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A MONITORING SYSTEM FOR TPS LINAC

C.L. Chen†, H.P. Chang, C.S. Fann, K.L. Tsai, National Synchrotron Radiation Research Center, Hsin-Chu City, Taiwan

Abstract

Since 2014, TPS Linac system has been operating regularly. In order to keep a high stability during a long operating time, it is important to develop a monitoring system to monitor all sub-systems' parameters, including setting values, reading values, control inputs and outputs. This system is not only recording all above mentioned parameters, but also provides an efficient diagnosis in case of troubleshooting. Because the controlling system in TPS Linac is using Siemens S7-300 PLCs, Simatic WinCC is utilized to develop a historical recorder to archive operational analyses, and operator activities in operation. This paper attempts to show a complete solution for the integrated software structure and its resulting process analysis.

INTRODUCTION

TPS Linac comprises of a 90 keV thermionic gun, a 500 MHz subharmonic prebuncher (SPB), primary buncher unit (PBU), final buncher unit (FBU), and three 5-meter accelerating sections. The electron beam leaves the surface of the thermionic gun with 90 keV, and is accelerated to 150 MeV by three 35 MW pulse forming network (PFN) klystrons [1]. The control of TPS linac system is using S7 Siemens distributed PLCs, which are connected in an identical Ethernet. All signals of the PLC system are monitored by a general control system, which provide a real-time data for operators. This general control system, which is programmed with EPICs and is using a soft IOC, allows operators to change the setting parameters in order to optimize the linac performance. The operators can use the graphical user interface (GUI) to monitor the current status of electron source, three RF modulators, RF distribution, magnets, and vacuum gate valves.

Together with the distributed PLCs, the control system provides a reliable and efficient user interface for operators while the linac system is operating. The controlling system provides user to change setting parameters and monitor their reading values instantaneously. All interlock signals and error messages are shown on the GUI for operators to check the linac system and to resolve the causes. All incidents which are caused by activated interlock are reported to responsible personnel. TPS is running at top-up mode continually with an injection every 4 minutes. If an interlock is activated, it would stop the linac system for the further checks. This may cause the termination of top-up injection process. Firstly, if the sequences of PLC's signals, which are triggered to activate the system interlock, are recorded with time stamps, these information can help to understand the actual causes and reduce the down time. Moreover, the increase in wear on the system is taken more seriously, because the linac system is operating 24 hours a day. Some linac output signals, such as klystron filament voltage and power dissipation energy, are becoming increasingly important. These outputs are changing slightly year by year. So it is necessary to record these outputs yearly and find out the tendency before the components are worn out completely. A commercial monitoring software, so called Simatic WinCC, can fulfil the above two requirements. It is used to monitor and record the linac operation processes. This paper presents the software structure in detail and provides an example of how to determine a PLC noise interference by using WinCC.

CONTROLLING SYSTEM LAYOUT

Simatic WinCC is a window-based software which is developed from Siemens. It is a supervisory control and data acquisition (SCADA) and human machine interface (HMI) system, which is designed for Siemens PLCs [2]. TPS linac system was delivered by Research Instruments (RI). The entire system is using Siemens' S7 PLCs as its main controlling system. This is a great compatibility of using the Simatic WinCC to monitor TPS linac system. Figure 1 shows the overview of the connection of PLCs in TPS linac. All PLCs are connected in the same local area network (LAN). All signals of the PCL system can be sent or received in this network, shown in Figure 1.

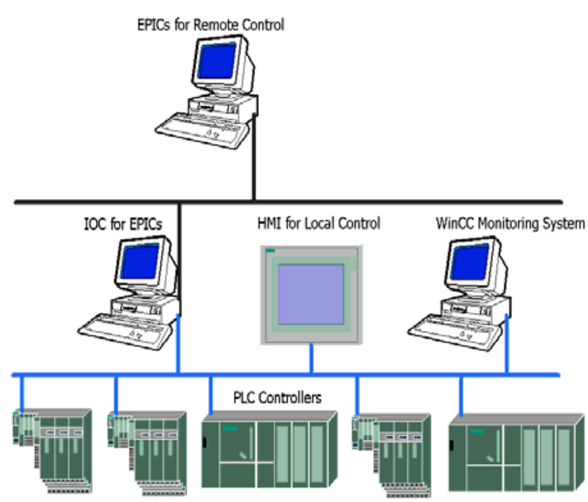

Figure 1: Overview of the connection of PLCs.

In the existing TPS linac system, all signals, including interlocks, setting parameters, and monitor values, are managed and programmed with EPICs in a soft input/output controller (IOC). The functionality of WinCC

† clchen@nsrrc.org.tw

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is much similar with the EPICs in the soft IOC. WinCC provides with a visualization system under Windows for operators to monitor Linac machine status and to trace process states and historical data (measured values, interlocks, user data) from the process database. These process data can be stored in a large storage space of computer. By obtaining the historical values from the database, it is easy to understand system performance or machine status from the statistics archived trends. The following paragraphs will describe how to implement WinCC into the TPS linac system with a new archiving function.

INSTALLATION AND SET-UP OF WINCC

WinCC is installed in a Window-based computer. A TCP/IP communication channel is established to connect to all Simatic S7 Controllers. Firstly, it is an important step to ensure a proper connection between WinCC and all PLCs. Because both PLCs and WinCC are developed by Siemens, there are not any additional drivers needed during the installation procedures. Figure 2 indicates the TCP/IP setting page in WinCC communication page. In the dialog window of Connection Parameter – TCP/IP, IP address has to be set to the destination PLC's IP. The PLC's IP can be found from the hardware configuration.

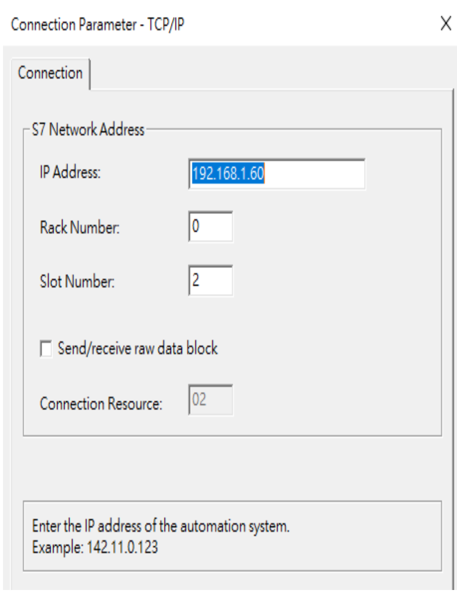

Figure 2: TCP/IP setting page in WinCC.

Secondly, all interlocks, setting parameters, and monitor values have to be added into WinCC's Tag Table, shown in Figure 3, and assigned their corresponding Data Blocks (DB) names. These DB names can be found from the destination PLC's Step 7 program code. When all necessary data points are created in Tag table, they are now ready for showing real-time process values and process interrupts. Figure 4 shows linac modulator GUI display. Both setting and measured reading values are shown in the same page.

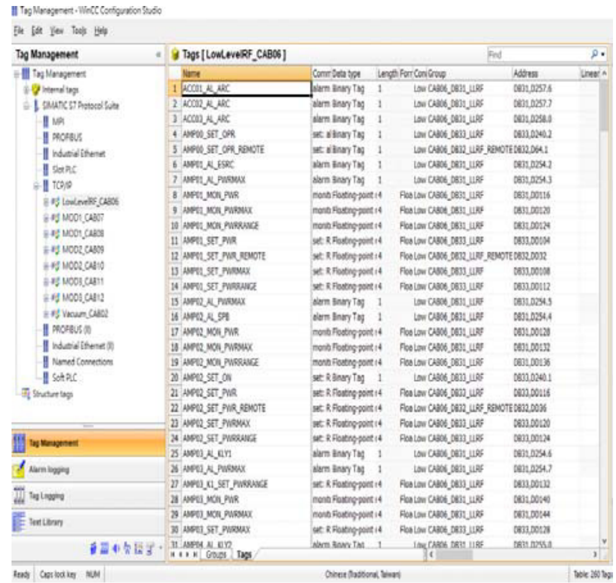

Figure 3: Tag page for all monitoring and set values.

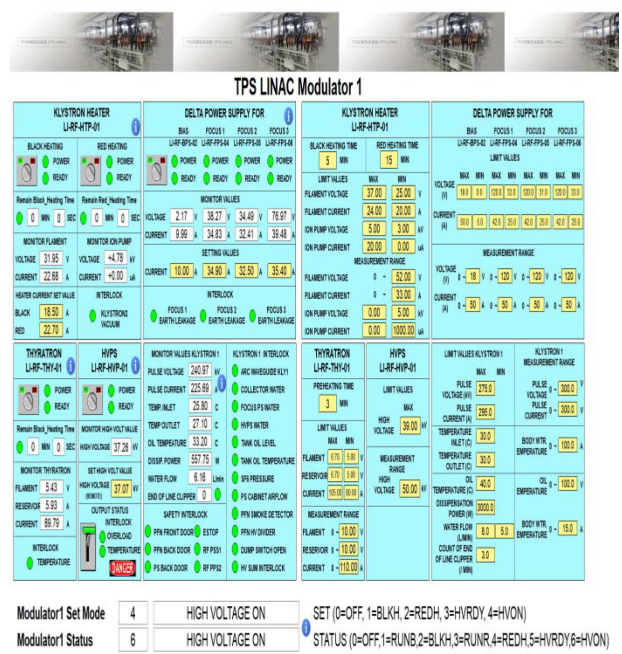

Figure 4: Graphic User Interface (GUI) for Linac Modulator.

Finally, the most benefit of using WinCC in TPS Linac system is the archive system. All important process values and interlocks can be saved in a historical format. These data can be retrieved from the database to trace the historical values at any specific time periods. Moreover, process interrupt sequences can be recorded and provide more information about system failure. The measured values and interlocks are stored in an archive hard disk; the size of which can be configured for a long archiving period. Process values are displayed via WinCC online Trend Controls, which display the data in the form of a

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trend with a time stamp. Figure 5 shows the historical RF pre-amplifier outputs at 4-mintues top-up injection. The RF amplifiers are switched on at every four minutes for injection. The sampling rate for WinCC for monitoring these parameters is at 500 ms.

In the 4th quarter of Year 2018, linac system had experienced unexpected trips in one of three modulators during the regular operation. These unexpected trips occurred, then terminated the injection process from linac. These occurred frequently without any interlock indications. When it occurred, all DC power supplies for focusing magnets in klystron 2 are switched off and on in as fast as 2 seconds. By using WinCC's archive system, the suspected PLC controlling points were selected and monitored. When the incident was occurred, all the process interrupt sequences are recorded. This shows an evidence for ease of tracing trigger points and reduce the trouble shooting time. In this case, a communication noise interference was pick up in a photoelectric converter, then caused an interruption between two PLCs. Figure 6 shows the difference archiving data in the normal operation, and the status changed when a noise interference was pick up. By comparing of these two states, it is easy to find out the interrupt sequences.

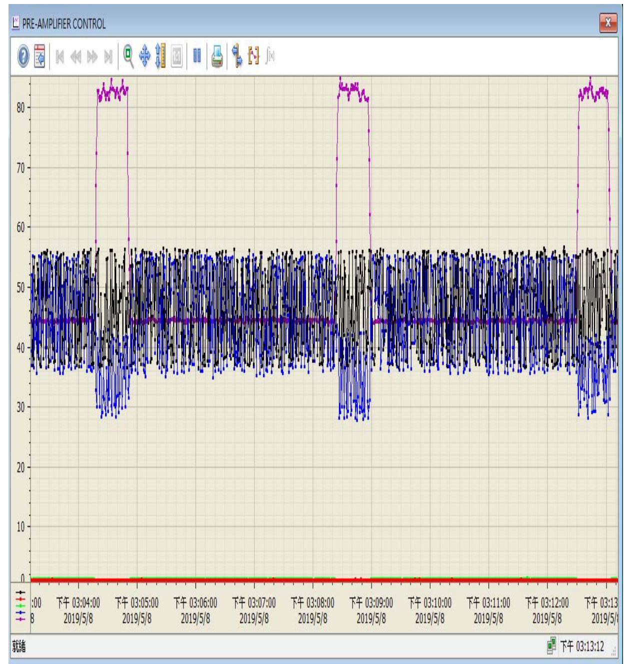

Figure 5: Historical data for RF pre-amplifier outputs at 4-mintues top-up injection.

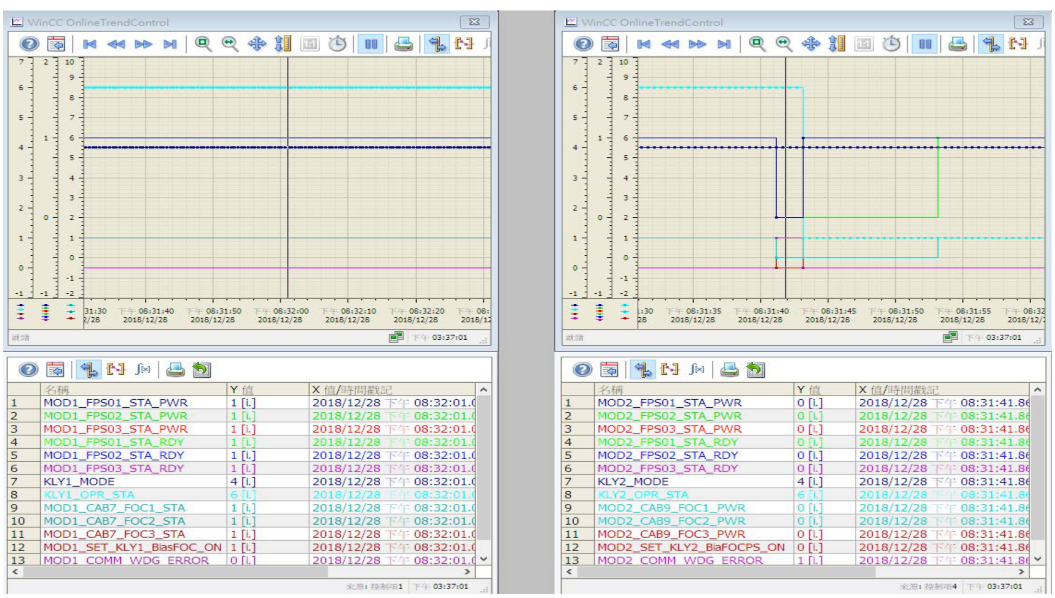

Figure 6: Archiving curves for all focusing magnet power supplies at normal operation (left) and system failure (right).

CONCLUSION

A monitoring system by using WinCC is implemented in TPS Linac successfully. All setting parameters, reading values, process sequences are recorded to provide additional information for system health check or trouble shooting.

REFERENCES

[1] *TPS Linac Operation Manual,* Research Instruments, Jun. 2011, pp. 12-15.

[2] https://w3.siemens.com/mcms/water-*industry/en/Documents/SIMATIC_WinCC.pdf*