VIBRATION AND BEAM MOTION DIAGNOSTICS IN TLS

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Abstract

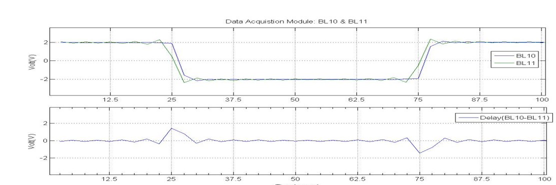
High beam stability is essential in a modern synchrotron light source due to small emittance. Beam motion caused by various factors should be remedy by various approaches to achieve high beam stability. Vibration will deteriorate beam stability and need considered as a part of beam diagnostic. An integrated environment for beam orbit and vibration monitoring systems were set up for various studies. Implementation details and some beam observation will be presented in this report.

INTRODUCTION

Taiwan Light Source (TLS) is an operating synchrotron light source since 1993. The same site will host another 3 GeV synchrotron light source: Taiwan Photon Source (TPS); which has been under construction since 2010. The excavating and pile-sinking at some specific time window in the civil construction works caused large ground motion suddenly, furthermore deteriorated the stability of TLS beamline intensity (ΔIo/Io) from 0.1% to 10% or more. Besides, the stability of intensity between beamlines is not always consistency, either. In contrast with the inconsistency intensity between beamlines, the spectrum of electron beam is concordant while normal operation and large vibration occurred. The difference between girders might be one of reasons we suspected. To figure out these inconsistent results, the vibration diagnostic system is necessary to build and planned to be integrated with current diagnostic system. In this report, the vibration diagnostic system will be presented as correlation with electron orbit, photon beam and vibration.

DATA ACQUISITION FOR VIBRATION AND BEAM MOTION

Vibration has become an important factor which should be considered for beam diagnostic in recent years. An integrated vibration and beam motion monitoring system will be very helpful for on-line monitoring and help to identify sources and reasons. To implement a vibration monitoring system which is compatible with the accelerator system, the vibration data acquisition hardware should comply with the PC/Linux environment which is the standard platform of the TLS control system. Most of the commercial available measurement systems are working on some PC/Windows or proprietary environment only. Measurement of a large volume of sensors distributed a large geographical area with long cabling is not desirable, either. Therefore, a small channel count per unit with a suitable connectivity mechanism is high desirable. Finally, 4 channel, LXI-C comply DT8837 was chosen. This device can connect to voltage signals or ICP accelerometers at any places around the storage ring or experimental floor with only Ethernet connection. The LXI trigger bus cabling is inconvenient for a highly distributed system, an UDP trigger packet to start or to stop the data acquisitions provide a mechanism for synchronization among multiple DT8837s. It cannot synchronize the ADC clocks between different DT8837s is the drawback of this scheme. To test the synchronism of the approach, two DT8837s are connected to a 10 Hz 2V square wave signal. The typical measurement signals are shown in Fig. 1 (a), the time variation (delay) of the square wave edge between two signals captured by different units can be used to estimate the phase different. The delay is differed for one sampling period maximum (2.5 ms for 400 Hz sampling). This time difference will drift slowly (unit dependent, ~ 30 sec for 400 Hz sampling) which is caused by the beating of the ADC clocks difference amount inputs. Higher sampling frequency can reduce this situation. Difference of both acquired data from two units for difference sampling frequency with the same square wave input shown the UTP trigger package will be not contributed sensible delay problem for the sampling frequency up to 10 kHz. The phase difference (time difference) for analysis frequency up to 100 Hz, 400 Hz is still acceptable.



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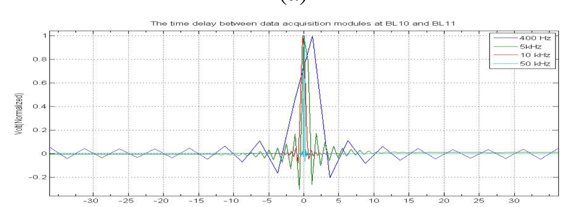

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Figure 1: (a) The test result of DT8837 data acquisition modules and time variation with 400 Hz sampling rate. (b) The test result of DT8837 data acquisition modules with different sampling rate.

EPICS IOC is used to control DT8837 and convert data unit of the received data. To observe and analyse the vibration trend, the system supports two operation modes: one is real-time mode which updates and archived the waveform continuously and the other is on demand by manual or triggered by events.

There are two nodes to capture the beam orbit data from the 10 kHz data stream of the BPM system (Ethernet grouping of the BPM Libera Brilliance units) are also available for orbit motion analysis.

In Fig. 2, all data such as electron beam, photon beam and vibration are synchronized by a software trigger in 100 msec. 10 Hz data from ILC could be acquired in real-time and archived, the fast transient motion could be also observed in adjustable higher time resolution and sampling rate up to 10 kHz.

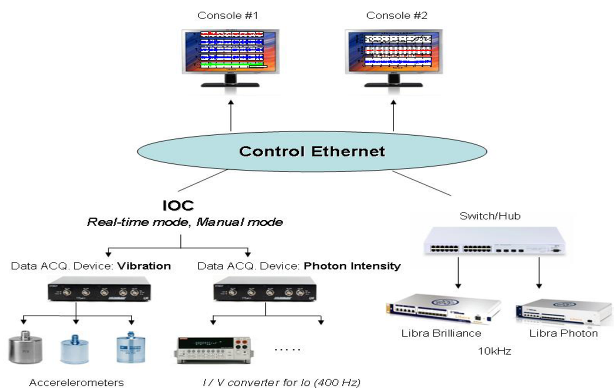


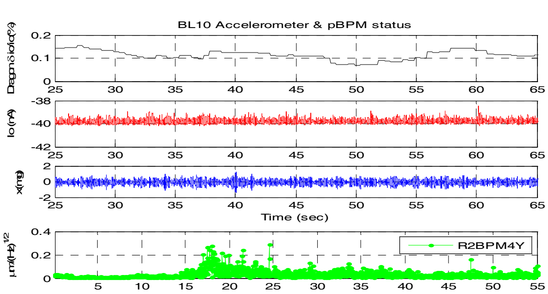
Figure 2: The data acquisition system for vibration diagnostic with other subsystem.

VIBRATION ANALYSIS WITH BPM DATA

To clarify the relationship between vibration and beam stability, two strategies have been considered: the status of normal operation and TPS is under construction. For experiment, photon BPM between BL 10 and BL 11 are chosen and the monitoring electron BPMs are R2BPM4 and R2BPM1.

The Status of Normal Operation

The status of beam stability at normal operation is showing in Fig. 3. The stability of beamline intensity (Δ Io/Io) is below 0.1%, and the stability of electron beam is also within 0.5 um below 50 Hz. In comparison with the BL10 and BL11, the spectrum of electron beam from R2BPM4Y and R2BPM1Y are quiet similar. However, the amplitude of vibration and photon intensity Io of BL10 and BL11 are not. It seems the mechanical structure of BL11 (0.006 mg) is more stable than BL10 (0.06 mg). Thus it can be seen that the vibration characteristics of two beamlines are not always consistent.



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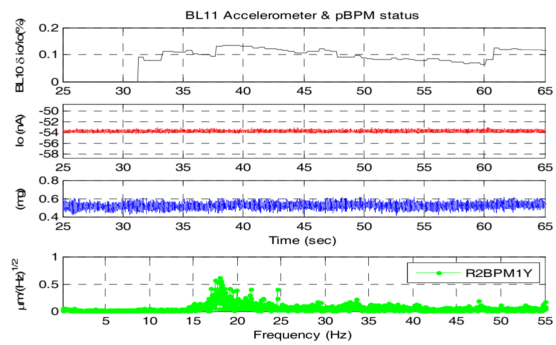

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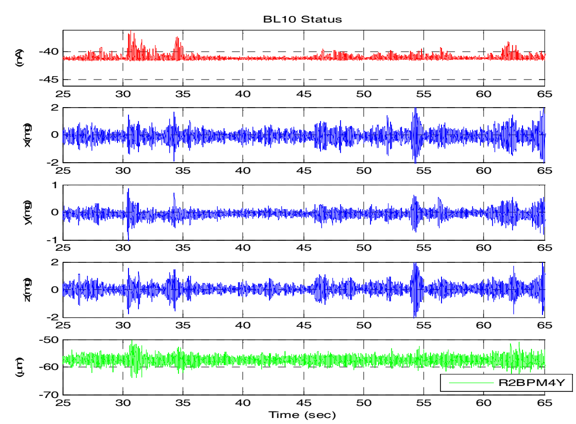
Figure 3: (a) BL 10 Io, x-axis vibration and electron BPM: R2BPM4Y. (b) BL 11 Io, x-axis vibration and electron BPM: R2BPM1Y.

The Vibration Caused by Pile-Sinking While TPS is Under Construction

In Fig. 4, it shows enormous photon intensity (Io) variation due to the large vibration occurred when excavating or pile-sinking works in proceed at some occasion.



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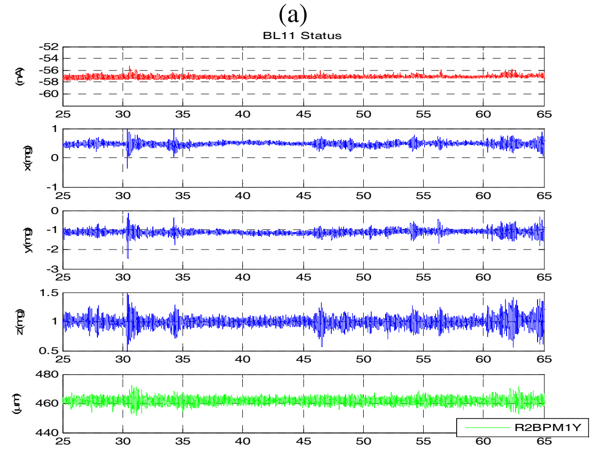

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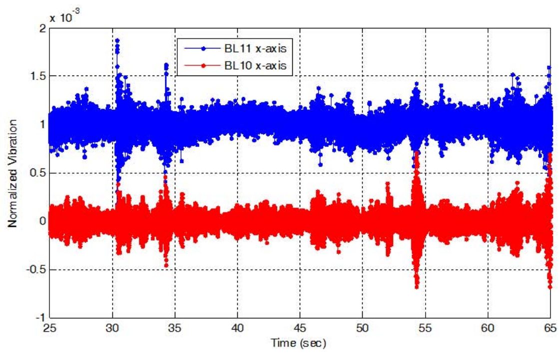
Figure 4: (a) Time series data of BL 10 Io, X, Y and Z-axis vibration and electron BPM R2BPM4Y. (b) Time series data of BL 11 Io and X Y and Z-axis vibration and electron BPM R2BPM1Y during pile-sinking process of the TPS civil construction.

The spikes of vibration occurred simultaneously and the correlation coefficient is relative high at the time shifting interval from 0.4 to -0.4 sec in Fig. 5. Furthermore, the amplitude of three-axis and photon intensity Io of BL11 is also smaller than BL10. According to the above reasons, it can be inferred that vibration source caused by the same source but the spectrum inconsistency is due to the different natural frequency of different supports structure and chambers of different beamline.



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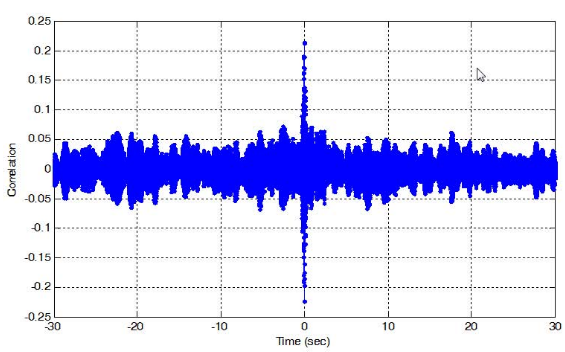

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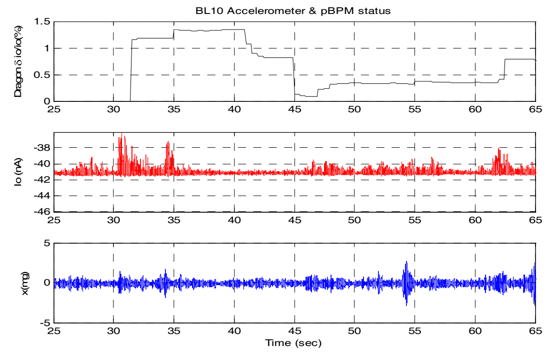
Figure 5: (a) BL10 and BL11 x-axis normalized vibration. (b) The correlation between BL10 and BL 11.

△Io/Io Change Study

In comparison with the stability △Io/Io of BL10 and BL11, one of them became worse sometime, the other remained normal. But, both of the electron beam orbit are steady. In Fig. 6(a), the stability of BL11 is better than BL10. So, it is inferred there is a local vibration event nearby the BL10. In other words, indicator △Io/Io is not a reasonable parameter to determine the relationship between electron beam and photon beam. Besides, the deflection of photon beam is not the mainly resulted from electron beam even if the instability caused by global vibration but the local vibration contributed more. In fact, the electron beam is more stable than photon beam when large vibration occurs.



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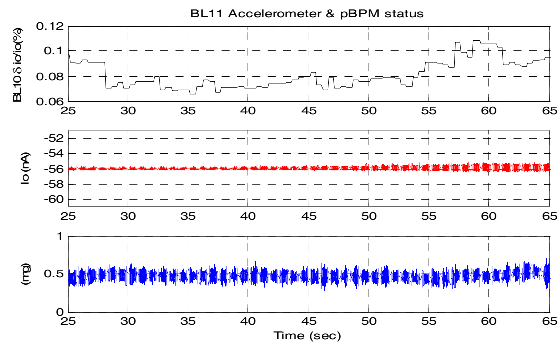

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Figure 6: (a) Time series data of BL 10 Io, △Io/Io and x-axis vibration. (b) Time series data of BL 11 Io, △Io/Io and x-axis vibration when ground vibration occurring.

SUMMARY

In this report, we show the data acquisition of accelerometers and clarify some contradictive events among electron beam, photon beam and vibration while TLS is operating. For instance, the inconsistency of △Io/Io between beamlines was possible resulted from local grounding vibration. In addition, the characteristic between different beamlines girders are quiet differed. The firmness of storage ring girder is better than beamlines and electron beam which is more immune from vibration than photon beam.

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