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HEPS-TF SUPERCONDUCTING WIGGLER CONTROL SYSTEM*

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Abstract

Superconducting Wiggler (SCW) is an important development direction of insertion devices for modern light source.it is also the key technology of High Energy Photon Source Test Facility (HEPS-TF) Insertion device system research. SCW control system involves power supply, cryogenics vacuum and other devices' control. Serial port server was built for the SCW control system, with EPICS DB to make the PID algorithm for heater & superconductor cavity pressure, temperature, and with Ziegler-Nichols method to quickly find appropriate PID parameter.

INTRODUCTION

Superconducting Wiggler (SCW) is the key technology of High Energy Photon Source Test Facility (HEPS-TF) Insertion device system research. SCW controlled equipment includes three digital power supplies, several cryogenic temperature acquisition instruments, vacuum gauges, pressure gauges, heaters, pressure relief valves and so on; see Figure 1.

Figure 1: Superconducting Wiggler (SCW) control system at field site.

ARCHITECTURE OF SCW EPICS CONTROL SYSTEM

The hardware of SCW control system is designed with distributed control structure. Several serial servers are used to collect digital signals from controlled devices to EPICS IOC. Serial servers communicate with controlled devices using RS485/RS232 bus.

The software architecture of SCW control system (Figure 2) adopts EPICS system, which communicates with serial servers by Streamdevice driver support [1]. In EPICS IOC, EPICS DB [2] is reasonably designed to make PID algorithm and judgment of the valve switch.

EPICS CSS is used as user interface development tools and embedded JavaScript for power supply's control.

EPICS archiver is used at field site to facilitate the storage and query of historical data.

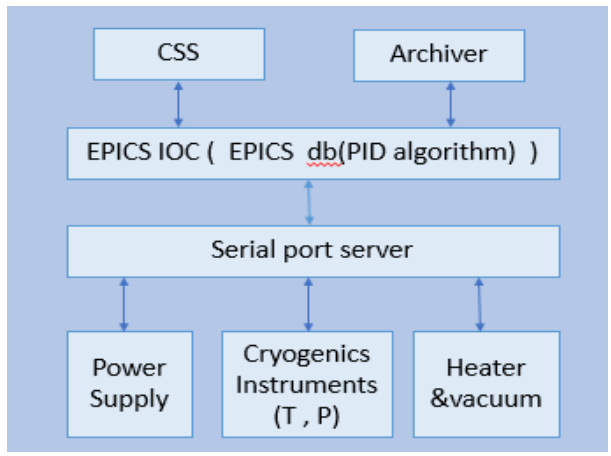

Figure 2: The structure of SCW EPICS control system.

REALIZATION OF PID ALGORITHM AND ZIEGLER-NICHOLS METHOD

Because all equipment signals such as pressure, heater current and magnet temperature have been collected into EPICS DB as digital signal, incremental PID algorithm have to realize in EPICS IOC with EPICS DB design.

Incremental PID algorithm is

$$\triangle U(k)= U(k)-U(k-1)=K_P(e(k)-e(k-1))+k_i e(k) +k_d(e(k)-2e(k-1)+e(k-2))$$

The calculated increment is only related to the deviation of the last three acquisitions. We adopt Ziegler –Nichols method to get the PID parameters quickly and adjust slightly to get the proper PID parameters for control system.

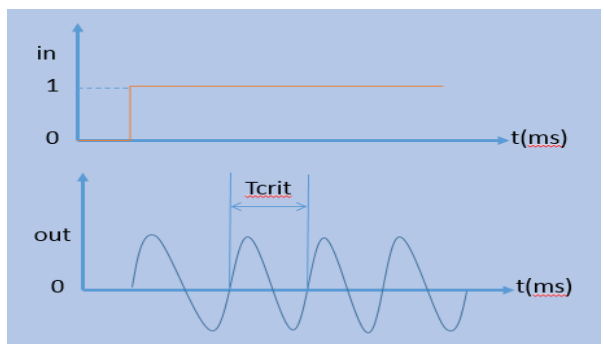

Figure 3: Ziegler-Nichols method step response.

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Ziegler-Nichols method make a priori assumptions on the system model, but do not require that these models be specifically known .it is based on plant step responses.

First constructing closed-loop control circuit and determining stability limit by stimulating the system a step responses (Figure 3).

Second calculating controller parameters based on formula as Table 1. SCW CSS interface shown in Figure 4.

Table 1: Ziegler-Nichols Method Formula.

	KP	Tn	Tv	KI	KD
P	0.5KPcrit	---	---	---	---
PD	0.8KPcrit	---	0.12Tcrit		KP*Tv
PI	0.45KPcrit	0.85Tcrit	---	KP/Tn	---
PID	0.6KPcrit	0.5Tcrit	0.12Tcrit	KP/Tn	KP*Tv

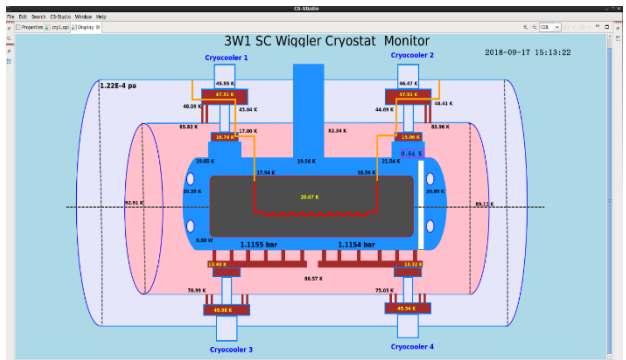

Figure 4: SCW CSS interface.

CONCLUSION

The HEPS-TF SCW control system was built by Serial port server & EPICS, realize the power supply control, cavity pressure interlock protection, data acquisition & storage and PID algorithm .it has a good performance in the field test.

REFERENCES

[1] https://epics.web.psi.ch/software/streamdevice/doc/index.html

[2] https://wiki-ext.aps.gov/epics/index.php/RRM_3-14