OPERATION STATUS OF SSRF POWER SUPPLIES AND INTERLOCKS FOR TOP-UP OPERATION

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Abstract

Digital switching mode magnet power supplies are used in SSRF which have been operating since 2008. Summary of the operation and maintenance of these power supplies will be shared over here. The availability of the power supplies is increased steadily over the past 4 years. And the power supplies interlocks for the SSRF top-up operation will be also introduced in this paper.

INTRODUCTION

There are about seven hundred digital magnet power supplies operating in Shanghai Synchrotron Radiation Facility (SSRF) now, only 6 for ramping and the other are static magnet power supplies. 33% digital control cards were developed by SSRF power supply group and 67% cards were imported form Diamond Light Source. The two type cards can be instead each other for the compatible hardware.

All the magnet power supplies were divided into 3 types according to their output power. One is middle power converter, include the steer, linac and transport line power supplies; The other is storage ring quadrupole magnet power supplies; The last one is huge power supplies, include ramping power supply for booster ring, and the dipole, sextupole power supply for storage ring.

There are about 10% back-up for the middle power supplies, once which is failure, just need take about less than 20 minutes to replace it. For storage ring Q power supplies, there are 5% chopper and one DC bus back-up also. All the power supplies should be checked at the machine maintain time. For the biggest power supplies, routine check is needed and some key components should be replaced every year.

All the power supplies were accomplished by the end of 2007 and have been operating for almost 4 years. The Mean Time Between Failure (MTBF) is getting longer and longer.

ANALYZING THE MTBF OF THE MAGNET POWER SUPPLIES

From 2008, we began to statistics the MTBF of all the power supplies and try to get better. The MTBF increases 11% every year from 2008 to 2010. Less than 20 shutdown times is expected in 2011, Figure 1.

For the communication broken-link problem, figure 2, it is very difficult to find the real reason for the problem for it is just happened on imported cards and there are several tens broken-link over about 300 power supplies a year. According to the operation experience, temperature, dust and hardware may be the three main causes of broken-link.

On the other hand, the VME system is not a negligent factor. Sometimes VME was needed to reboot, sometimes the fiber should be re-pluged to re-link the digital cards.

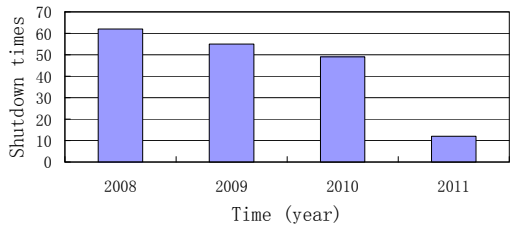

Figure 1: Power supplies shutdown times

Power supplies shutdown times decreased 11% every year from 2008 to 2010.

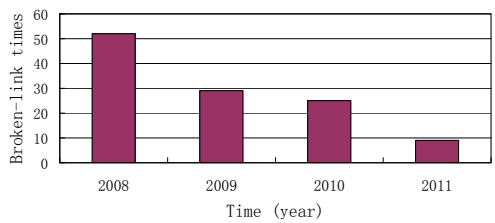

Figure 2: Communication broken-link times

Communication broken-link times stepped down notably in 2009 for the dust on the DSP was cleaned and some defective DSP cards were replaced.

For the Middle Power Supplies

Figure 3: Middle power supply and the plug and play fan module

After about a year continuous running, cooling fans often caused power supplies shutdown, figure 3. When the pulse type fan was running normally, which should generate a pulse signal every turn, but the pulse often trigged the interlock circuit mistakenly. The power supply could be run again by reset, but which may be trigged mistakenly again. All fan interlock signals were masked for several months until new plug and play fans module

were used. The power shutdown times were reduced effectively since that time, figure 4.

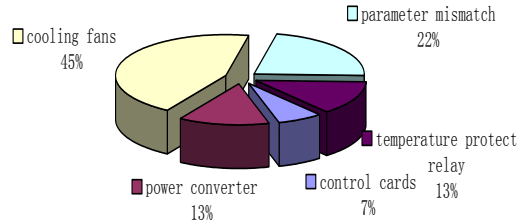

Figure 4: Pie for middle power supplies shutdown reasons

The second main reason was the parameter mismatch, for the real mean of every parameter of the imported cards was not understood clearly at first. All the cards parameters were updated and the problem was solved.

Quadrupole Power Supplies for Storage Ring

Figure 5: Storage ring Q power supplies for one station

There are 40 dc buses and 200 converters to power the storage ring quadrupole magnets. All these power supplies ran with imported digital cards until May, 2011. All the power supplies were distributed in 20 stations along the technical corridor, figure 5. For each station, there are 10 chopper type magnet power supplies fed by 2 DC bus sources.

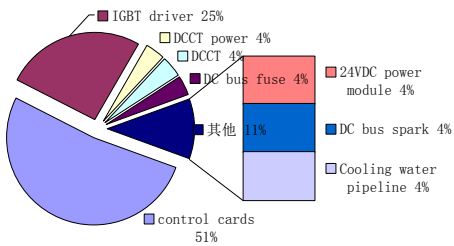

Figure 6: Pie for Q power supplies shutdown reasons

Figure 6, control cards contributed the most shutdown times and it would be talk about later. The IGBT driver EXB841 was the second main reason to make the power shutdown. A restorability resistor fuse was installed on the IGBT driver card. The resistor stood nearby the EXB841 chip, after continuous operating at the rated current for long time, the chip was heated up by the resistor and caused the chip disorderly. When the power supply box was opened, all the components were cooling and could operate normally. It took us long time to find the reason. All the 200 power supplies were fixed at Jun. 2009. Some other factors were found also, such as DCCT, +24V DC power and etc, these happened occasionally for all the power supplies.

Huge Power Supplies

All the 10 huge power supplies were produced by a company, so most modules were same，such as IGBT and driver card, interlock system.

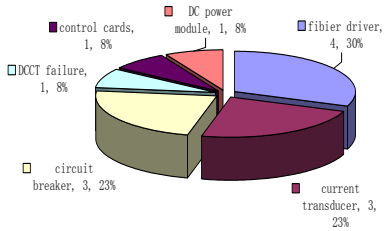

Figure 7: Pie for huge power supplies shutdown reasons

The SN75451 was breakdown several times, although which was used to drive two HFBR-1528 according to datasheet. All the 24 such driver cards were replaced by new designed cards and such shutdown never appeared since that time. The second main factor caused the ramping power supplies shutdown was a current transducer which was used to inner current loop. The transducer was damaged due to not rightly installation.

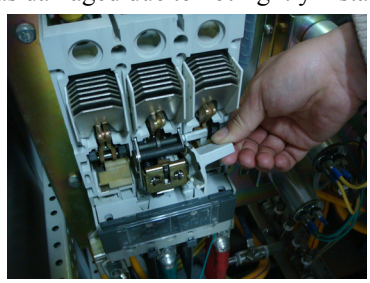

Figure 8: The contactor handle was broken

The contactor handle of storage ring dipole magnet power supply was broken 3 times, figure 8. It was incredible but happened. Any reasonable explain were not gotten from the contactor company until now.
Absorb capacitor must be replaced for the colour of capacitor getting dark every year, some even have a fracture on it, figure 9. All of 120 capacitors should be replaced every year and this did not cause shutdown until now.

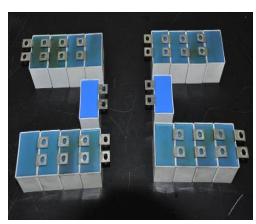

Figure 9: The absorb capacitor blue colour turned to black after a years running and should be replaced every year.

The Import-digital Control Cards

Figure 10: Some pins of the DSP contacted each other.

Communication broken-link is a second main problem for SSRF power supply system. Both the VME control system and the cards should be responsible for broken-link. Most of time, cards can be reset to re-link again. The optical fiber should be re-pluged sometime. Cards should be replaced only when reset cards and VME invalidly. 10 DSP and 10 ADC were fixed and returned by Diamond light source and some cards are being fixed now.

The Home-made Digital Control Cards

The home-made cards are hardware compatible with the import cards. The home-made one has two communication modes, one is MANCHESTER and the other is RS232 which could be selected by software.

Five Q power supplies were used home-made digital cards at May. 2011. The stability was better than 20ppm.

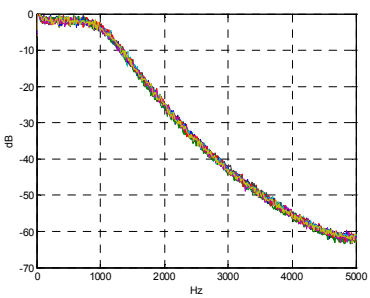

Figure 11: The fast orbit steer power supplies reached 1kHz bandwidth with home-made digital cards.

The new home-made cards were used on the fast orbit steer power supplies which bandwidth got 1kHz.

INTERLOCKS FOR TOP-UP OPERATION

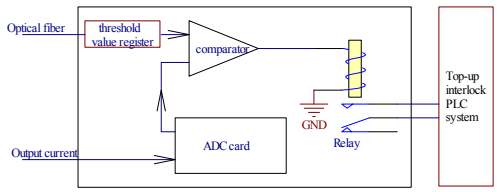

Figure 12: Schematic of interlocks for Top-up

According to the physical design, once the output current of the storage ring and high energy transport line dipole magnet power supply are out the rated window which is ±3% rated current, power supply should give an interlock signal to the SSRF Top-up safe interlock system. All the interlock function is finished in the digital cards, figure 12, and the threshold value can be set by software at control room. In order to utilize the operating system and equipments, the digital cards were used over here.

There are 9 storage ring sextupole and 200 quadrupole magnet supplies which also need to have the interlock functions, but limit by funds, software was used to calculate and give a soft interlock signal to the Top-up safe interlock system.

SUMMARY

Overall, the MTBF of SSRF power supplies increased more than 20% before 2010, and the shutdown times are expected less than 20 times in 2011. New digital cards were developed and applied on the quadrupole and fast orbit steer power supplies, also applied on the interlock system for Top-up.