonance will perform in next step. Preliminary longitudinal BTF performed also. Analysis acquired BTF data and prepared next experiment is underway.

7. REFERENCES

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