A NEW FAST RF TRIP DIAGNOSTIC SYSTEM IN SSRF*

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Abstract

A RF trip diagnostic system is essential to find out the trip source when a trip happened. In this paper, a fast RF trip diagnostic system, in storage ring RF system of SSRF, is reported. This system includes a synchronous acquisition recorder to sampling the trip data and a trip server to analysis the data. The recorder has more than 100 channels and maximum sampling rate of each channel is up to 60 MS/s. High precision I/Q cards are designed to detect RF signals. Trip server has been developed to process the trip data.

INTRODUCTION

In storage ring of SSRF, three RF stations including three SRF modules are adopted. After a trip, it's essential to locate where the real problem comes from. If from RF system or beam? Which RF station? What's the source problem?

Interlock system is a tool for the preliminary judgment of a trip (see Fig. 1), but unfortunately the judgment for RF system is often not correct or not exact. For example, a RF trip nominally caused by the reflected power of RF cavity may be actually due to the magnet problem.

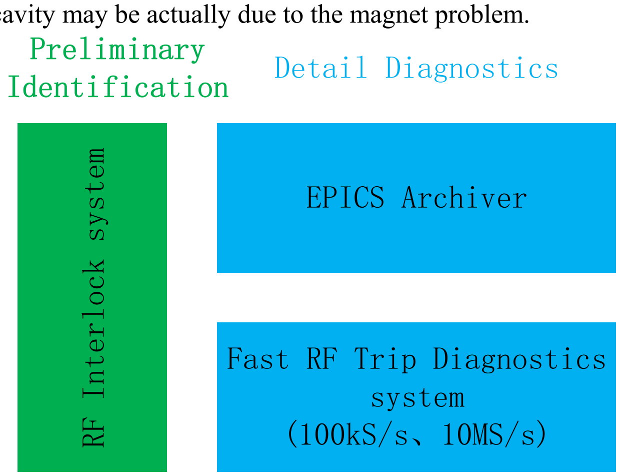

Figure 1: Tools to analyse a trip.

A post-mortem diagnostic system, which can synchronously acquire all valuable signals, is required to achieve exact conclusion of a trip. EPICS archiver can help, if the resource problem is slow signal, like water temperature or flow. A fast RF trip diagnostic system can make us to see clear the phenomena pre and post one trip.

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NEW FAST RF TRIP DIAGNOSTIC SYSTEM

Before 2015, the fast RF trip diagnostics system is fabricated by two LDS Dimension 4i which is a type of data recorder having 16 synchronous acquisition channels and 200 kS/s maximum sample rate each channel [1]. After several year operations, neither the channel number nor the sampling rate is sufficient to find the trip source. A new generation of RF trip diagnostics system based on PXI is established from 2015.

Multi-channel I/Q demodulator cards are adopted to detect the RF signals. All selected signals are synchronously acquired by PXI and then processed by trip server (see Fig. 2).

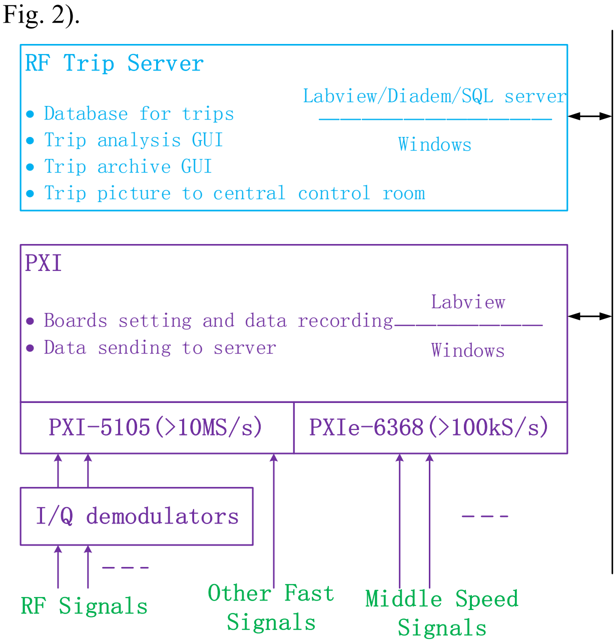

Figure 2: architecture of new diagnostics system.

Recorded Signals

In storage ring RF system of SSRF, there are nearly one thousand physical signals with different response time.

Nearly all signals are recorded by EPICS archiver, which can help us if a slow signal trips or to search the long period trend of all signals.

We use PXI to record some selected fast signals.

a) ~1 ms, vacuum gauge of SCC and vacuum chambers among 3 SCCs
b) ~10 µs, arc, MPS, orbit, high voltage of klystrons, other fast interlock signals, etc.
c) ~1 µs, RF loop signals, like LLRF output, incident power to cavity, BPM signal, etc.
d) ~100 nS, all kinds of cavity pickups.

I/Q Demodulator

To detect RF signals, we developed multi-channel I/Q demodulator cards (see Fig.3), with which both amplitude and phase can be acquired [2].

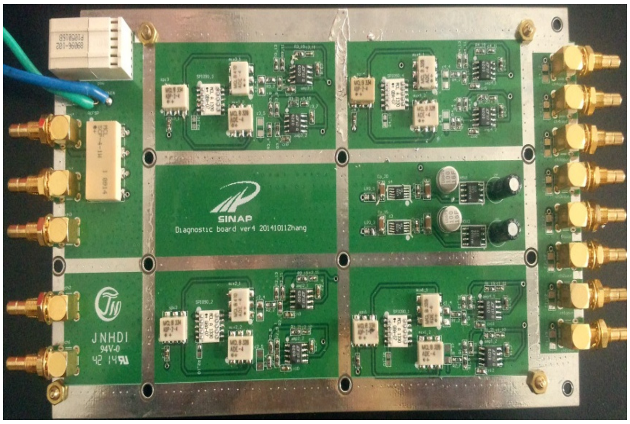

Figure 3: 4-channel I/Q demodulator card.

We test the card with PXI-5105, which we adopt in the PXI. When the RF signal is -6.3dbm, the precision is

- Amplitude <+/-1.5 %;
- Phase <+/-0.9 °.

Signal delay was also tested, the result is

- <4 ns.

PXI

We choose NI PXI as a recorder, because the precision of the time and trigger signal is very high and the system is easy to develop.

Seven PXI-5105 are selected to acquire signals c) and d). Each of them has 8 channels and up to 60M sample rate. Bigger on-board memory is preferred. We choose 128M version, with which 0.8 second trip data of each channel can be stored when the sample rate is 10M.

Three PXIe-6368 are selected to acquired signals a) and b). Each of them has 16 differential channels. And 100k sample rate is set. The differential input can make no interference to whole RF system.

All above cards are installed in a PXIe-1085 crate.

Trip Server

A trip sever has been developed to process the trip data from PXI. After a trip happens, firstly the Labview program scales all the data to engineer value, including transferring I and Q of RF signals to amplitude and phase. Then the Labview program will send a trip picture named by the trip time, from PXI, to the centre room by FTP. A *.tdms* file is generated, also named by the trip time, and can be opened by Diadem, for post-mortem analysis.

SQL server technology is also adopted to archive trip data. After each trip, operator will input essential information, like trip type, trip description, with which operator can retrieve all trip data later (see Fig. 4).

Figure 4: archiving and retrieval GUI.

TYPICAL TRIPS DETECTED

More signal channels and bigger sample rate make us find more trip information, with which we can solve the problem sooner.

Problem with the Remote Control Card for No2 Klystron's Anode Power

On September, 2015 we met this problem. The voltage of No2 klystron's anode power drop occasionally in some milliseconds. Interlock system indicated No2 RF station is not the first trip station, which was also verified by diagnostics system (see Fig. 5-①). Nothing abnormal happened when we tried to recover RF system. But we found the anode voltage dropped before the trip in some milliseconds (see Fig. 5-②), which decreased the gain of the klystron. After second trip we exchanged the anode power. After third trip this problem disappeared after we exchanged the control cards to anode, which is the source problem.

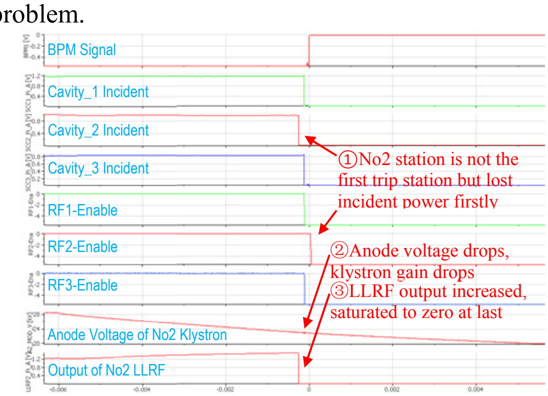

Figure 5: 201510162026 trip. Anode voltage drop led to beam dump.

Huge Jump of No3 SCC's Pick-Up Signal

This problem happened two times, one on November, 2015, the other on March, 2016. A huge jump of No3 SCC's pick-up signal was detected. The width of the pulse is from 2 μs to 20 μs (see Fig. 6). Big gas release from RBT taper was followed (see Fig. 7). We decreased

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the cavity voltage from 1.68 MV to 1.6 MV and this problem has not happened up to now.

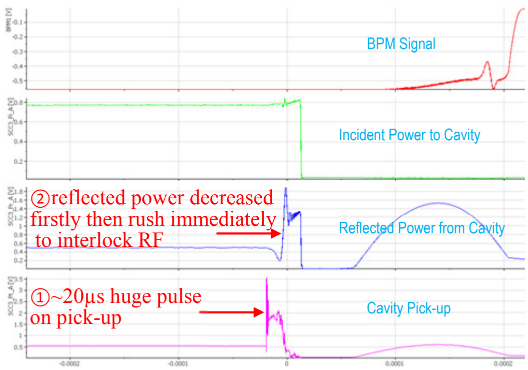

Figure 6: huge jump on pick-up signal

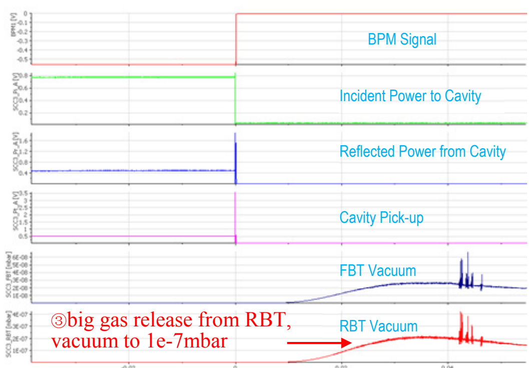

Figure 7: big gas release after the huge jump of cavity pick-up signal.

FBT Vacuum Interlock of No1 SCC

FBT vacuum interlock happens 6~7 times every year. Up to now we have no method to fix this problem. The change of vacuum gauge on FBT and nearby were acquired by dignostic system (see Fig. 8), which verifies the FBT is the sourse of gas release.

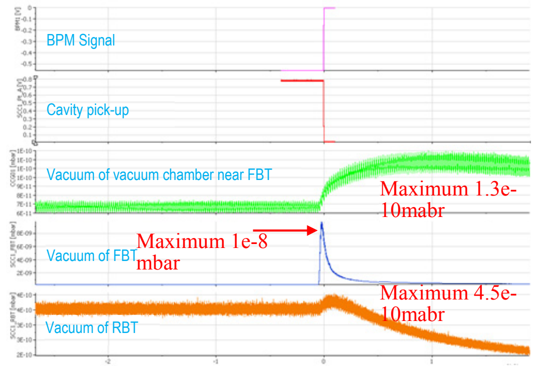

Figure 8: FBT is the source of gas release.

CONCLUSION

A new Fast RF trip dignostics system has been devloped in SSRF. After working in RF system of storage ring from Sept, 2015 this system greatly help us to analysis various of RF trips.

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