TLS OPERATION INFORMATION MANAGEMENT: AUTOMATIC LOGGING TOOLS

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Abstract

The Taiwan Light Source (TLS) has been operated in the Top-up mode since October 2005 and has maintained a beam current of 360mA since 2010. Several essential parameters and waveforms are constantly recorded as routine accelerator operation reference. Therefore, five LabVIEW-based data and waveform logging software programs have been developed for the purpose of preliminary diagnose at the TLS. In this report, certain actual cases in regular operation are presented.

INTRODUCTION

In preparation for the operation of the second synchrotron accelerator Taiwan Photon Source (TPS) in NSRRC, which is under construction currently, diagnostic data of abnormal events that occurred in TLS becomes invaluable.

Several automatic logging tools in TLS control systems, combining hardware equipments developed by the IC group with software programs written by C.C. Liang, were established to store data in the parameter data server. The automatic logging tools include an operation data logger, a booster and kicker waveform recorder, a 10Hz kicker waveform capture and playback program, and a fill pattern recorder.

AUTOMATIC LOGGING TOOLS AND DIAGNOSTIC EXAMPLES

Operation Data Logger

This program was established by T.F. Lin[1]. Improvements were made since then based on the key parameters of machine status and statistical information collected routinely in this program in a readable form for TLS operators to grasp the operation conditions and meaning of parameters in transaction. Such information is also integrated for a fast flip overview (Figure 1) of the future operation information management.

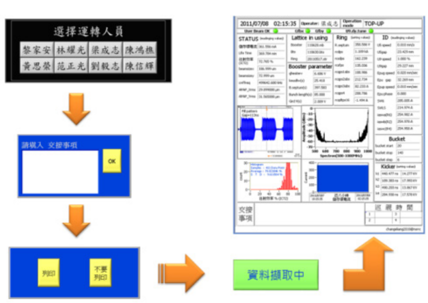

Figure 1: Operation data logger.

1. *Index the current state of TLS* contains time, operation personnel on duty, operation mode (top-up mode or decay mode), storage ring current, beam lifetime, injection efficiency, beam size, RF frequency, the position corresponding to the ideal track (RMS), tune and the status of feedback system .
2. *Current Lattice file* contains the lattice data of the storage ring, transmission line, and booster.
3. *Essential parameters of the booster* contain the setting values of e-gun heater voltage, high voltage of klystron modulator, booster septum, bunch length and grid voltage.
4. *Essential parameters of the storage ring* contain the setting values of septum magnet, dipole magnets, quadrupole magnets, sixtupole magnets and rcqdtps16 magnet. The quadrupole magnets frequently need to be modified, because the U9 dynamic tuning system controls two quadrupole magnet families, rcqps1abs and rcqps2abs. If a small amplitude adjustment is needed, rcqdtps16 is the best choice.
5. *Insertion devices (IDs)* contain reading values, gap, speed, phase and other information of all the insertion devices, including U50, U90, EPU, SW60, SWLS, and three IASW.
6. *Bucket address setting* contains setting values of the bucket initiation, interval and the end position, which all affect the bunch density. Bunch length setting can determine the special filling pattern, which has important influence on the operation conditions.
7. *Kicker magnet setting* contains setting values of timing and voltage of kicker magnets. These values, having huge influence on the injection efficiency and partial beam loss events, are worth of paying attention to.
8. *Fill pattern* is recorded while the gap value is calculated by the program every minute to observe the partial beam loss. Other abnormal event can be found by comparing fill patterns at different time. Feedback systems can be affected due to the abnormal pattern.
9. *Spectrum pattern* of R5BPM8∑ between 500MHz to 1GHz is recorded in the program. Instability can be observed from the patterns. By analyzing the patterns, unusual peaks appear in association with those events.
10. *Statistical chart* covers the injection efficiency from the transmission line to the storage ring in the past

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eight hours. The average and standard deviation are also calculated.

11. *Chart of the stored current* in the past eight hours helps the operation personnel between shifts to understand the situation of TLS easily.

Booster and Kicker Waveform Recorder

This program integrates the existing detectors and current transformers at booster. Real time parameters are obtained from a data server which has been established by the IC group. It collects 5~6 oscilloscopes' pattern, beam current, booster current, and temperature of linac system, and refreshes every minute in top-up operation. Each channel will be discussed in the following paragraphs.

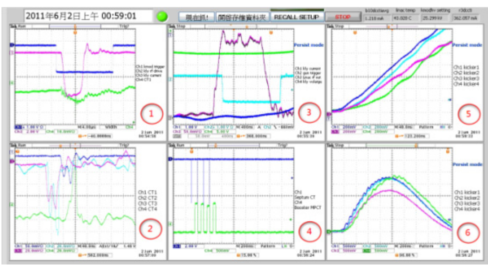

Figure 2: The screenshot of "Booster and kicker recorder" (previous version)

In the first oscilloscope, choose the CT1 (Current transformer 1) signal as a trigger signal, and monitor other signals of klystron from CH1:klystron modulator trigger; CH2:klystron RF drive power; CH3:klystron current; CH4:Current transformer 1, respectively. If the electron gun is regularly triggered, but the klystron does not work properly, it can be detected from this picture.

In the second oscilloscope, choose the gun trigger signal as an external trigger signal, and monitor others of CT1~CT4 from CH(Channel)1~CH4, where current transformers are located at the rear of electron gun, the front of LINAC, the rear of LINAC, and behind the 60 degrees bending magnet as shown in Figure 3. If the booster current decreases gradually, changes of waveform are noticeable in this frame as an indicator of the abnormal section.

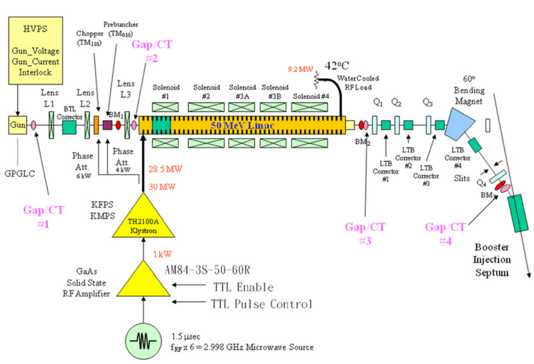

Figure 3: The synoptic of the 50MeV LINAC system of TLS.

In the third oscilloscope, choose the gun trigger signal as a trigger signal, for each channel of CH1: klystron current, CH2: gun trigger, CH3: LINAC RF output, CH4: klystron voltage, and Ref3: LINAC RF output in normal condition, respectively. If the CH3 waveform does not perfectly match with Ref 3, it indicates that the linac is not working properly and the booster current will be reduced.

Channels shown in the fourth oscilloscope are CH1: Septum CT and CH4: booster MPCT. The precise injection efficiency can be calculated by counting septum magnet's signal trigger times then summing the corresponding booster current and the storage ring current value in every injection cycle.

The fifth and sixth oscilloscopes are used to observe four injection kicker waveforms. The difference among them is the time scale. Each channel is corresponding to each injection kicker. Due to the logical trigger setting, kicker misfire can be observed in the pattern.

Case 1: In the early hours of May 24, 2010, booster current vanished. According to the waveform from "Booster and kicker recorder", the malfunction of linac system was identified immediately as shown in Figure 4. Based on the past experience, this pattern is likely due to an arcing event in the klystron's high voltage tank. In the past, operation personnel must constantly watch the oscilloscope to notice this kind of event. With the automatic logging tool, the problem can be found quickly.

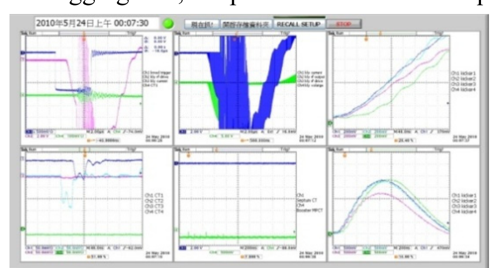

Figure 4: Arcing event pattern in "Booster and kicker recorder"

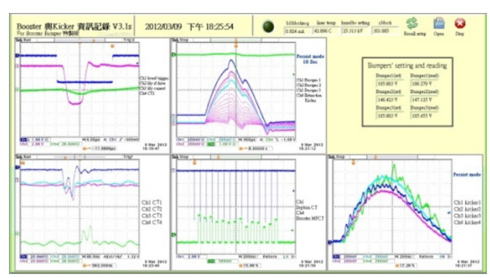

Figure 5: Bumper 3 missing fire event pattern in "Booster and kicker recorder"

Case 2: On March 9, 2012, bumper 2 in the booster misfired, resulting in the current not being extracted to the transmission line. This incident was perceived since February 9, 2012 and prevented the beam current in the storage ring to stay at 362mA during the top-up operation. At that time, the booster current signal was intact, yet unsuccessfully to be injected to the storage ring. This situation occurred intermittently at first; then it happened more frequently. The staff on duty entered the booster to check in the afternoon of the same day, but unable to identify the problem. As the top-up mode restarted, the anomaly did not happen for few hours. In order to clarify the problems and to ensure the function of the bumper, “Booster and kicker recorder” was modified to include the bumper waveform. Persistent mode is necessary in this case. The waveform will overlapped for 10 seconds until the end of injection cycle. The event was observed on March 9th as shown in Figure 5. The purple waveform in the upper middle diagram is bumper 3 signal which is the only abnormal one. The cause of failure of the top-up operation was identified.

10Hz Kicker Waveform Capture and Playback Program

In order to capture more precise waveforms, the unique segment function of high-end oscilloscope is needed. This function can capture every single waveform during the injection cycle. The program saves all of the patterns by time, a function missing in the low-end oscilloscope. The program has both capture and playback functions, which are executed separately.

Logic trigger function is used in the LeCroy SDA11000 oscilloscope to recognize a misfire or a draft event of a kicker.

Case 3: At 23:00 on April 21, 2012, beam loss caused by the draft of kicker 3 occurred at the third time of injection. The stored current decreased from 302mA to 278mA. In this case, the image of “Booster and kicker recorder” was unclear and could not accurately identify the drift. However, nearly 50ns delay of kicker 3 was observed clearly in “10Hz kicker waveform capture and playback program” as shown in Figure 6.

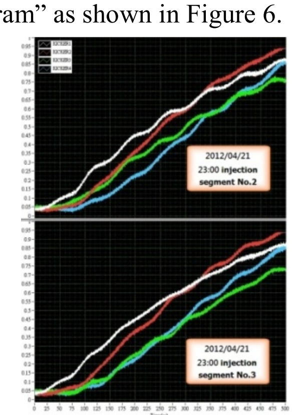

Figure 6: The waveform of kicker 3 with a 50 ns draft.

Fill Pattern Recorder

In order to observe the changes of fill pattern due to partial beam loss at TLS, R5BPM8Y is used as the signal source, with a trigger signal of 2.5MHz which is synchronized with the storage ring. The fill pattern and buck address number are recorded every minute by this program which also calculates the gap value for each one.

Case 4: From 23:17 to 23:18 on March 15, 2012, there was a partial beam loss event observed in the fill pattern as shown in Figure 7.

Different causes of the partial beam loss events have different fill patterns. As demonstrated in case 3, fill pattern changed to hexagon due to the partial beam loss caused by the kicker draft event. The gap of fill patterns is different in Figure 8.

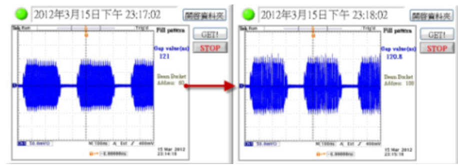

Figure 7: Partial beam loss event on fill pattern.

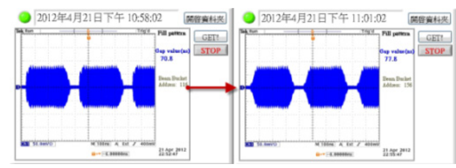

Figure 8: Kicker 3 draft event on fill pattern.

DATA ACQUISITION SETUP

In order to keep communication clear and easy for maintenance, the GPIB connection was replaced by the Ethernet connection. The computer for the control system has dual Ethernet cards for public IP and private IP. The private network is for instrumentation, and the public network can connect to the database built by the IC group.

There are seven Tektronix TDS 3000 type model oscilloscopes, one Tektronix 3048B spectrum analyzer, and one LeCroy SDA11000 high-end oscilloscope for measuring signals. All of the signal sources are provided by the IC group. The system architecture diagram is shown in Figure 9.

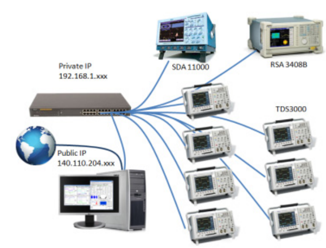

Figure 9: Data acquisition setup of automatic logging tools.

SUMMARY

The automatic logging tools offer excellent features such as easy to use, easy-to-maintain Ethernet connection, easy-to-perform preliminary diagnostics by comparing images, and convenient to customize for special cases.

These tools have successfully assisted many preliminary diagnoses on problems and personnel to gain expertise on the reliability of TLS operation.

REFERENCES

[1] Tsai-Fu Lin *et al.*, “LOGGING OF OPERATION DATA AT TLS”, PAC’07, 2007.

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