ELECTRICAL POWER AND GROUNDING SYSTEM STUDY AND IMPROVEMENT AT TLS

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Abstract

The effect of the electrical power and grounding systems on the beam stability is studied at the Taiwan Light Source (TLS). Based on the study, some major improvements are accomplished at TLS. The electric power SCADA (Supervisory Control And Data Acquisition) system is established to remotely monitor and control the electrical power conditions. The soil resistivity data at TLS is collected and a new grounding system of low impedance (0.18ohm) is constructed. Grounding signals and electric potential are collected at some grounding boxes. Grounding electric potential is observed effected by injection at some specific local grounding boxes. Grounding electric potential difference is also found between the new and old grounding systems. These two grounding systems will be connected as one and rearranged to cope with the grounding related problems.

INTRODUCTION

In order to provide higher electrical power quality, the TLS has implemented some electrical power system upgrading projects [1]. Following the online monitoring and archive systems of the de-ionized water and air condition system established [2], the remote online monitoring and control system of the electrical power system, known as the SCADA system has been set up and upgraded for the past three years. The SCADA system has also been merged into the utility archive system to correlate with beam quality and data of other utility systems and enhance its analysis function.

Beside the electrical power system, grounding system is another crucial but apt to be neglected issue. Providing the safety and electrical reference level function, on the other hand, grounding system also could be a major electrical noise path and even induce EMI problem. Thus, special care must be taken when the grounding system is constructed, employed and maintained. TLS has made many efforts to improve the grounding for these years. One of the major projects is to construct a new low impedance grounding system. In the design phase, the soil resistivity data at three different locations in TLS were collected according to “Four Pole Method” [3]. The soil resistivity values are in the range of 120-180 ohm-meter, depending on location and weather. The grounding resistance of the new grounding system was measured according to the “Fall of Potential Method” [4]. The grounding resistance is 0.18 ohm, which is 10% lower than the designed value. However, the grounding potential difference between the new and old grounding systems is observed. The combination and rearrangement of these two grounding systems is under planning currently.

ELECTRICAL POWER SCADA SYSTEM

The electrical power system at TLS consists of two independent electrical power feeders from the Taiwan Power Company (TPC) of 11.4 KV and 4500 KW contract capacity currently. These two main feeders and its circuit breakers, labeled as CB-U1A and CB-U1B, are located in the Utility building then distributed to each individual building, as shown in Fig. 1. The feeder under the circuit breaker CB-U3A, for the storage ring, is the most loaded and important one. Most of the relays and multimeters of the SCADA system thus are mounted under the feeder.

Totally nine terminal feeders, ABB REF541 high voltage relays, not only served as conventional protect relays, but also are used to control, measure and supervise the high voltage network. Four of such relays are respectively mounted on the CB-U1A, CB-U1B, CB-U3A and CB-U4A in the utility building. Other five relays are mounted in the storage ring building.

Moreover, there are thirty electric power multimeters installed at different local sites in the storage ring and utility buildings respectively. The SCADA system is still kept expanded by means of adding the monitoring sites. For example, the latest electric power multimeter, mounted in January 2003, is used to monitor the feeder for the quadrupole magnet power supply. A new KVA Automatic Voltage Regulator (AVR) of 300KVA was just installed to improve the voltage variation. This AVR can suppress the voltage variation from ±3%, which is the nominal variation specified by the TPC, to ±0.15%, as shown in the Fig. 2.

LOW IMPEDANCE GROUNDING SYSTEM

The old grounding system at TLS was constructed with the storage ring building construction and just for the general safety purpose. A new low grounding system of low impedance is necessary to reduce the noise of signal-sensitive instruments. Thus, TLS had started and design the low impedance grounding system project in 2000.

The original design of the grounding resistance was set as 0.2 ohm. In order to accurately reach this goal, the soil resistivity collection was necessary. The new grounding system drawing is shown in Fig. 3. The soil resistvity of three locations were measured. According to the "Four Pole Method", as shown in Fig. 4, the distance, L, between the adjacent two electrodes must be changed to obtain the soil resistivity in various depth. The same measuring procedure must be taken twice in two orthogonal directions in one area. The soil resistivity are measured in the range of 120-180Ω -meter. The value will be different as the weather changed. Basically, the soil resistivity will get decrease as L increases. Once the soil resistivity is collected, the grounding resistance can be evaluated.

In the Fig. 3, the new grounding system is composed of nine copper tubes, serving as the electrodes, and a bare copper wire of 650 meters long connecting with the nine electrodes. Each copper tube, 2 inch in diameter and 30 meter long, is buried in a well of 4 inch in diameter and 30 meter in depth, while the bare copper wire is buried in the middle of a 45cm × 30cm ditch. All electrodes and the bare copper wire are covered by Bentonite.

The new grounding system is classified as "clean" and "dirty" subsystem for technical and conventional facility use. There are four locations on the bare copper wire where connected into the storage ring through eight copper wires. These eight copper wires, where four are classified as clean and others as dirty, are connected through two circle buses respectively in the storage ring.

GROUNDING RESISTANCE MEASUREMENT

The grounding resistance is measured by means of "Fall of Potential Method" according to IEEE std81-1983, as shown in Fig. 5. In the Fig. 5, C, E and P represent the current electrode, the electrode of grounding system and the auxiliary electrode, respectively. Referring to Fig. 6, which shows voltage vector relation among V_{23F} ,V_{23R} and V_{23S}, the grounding resistance, R, can be obtained by the following formula

$$R = \sqrt{0.5 \times (V_{23F}^2 + V_{23R}^2 - 2V_{23S}^2)} \Big/ I \quad \text{..........} \quad (1)$$

where V_{23} is the potential difference between electrodes C and E. Subscript F and R represent the cases of the current injection through electrodes C and E respectively. Subscript S is the case of the background stray current existed in the ground. I is the injection current. In the real case, the same measuring procedure was taken three times as current I=0, 10 and 20 A. According to Eq. (1), the grounding resistance R are obtained as 0.18 ohm.

GROUNDING SIGNALS AND ELECTRIC POTENTIAL DATA

There are two equipments to grounding signals. One is a Tektronix TDS3054 oscilloscope equipped with a P60139 voltage probe with 500MHz bandwidth for the transient measurement, while the other is a FLUKE 43B electrical power quality analyzer with 20MHz bandwidth for long tern recording.

Fig. 7 shows the grounding signals of the high frequency power supplies when the beam is shutdown. The maximum frequency is up to 75MHz and the duration between two adjacent pulses is about 5μ s. The signal also appears as the beam is in operation. The source of the signal or noise is still left to be examined.

Fig. 8 is transient potential difference between the new and old grounding systems when the beam is in injection. It shows that beam injection could induce the transient potential difference between the two grounding systems up to 6-8 V. Long-term recording by the FLUKE 43B also shows the similar phenomenon.

CONCLUSION

The electrical power SCADA system has been established and upgraded. The SCADA system consists of nine ABB REF541 relays and thirty multimeters mounted on different local sites and is merged into the utility archive system.

The new low impedance grounding system is constructed and the grounding resistance is measured as 0.18 ohm, which is 10% lower than the designed value.

The grounding signals and the potential difference between the new and old grounding systems are collected. Both transient data and long tern records show 6-8V potential difference due to injection.

ACKNOWLEDGEMENT

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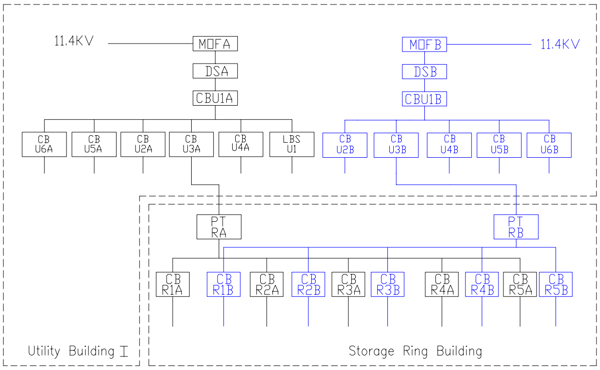

Fig.1: Electrical Power System at TLS.

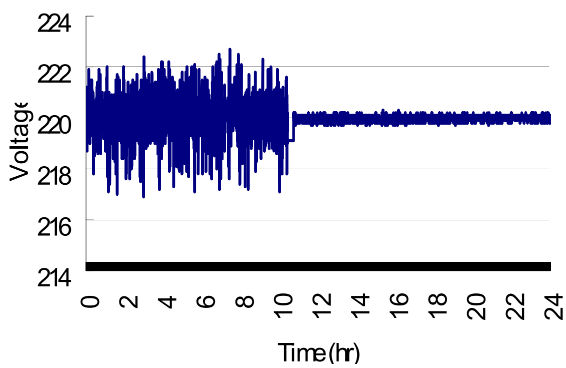

Fig. 2: Voltage variation improvement for the Quadrupole Power Supply.

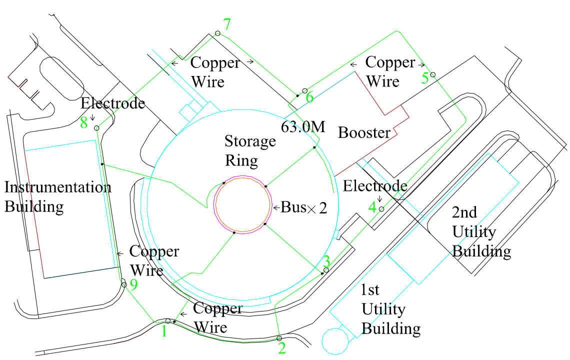

Fig. 3: New grounding system.

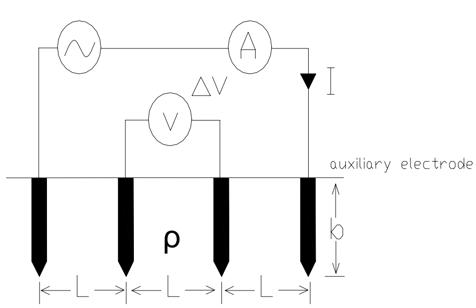

Fig. 4 : Four pole method.

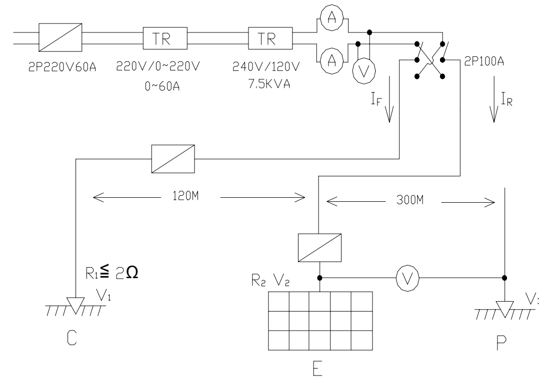

Fig. 5: Fall of potential method.

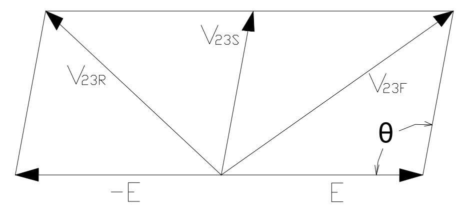

Fig. 6: Voltage vector relation among V_{23F} ,V_{23R} and V_{23S}.

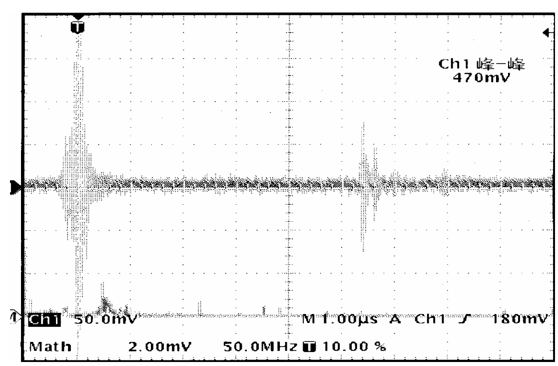

Fig.7: Grounding signals of the high frequency power supply.

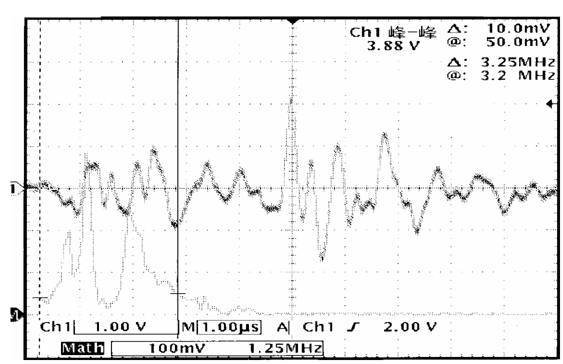

Fig.8: Potential difference between the new and old grounding systems.