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ELECTRICAL POWER SCADA SYSTEM OF TAIWAN PHOTON SOURCE

Tzong-Shyan Ueng, Yung-Feng Chiu, Yu-Chih Lin, Kung-Cheng Kuo, Jui-Chi Chang, Wen Shuo Chan, NSRRC, Hsinchu, Taiwan

Abstract

The architecture of power SCADA system of TPS and its monitored real time data are described in this report. The on-line monitored and measured items include voltage/current, real power/reactive power, power factor, harmonic distortion, etc. These data are presented. The electric energy, the power quality and the harmonic distortion obtained with the SCADA system are used to study the status of the power system, and also provide information for the future improvement.

INTRODUCTION

The Taiwan Photon Source (TPS) is a newly constructed accelerator facility in National Synchrotron Radiation Research Center (NSRRC). It is adjacent to Taiwan Light Source (TLS). This new storage ring has 518 m in circumference and can deliver electron beam of 3.0 GeV and 500 mA, which is much more elaborate than the present TLS facility. During the last 20 years, the researchers have used TLS to produce many excellent scientific research results. Adding TPS to the present facility will provide the researchers with needed facility and resources to stay ahead in the scientific and technological competition. In order to keep this new synchrotron facility running smoothly for producing excellent experimental results, an electrical system with a good power quality is crucial.

ELECTRICAL POWER SYSTEM AND ITS LOADS

The electric power used in TPS is provided by Taiwan Power Company (Taipower) through two main distribution feeders, feeder A and B, to the main substations for TPS in NSRRC. These two feeders have rated voltage of 22.8 kV each. The power demand from Taipower is 12.5 kW. Two local generators can deliver 2000 kW for emergency need. There are 17 local substations for the power loads in TPS. All the loads are sorted and distributed evenly on the two feeders, Fig. 1. The loads of the accelerator facility are mostly for the subsystems of accelerator and the experimental stations, while the loads of the utility system are chillers, pumps, air handling units, smoke exhaust fans, hot water furnaces and those utilities for public use.

MONITORING AND DATA ACQUISITION SYSTEM

The real time monitoring and data acquisition system used for the TPS power system adopted the graphical programming approach but with one-line diagram in mind. This system has functions of I/O communication, storing trend data, real time alarm and remote GUI operation. In Fig. 2 the GUI of SCADA system shows the control panel of the main feeder A which displays the real time values of real power, maximum demand power and reactive power in main feeder A. It also displays voltage, current and power consumed at each substation. More information of the power system can be seen by further clicking the icon on the screen. The communication architecture adopts the Modbus RTU communication protocol, Fig. 3. The protection relays, digital multi-meters, thermal relays, automatic power factor regulators (APFR), DC chargers, generators and air circuit breakers (ACB) are connected to the I/O servers, then, the I/O servers convert the communication protocol to Modbus TCP protocol and communicate to the main server using optical fiber through Ethernet switch. The optical fiber is connected as a ring type which can transfer data in both directions to the two main servers. These two servers can access data from the I/O servers and monitor the status of devices simultaneously. Each server can also be used as backup of the other server in case one server is failed.

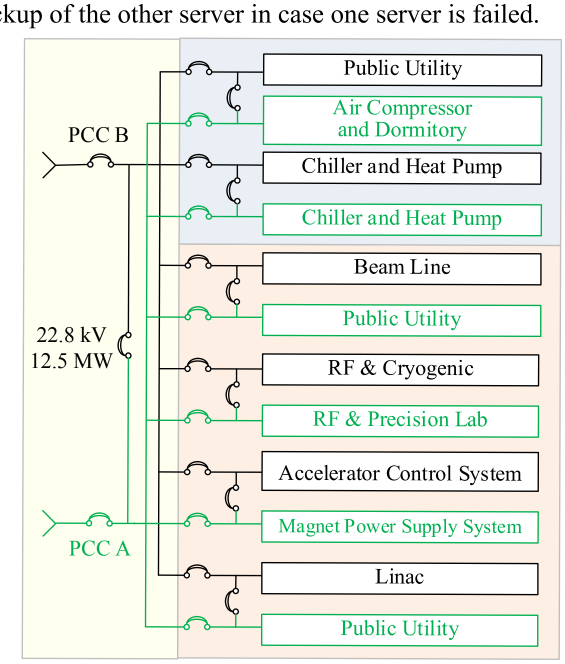

Figure 1: Block diagram shows the loads used at TPS.

MEASUREMENT AND ANALYSIS OF POWER QUALITY

The real time information of feeder B measured by the power SCADA system are shown in Fig. 4. The feeder B provides the power for most of the accelerator subsystems. It shows the voltage/current of each phase, real/reactive

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power, harmonic distortions, frequency and power factor. All these information can be displayed as trend charts and preset warning limits. In Fig. 4, one can see that the power factor in this feeder is 99%. This result from that APFRs were installed in the low voltage feeders for power factor corrections. The short circuit current of Taipower's rated voltage of 22.8 kV and short circuit capacity of 500 MVA is 12.66 kA. The maximum load current at PCC, I_L, monitored during the recent year at the main feeder for TPS is 145A. According to IEEE 519-1992, the current distortion limits for general distribution systems in this I_{sc}/I_L range is 12%. The total harmonic distortions measured in the feeder of TPS is about 8.2%, thus, it is within the limits specified in IEEE 519-1992 [1].

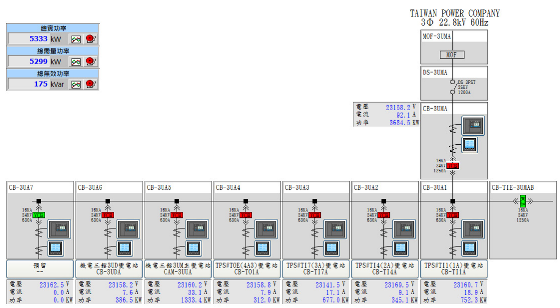

Figure 2: The main page of GUI of power SCADA.

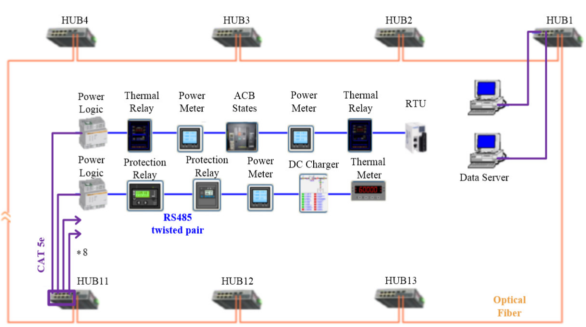

Figure 3: The communication architecture of SCADA.

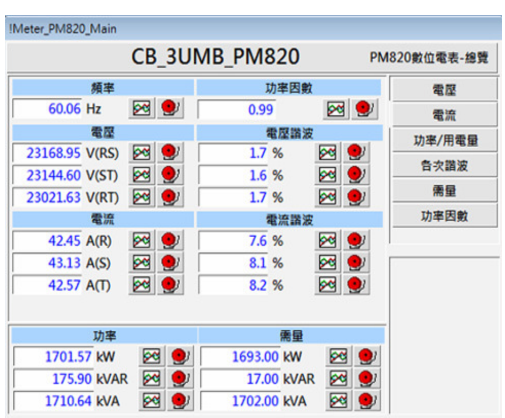

Figure 4: The real time information of feeder B measured by the power SCADA system.

During the recent commissioning of TPS accelerator, the 3-phase voltage and current value have been studied. For the feeder A the 3-phase current imbalance rate is about 2.0% and that for the voltage is 0.29%. As for feeder B the 3-phase current imbalance rate is about 0.95% and that for the voltage is 0.3%. All these voltage values are lower than those recommended in the IEC 1000-2, which has limit of 2%. In Fig. 5, the power demands and the power factor at the time of measurement, and also the historic peak value are shown. With these demand values one can adjust the use of electric devices so the power consumed will not over the contracted demand capacity.

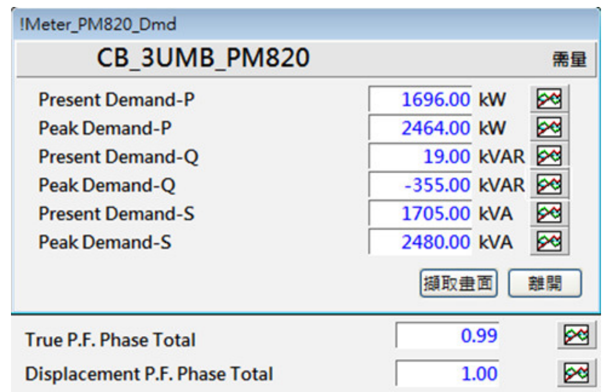

Figure 5: The power demands and the power factor at the time of measurement, and also the historic peak value.

In order to reduce the power consumed in the utility system, the variable frequency drives (VFD) have been installed for the water pumps, heat pumps, air handling units and chillers. In order to limit the total harmonic current distortions filters were installed in the input sides of VFDs. In Fig. 6, the 3rd, 5th, 7th, 9th, 11th and 13th order harmonics after installing the filters are seen. It shows the total current harmonic distortions are reduced to smaller than 5%.

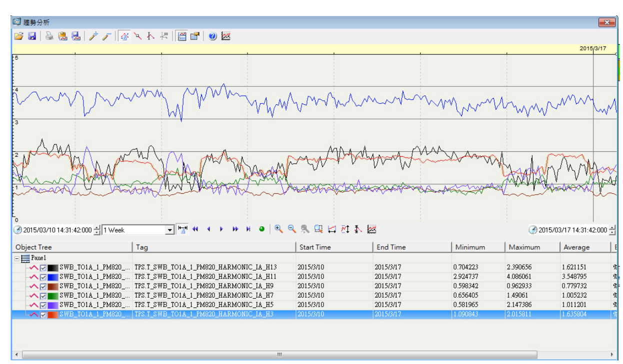

Figure 6: The 3rd, 5th, 7th, 9th, 11th and 13th order harmonics after installing the filters.

The low voltage power system inside the TPS building was installed and distributed according to the loads needed by the subsystems. The power SCADA can monitor the temperatures of substations and transformers,

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the abnormal status of emergency generators and DC chargers, trips of ACB/VCB (vacuum circuit breaker). In the event a fault occurs, it will notify the operators to clear the fault. In Fig. 7, the temperature and the humidity of a substation are shown. The temperatures in the windings of transformers and the panel can also be seen by further clicking the icons. The operators can check if the temperatures of AHUs and transformers are in normal condition.

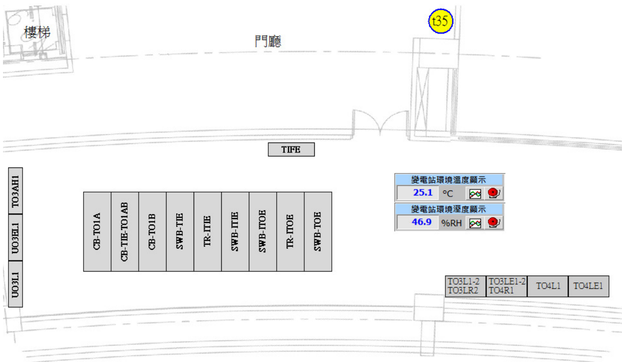

Figure 7: The temperature and the humidity of a substation.

In order to allow the operators to discover the unexpected incidents as soon as possible, the power SCADA can send alarm to warn the operators according to the preset high/low limits of the monitored events. The important information such as time when fault occurs, status, etc. will be recorded for diagnosis purpose.

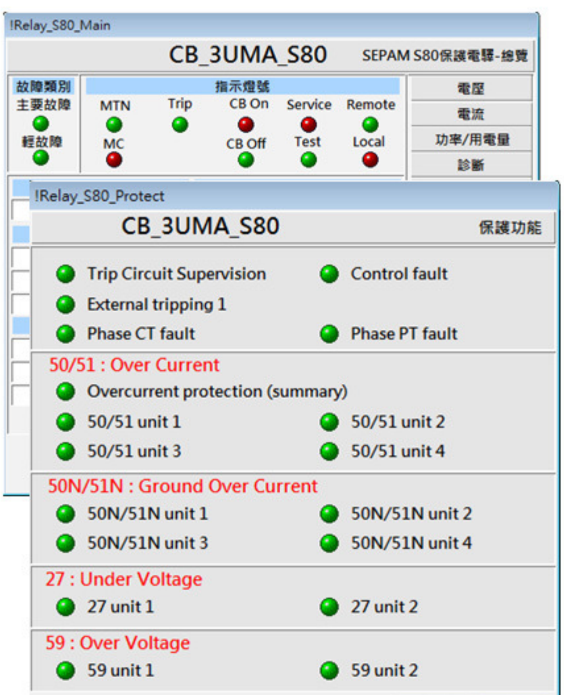

Figure 8: The status of protection relays.

For increasing the reliability of protection coordination, an external protection relay has been installed for each VCB. Through the multi-function digital protection relay and its remote communication ability the operator can confirm the status of each VCB. The status of protection relays is shown in Fig. 8. In the figure, the status of fault alarm, motor charge, trip, CB status and many more information can be seen. The fault current and the cumulative breaking current are also recorded. The indicators of fault events of protection relay are shown in Fig. 8, too. When a fault occurs in the distribution system, proper protection coordination will guide the related circuit breakers to trip according to the preset sequence. This will avoid the improper trip or delayed trip to minimize the accident. In Fig. 9, the power SCADA shows a tripping curve display of feeder A. The order of the protection relay from the upper stream to the lower stream is CB-3UMA, CB-3UA1 and CB-TI1A. These curves are computed to display in the plot without crossing so the power can operate normally.

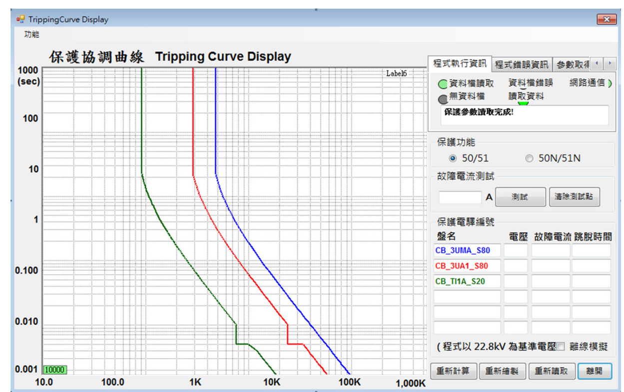

Figure 9: A tripping curve display of feeder A.

CONCLUSION

The use of power SCADA system provides the control and the information acquired from remote equipment. It enhances the operator's ability to manage the power system. Any faults occur in the system can give alarms to the operators, so they can analyze the causes of faults and take immediate measures to clear the faults and recover the system to normal. From analyzing the accumulated long period of data, the conditions of devices in operation can be understood. Thus, the problematic devices can be discovered early and replaced or repaired beforehand to avoid or minimize the false operation of power system. In the near future, many more devices are planned to be included in the power SCADA system to further enhance its function.

REFERENCES

[1] IEEE standard 519-1992, "IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems", IEEE, New York (1993).