THE IMPROVEMENT AND DATA ACQUISITION SYSTEMS ON ELECTRICAL SYSTEMS AND GROUNDING NETWORKS IN NSRRC*

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Abstract

The purpose of this paper is to declare the improvement on electrical and grounding systems in NSRRC. In electrical power system, an Automated Voltage Regulator (AVR) was established to the quadrupole magnet system in 2004. The variation of voltage supply from Taiwan Power Company (TPC) is reduced from ±3% to ±0.15% through the AVR system. And a Supervisory Control and Data Acquisition (SCADA) system was also setup to monitor the electrical power conditions in each power station. After the high precision grounding systems were constructed in 2004, the stability of beam line was raised. For comprehending the grounding current and noise control, a grounding monitoring system with 16 channels was built in the storage ring. The grounding currents of 4 kickers, one septum and grounding bus are on-line monitored. Two Electromagnetic Field (EMF) apparatuses were also installed to collect electrical and magnetic fields in the R1 section. It was observed that the electromagnetic field was correlated to grounding currents in certain locations. Injection effects were clearly found in most monitored data. Expansion of the grounding monitoring system and the analytical software will be integrated in the next step.

ELECTRICAL POWER SYSTEM

In electrical power system, the Automated Voltage Regulator (AVR) and Uninterruptible Power Supply (UPS) were established to the different magnet systems in 2004. The purpose of AVR and UPS systems are to stable the power supply of the magnets. Consequently, the beam line was also more stable and more efficient than before. One example is that the variation of voltage supply to a quadrupole magnet from Taiwan Power Company (TPC) is reduced from ±3% to ±0.15% through the AVR system (shown in Fig. 1). This data was recorded by a Supervisory Control and Data Acquisition (SCADA) system, which was also setup to monitor the electrical power conditions in each power station.

In addition to the SCADA system, we also established another two high resolution power quality acquisition systems -ADX 3000. The two ADX systems were placed at the main power station (2nd utility building) and power substation for the storage ring (include the storage ring, but exclude the lab use). These systems are the same with TPC, so it adopted to record the sudden electric voltage drop from TPC.

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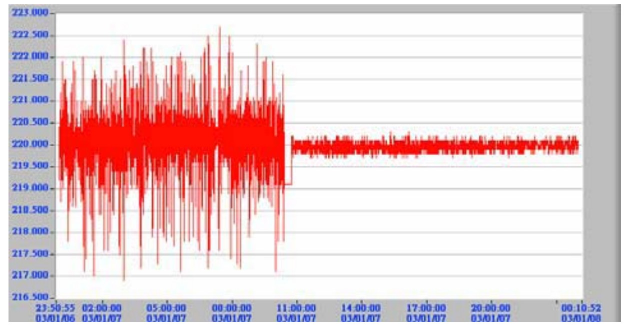

Figure 1: The effect of the AVR (Automatic Voltage Regulator) system.

Because the ADX system was developed in Taiwan, this system more accommodate for the environment in Taiwan. There are two modes for data acquisition, one is the normal mode, the other is transient mode. Thus, it is flexible for multi-function data recording.

For example, when there is an electrical voltage drop from TPC, it will record the exact time and the wave form for the voltage drop immediately. The trigger level of the transient mode of ADX system was set manually. Once the voltage drop above the trigger level, the ADX system will record as an “event”. The sampling rate of an event is 3,840Hz, the total length is 64 points. The resolution is 12 bits, and it is enough to record a complete waveform of an electrical voltage drop.

Fig. 2 shows the voltage drop from TPC on August, 2004. The voltage drop 30.1% because of the thunderbolt in Hsinchu area. This event affected the beam line of NSRRC, the beam was tripped by this event.

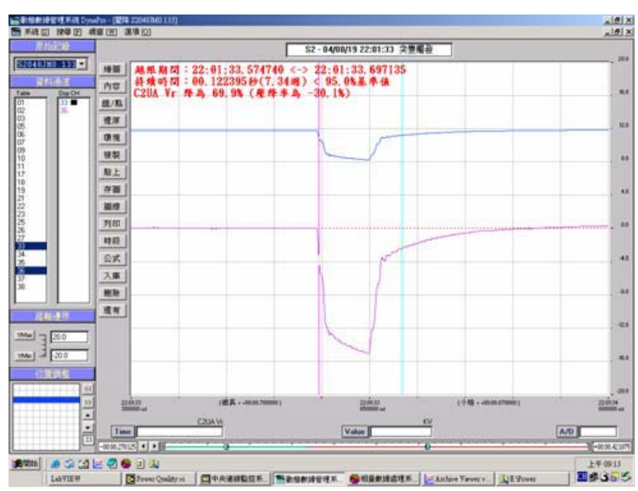

Figure 2: The “event” from TPC (2004/08/19 caused by thunderbolt).

HIGH PRECISION GROUNDING SYSTEMS

The new high precision grounding systems were finished on the beginning of 2004. The purpose of the new grounding system is not only for the general safety purpose, but also to reduce the noise of signal-sensitive instruments. After constructed the new grounding system, the stability of beam line was raised. For comprehending the grounding current and noise control, a grounding monitoring system with 16 channels was built in the storage ring. The grounding currents of 4 kickers, one septum and grounding bus are on-line monitored.

Fig.3 is the grounding current signal recorded during beam injection. The measurement locations are the 4 kickers, one septum and the 2 grounding buses around the R6/R1 section. The R6/R1 section in the tunnel is the region where the beam is stored from booster to storage ring through BTS (booster to storage ring). The 4 kickers and septum were also located in section R1. The two grounding bus was made by copper plate (60mm*5mm). The upper copper bus was divided to 6 sections; each section is connected to the local grounding box. The dipoles, quadrupole, sextupole magnets and correctors are connected on the upper copper bus. The down copper bus encircled the whole storage ring for the same voltage level. Upper copper buses were connected to the down copper bus in each section for the safety purpose.

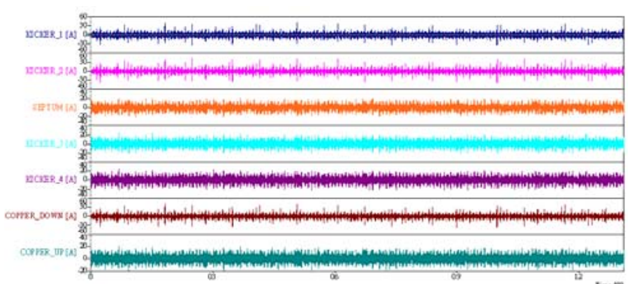

Figure 3: The grounding currents during injection. (2004/07/16 PM 2:09)

The sampling rate of the signals shown in Fig. 3 is 100 kHz. The kicker fire signals are not obvious in the time domain. Thus, we transfer the wave form of kicker 1 to frequency domain (Fig. 4). It is clear that there is 10 Hz peak in the frequency domain. It is exact the same frequency that kickers fire in TLS. The leakage current from kickers and septum were observed in the experiment. However, there should be no leakage currents from kickers in the perfect condition. It is very hard while kicker fired 3000 A, pulse during 1.2μs without any leakage current. But the leakage current effects must be evaluated for many instruments.

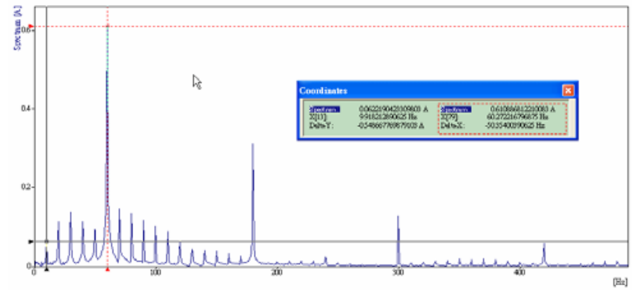

Figure 4: The grounding current of kicker 1 in frequency domain during injection. (2004/07/16 PM 2:09)

Next, the amplitude of the leakage currents has to be calculated. We changed the sampling rate to 5 kHz, calculated 500 points RMS value to examine the amplitude of the leakage. Fig. 5 shows that the leakage current from septum was about1.2 A during firing. The blue curve indicates the injection current of the beam in TLS. The red curve was the leakage current from septum. The data were recorded every 10 sec, thus, it needed 100 sec to inject electron from 100 mA to 200 mA. From this result, we could see that the leakage current happens while injection. The time is the exact fit to each other.

Figure 5: The beam current and the leakage current of septum while beam injection on. (2004/09/29 PM2:11~2:14)

After the examination, the leakage currents of all kickers and septum are raised from 300 mA to 2 A during beam injection. These leakage currents will affect the stability of the storage ring. Consequently, we tried to clarify the noise source.

ELECTROMAGNETIC FIELD MEASUREMENTS

Two Electromagnetic Field (EMF) apparatuses were also installed to collect electrical and magnetic fields in the R1 section. It was observed that the electromagnetic field was correlated to grounding currents in certain locations. Injection effects were clearly found in most monitored data.

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Fig. 6 is the electrical field measured by EMC-300 produced by Narda on 2004/09/04. The frequency range of the received signal is from 3 kHz to 60 GHz, sampling rate is 38.4 kHz, isotropic measured for 3 dimensions. The recorded data were transmitted by RS232 and optical fiber to the main computer. The red curve, blue curve and green curve indicate the *x*-, *y*-, *z*-axis electrical field, respectively. And the yellow curve is the RMS of the three axes. The results show that the electrical field were affected by the beam current and injection. The fields decay while the storage current decays. The peak while injection indicats that the electrical field increases when electron injection. It is reasonable and rational result.

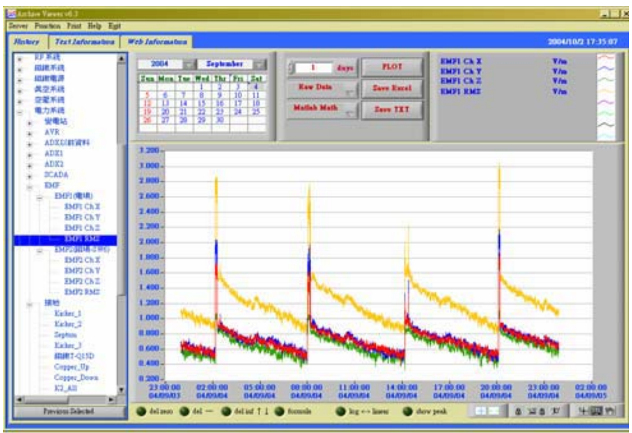

Figure 6: Electrical field measured on 2004/09/04.

The similar phenomena were observed in magnetic field. The same type instrument EMC-300 with magnetic sensor was applied to measure the magnetic field. Fig. 7 shows the magnetic field measured on 2004/09/04. Similar with electrical field, magnetic field decays while beam decays, and increases when beam injection. The magnetic field is about 0.09 A/m ~0.32 A/m in RMS data. The electrical field is about 0.8 V/m~3.1V/m in RMS. It is rational that the electrical field is higher than the magnetic field for synchrotron radiation.

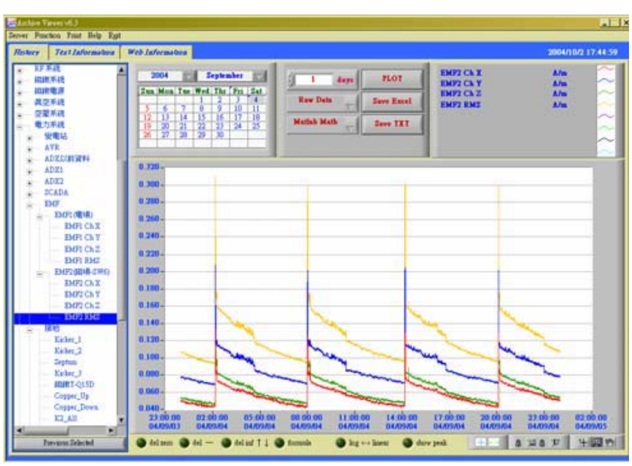

Figure 7: Magnetic field measured on 2004/09/04.

We also observed that the electromagnetic field has strong relation with the beam current, beam size and beam life time. Consequently, the E-, M-field is a good monitoring indicator for observation the beam quality.

CONCLUSION AND FUTURE WORKS

Some improvement works, including expansion of the grounding monitoring system composing analytical software will integrate in the next step. Detection and reduction of the grounding noise and electromagnetic noise will be the main work in the future.

REFERENCES

[1] IEEE Std 81.2-1991, "IEEE Guide for Measurement of Impedance and Safety Characteristics od Large, Extended or Interconnected Grounding Systems", (ANSI).

[2] J.C. Chang, J.R. Chen, K.C. Kuo, S.C. Lei, Y.C. Lin, "Electrical Power and Grounding Systems Study and Improvement at TLS" 2003 Particle and Accelerator Conference (PAC), May 12-16, 2003, Portland, USA, pp. 1476-1478.

[3] D. Kosc, "Grounding Practices – A System Wide Systematic Approach" IEEE Transaction on Industry Applications, Vol. 39, No. 5, Sep/Oct 2003.