

VIBRATION MEASUREMENT EXPERIMENT AT TLS

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Abstract

The oncoming completion of Taiwan Photon Source is closely constructed beside Taiwan Light Source (TLS). Few civil works are continuously under construction. Building the measurement, recording and analysis platform of software and hardware is the one of the main directions of operation group. To diagnose the instability problem of the light source, the external influence must be eliminated. One of the factors causing the instability is the physical vibration. Vibration measurement helps to evaluate if newly installed equipments are suited for adding on or the influence of the earthquake to the stability of TLS and to improve the light source quality for users.

Software has been developed to provide assistance to do some preliminary diagnoses at TLS. In this article, some actual cases in routine operation are also presented.

INTRODUCTION

Taiwan Light Source is a third generation synchrotron light source facility with 1.5 GeV beam energy and started its Top-up mode operation since 2005. The stability of the electron beam is extremely important to produce a high brilliance photon beam of small emittance which is one of main target performances of the storage ring. [1]

Vibration measurement has wide application on many accelerators and colliders such as the PSD (power spectrum density, unit: cm^2/Hz) measurement [2] on the girder of quadruple magnet for comparing the GM(Ground Motion) difference between day and night. The vibration sources vary including the air condition system, cooling water system, pump, cooler, tuning-fork effect and even the earthquake as well as the moving vehicles in the surroundings. When there is an unavoidable vibration source, avoidable vibration isolation schemes are adopted, such as the vibration isolation table [3] on ILC [4].

The light source stability of Taiwan Light Source (TLS) could be quantized by the existing $\Delta I/I_0$ system at Beamline18 (BL18). ΔI is the light intensity variation relative to the average light strength(photon flux) I_0 at beam line. The source of the light variation ΔI may result from local mechanical oscillation/vibration at beam line or the actual state of electron beam of overall synchrotron system.

Since vibration is one of the reasons that can introduce the instability problems to the photon beam, unlike the general PSD method distributed over the whole system region, the vibration status at the local area can also be adopted for mapping to photon stability in a simpler and

faster way relatively. Vibration measurement system at the local area can recognize whether the instability problems are arisen from the local vibration or other reasons.

MEASUREMENT SETUP

The vibration sampling point is located near the setup position of $\Delta I/I_0$ measurement system. $\Delta I/I_0$ measurement system of BL18 is shown in Figure 1. In this measurement system, the accelerometers were mounted at the pin-hole girder of BL18, as shown in Figure 2.

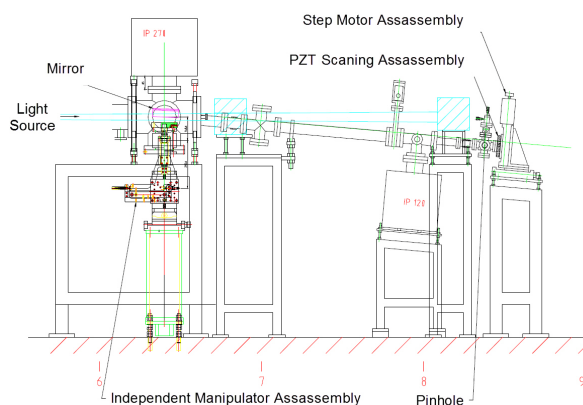


Figure 1: BL18 $\Delta I/I_0$ measurement system.

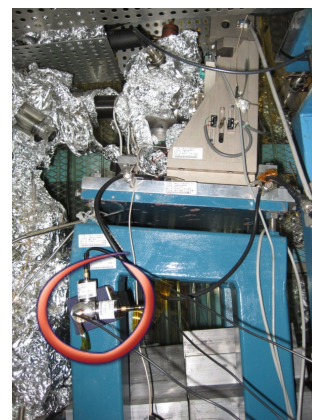


Figure 2: Three accelerometers were fixed on the last girder of I_0 system by a magnet.

$\Delta I/I_0$ measurement system of BL18 was firstly developed for LSGM beam line diagnosis [5], and then this technique is extended to be used at BL11 and BL18. This measurement system can detect the photon beam intensity (I) when it reaches the beam line. For best light

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quality, the pin-hole would be moved to the position with maximum signal (I_0) automatically and then kept detecting to obtain $\Delta I/I_0$. However, due to the serious interference occurred during the top-up injection period and the auto adjustment of pin-hole position for the maximum availability of I_0 , the detection execution avoids acquiring data from the injection period in every minute. The I_0 auto scanning and adjustment mechanism will be activated to find a new pinhole position when the $\Delta I/I_0$ value is larger than the high limit continuously for few minutes. The user interface of $\Delta I/I_0$ system is shown as Figure 3.

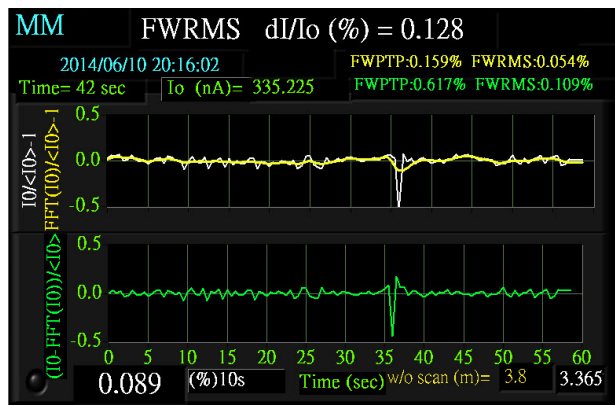


Figure 3: The user interface of BL18 $\Delta I/I_0$ system.

The vibration measurement sensors consist of three accelerometers on three orthogonal axis arms which were fixed on the BL18 girder by permanent magnets and connected to a National Instrument DAQ card (NI-9234 USB). The acquired data was then transmitted to and analyzed on a personal computer. The vibration sensor was made by Wilcoxon Research (model 731-207). It features a 10 V/g seismic piezoelectric (PE) accelerometer with integral electronics (IEPE) and the frequency bandwidth ranges from 0.2 Hz to 1,300 Hz at ± 3 dB level[6]. Since the accelerometer needs proper DC power to work, the DAQ card also has IEPE interface with 51.2KS/s sampling rate per channel to handle this local area measurement work.

Through the accelerometer, the vibration will then be converted to analog signals which will be digitalized by the DAQ card for data processing, storage and graph plotting in the computer. The application software was developed on LabVIEW platform. As $\Delta I/I_0$ grows higher than the trigger level, 10 seconds data just before the triggered event will be acquired and displayed on the developed Man-Machine interface and recorded with the date and time accordingly. The stored data can be traced back with other simultaneous events for diagnosis. The user interface of the developed program is shown in Figure 5.

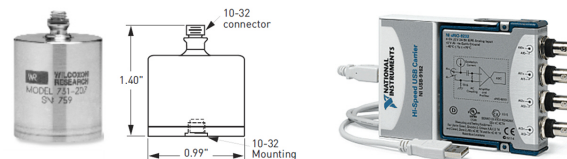


Figure 4: The accelerometer and DAQ card.

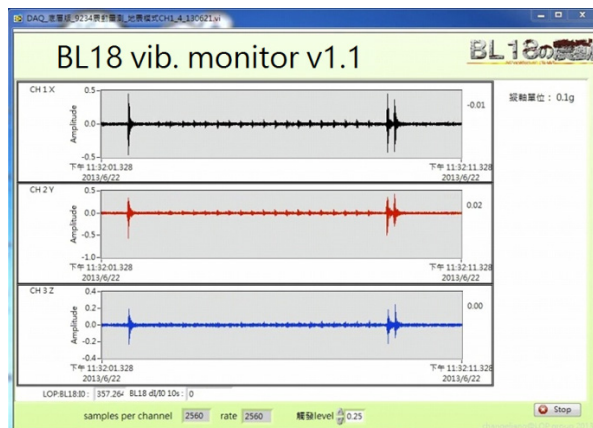


Figure 5: The GUI interface of BL18 vibration monitoring system.

MEASUREMENT RESULT: CASE STUDY

One of the cases that the vibration affected the stability of the photon beam happened on 09:13, 17th July, 2013. The vibration measurement system detected and recorded the vibration event (as shown in Figure 6). At the same time, the synchrotron historical Archive system also recorded an obvious I_0 drop from 350nA to 338nA as shown in Figure 7.

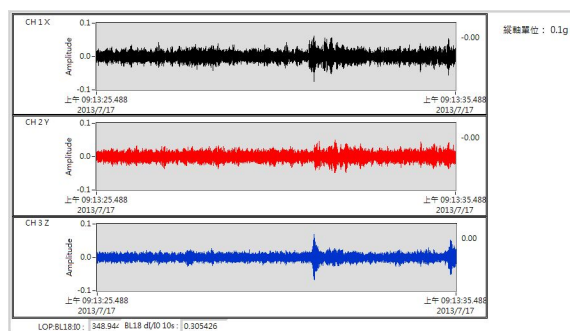


Figure 6: The poor $\Delta I/I_0$ event was triggered by vibration in the morning of 17th July, 2013.

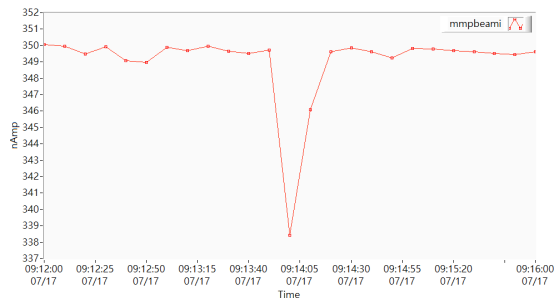


Figure 7: The monitored current value variation at beam line station 18 during the vibration period in the morning of 17th July, 2013.

OTHER APPLICATIONS

Besides mapping the vibration with photon beam stability, there are also other applications of this vibration measurement system. For example, the 4th section of TLS storage ring has a vacuum problem and installation of a new turbo pump is needed in 2010. Since the mechanical vibration of the turbo pump may affect the stability of the beam chamber, diagnose the status of the electron beam just before and after the installation of the turbo pump thus is required. Also, the vibration measurement can be adopted for estimating the effects of a turbo pump. Although 29Hz vibration frequency was monitored via Fast Fourier Transforming (FFT), this frequency has already existed before the installation of the new turbo pump. Without significant amplification of 29Hz oscillation signal, this oscillation may not have obvious disturbance on the electron beam.

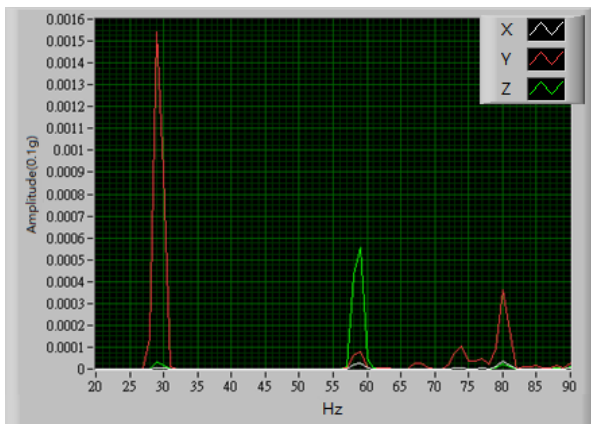


Figure 8: FFT the results of accelerometer after turning on the turbo pump.

SUMMARY

Vibration is one of the reasons that affect the quality of a photon beam. From the examples described in this article, using the accelerometer to measure the acceleration of a single position can be used in many applications. Besides estimating whether a newly inserted equipment affects the stability of electron beam, the poor

$\Delta I/I_0$ can also be used to investigate if it is caused by external vibration. Further study of the behavior of electron beam in vibration mode by beam dynamic physics is possible if accompanied with the fast BPM signals. By distributively locating the accelerometers in a wider space area with a proper time delay process, the location or the direction of a vibration source may be found at each vibration event. This issue could be further investigated in the near future to improve the beam quality of Taiwan Photon Source and ability of a fast initial diagnosis.

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