

SEQUENCE CONTROL SYSTEM OF 1-MW CW KLYSTRON FOR THE PEFP

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Abstract

The sequence control system of 1-MW CW klystron for the PEFP (Proton Engineering Frontier Project) has been developed in order to drive the 1-MW klystron amplifier. The system is able to control several power supplies and many environment conditions. The system was developed using the simulator which was made similar to real conditions. We had to solve problems to manage well in real site experiments. The hardware of sequence control and the interlock system are based on the Allen-Bradley's SLC500 Programmable Logic Controller (PLC). Also the system can be controlled by a touch screen at local mode or Ethernet network with high level HMI at remote mode

INTRODUCTION

I'll explain the klystron sequence control system about Low power RF System which is a field of the PEFP first step Accelerator Equipment Development Project. I designed the klystron sequence control system. I performed the investigation and comprehension about proton accelerator equipment, I checked to comprehend SPEC of the klystron (1MW, 350MHz), high voltage power, heater voltage power supply, modulating anode power supply, electromagnet power supply, ion pump power supply, high power RF system. On the basis of experience that Pong Light Source (PLS) has operated 60-75kw 500MHz klystron, We has developed sequence control system, power supply control system and low power RF system after investigating Tales TH2089 klystron specification and grasping the contents. The CW klystron is different from capacity of power supply and scale of cooling system according to output power, the CW klystron operation situation of tens kW can be applied MW class klystron because function of motion principles, operation step and all sorts of interlock is similar. Besides we installed power supply control panel which can monitor and control all sorts of klystron power supply systems. On the basis of it, we made klystron sequence control system to Programmable Logic Controller (PLC). There are two kinds of RFQ and DTL1, 2 in klystron sequence control system. All devices of klystron sequence control system (RFQ, DTL1, 2) are installed in each 19inches rack. The RFQ (Radio Frequency Quadrupole) for PEFP has been built which is a low energy accelerator for 3MeV photon beam. We installed at photon accelerator site after we developed control program using the simulator which was made in order to test the klystron sequence control system in a test lab. (Figure 1.)



Figure 1: Picture of simulator and PLC (front side).



Figure 2: Picture of simulator and PLC (back side).

SYSTEM CONFIGURATION & HARDWARE

The klystron sequence control system has to be creditable and stabilized. Besides, the klystron sequence control system must be extended easily according to change of signals. We decided to use Allen-Bradley SLC500 series which is well-known, creditable, being stable. We adopted SLC 5/05 processor with 10based_10Mbit/s. The klystron sequence control system was used Input Module(2), Output Module(1), Input/Output Combination Module(1), Analog Input Module(3), Analog Output Module(1), Power Supply Module and 10slots Crate. The PLCs have been extensively used in industry to automate variety of control and monitoring functions for many years. There are flexible, versatile and are built to withstand harsh factory conditions. The control signal is consist of digital input 33points, digital output 15 points, analog input 24 points, analog output 4 points. We installed 10.4 inch touch

screen in local area that sequence control was installed in order to make monitor and control easily. Using EasyBuilder 500 tool, we make monitor & control program on touch screen. After, we make graphic on Personal Computer. If we download monitor & control program to touch screen and connect with PLC, we can monitor and control of devices status in case of being normal. Touch screen is easily handled by user and RS-232C communication with PC, PLC. We can monitor and control about devices status on HMI screen with EPICS using Ethernet port of PLC CPU module.

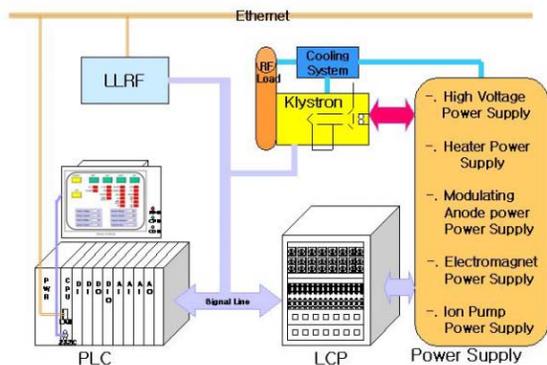


Figure 3 : Structure of sequence control system.

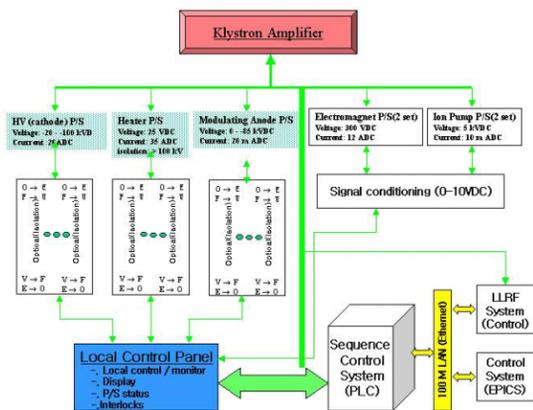


Figure 4: Block diagram of power supply.

SEQUENCE CONTROL PROGRAM

We select Remote/Local operation on touch screen or HMI. We check heater voltage is 0V and voltage of ion pump power supply1, 2 is 4.5-5.5kV and current of ion pump power supply1, 2 is bellow 10uA. Check normal of Klystron collector, Klystron Body, Klystron Cavity output, Circulator, Circulator load, water flow of RFQ(DTL1,2), Dummy load inlet temperature and Klystron window air cooling. If everything is normal, it becomes black heater ready status.

Black Heater Mode: select black heater mode on local touch screen or remote HMI. If we set heater voltage to 13V and it is same with reading value, begin to count with 15-minute time delay. Check transducer ON, turn on electromagnet1, 2 power supplies. If electromagnet power supply is between 9A and 12A, electromagnet power is OK status. If it is finish 15-minute delay counter, it becomes black heater normal status and standby ready status.

Standby Mode: select standby mode on local touch screen or remote HMI. If we set heater voltage to 13V and it is same with reading value, if heater current is between 19A and 20A, full heater voltage is OK status. In this case, 5minite time-delay counter start and turn on modulating anode filament power supply. After set modulating anode filament voltage on local touch screen or remote HMI. If it is same with reading value, turn on modulating anode grid power supply. It is set modulating grid power supply voltage. If it is same with reading value, grid is ready and modulating anode power supply is OK. After turn on TCU and arc detector, check work well. We confirm that 5-minute time delay counter is finished and external interlock signal is normal. If everything is normal, it becomes standby OK and HV ready.

High Voltage Mode: select HV mode on touch screen or remote HMI. After confirming whether VCB is normal or not, turn on VCB in case of being normal. After checking that high voltage power supply is normal, set operating beam voltage on touch or remote HMI. Adjust beam voltage using analog output in order to become up setting voltage. If high voltage power supply become normal and is same with reading value, it is HV OK status. If we set operating beam current and beam current is same with setting value, it is klystron ready status. If klystron window arc, reflect RF power, circulator arc are normal, turn on LLRF switch. ion pump 1,2 voltage/current, klystron inlet water temperature, Klystron collector temperature, Klystron body/cavity temperature, dummy load inlet/outlet temperature, Klystron collector water flow, dummy load water flow, forward/reflected RF power can be monitored.

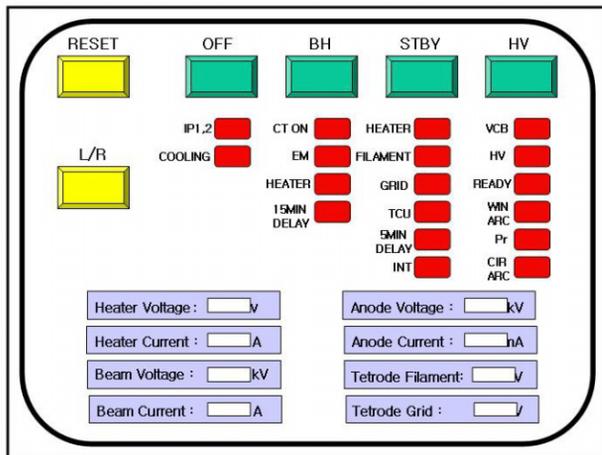
OPERATING MODE TEST

We can classify the klystron sequence control to four parts largely. Such as “OFF”, “Black Heater”, “Standby”, “High Voltage”. We can select to operate this on touch screen or remote HMI.

“OFF” status is the beginning condition of klystron sequence control system. If we select “OFF” at the same time of operation in Black Heater, Standby, High Voltage, it goes back “OFF”.

If “Black Heater” status is heater voltage is zero and emergency status is normal status, besides, cooling & temperature of klystron is normal status, we can select it. We check current transducer, electromagnetic1, 2 power supplies, setting heater voltage value, 15-minute time delay. If everything is normal, we can select next step called “Standby” status. If we select “Black Heater” at “Standby” or “high Voltage” status, it goes back “Black

Heater” status. If “Black Heater” is normal status, we can select “Standby” status. We confirm whether full heater voltage, modulating anode filament & grid voltage, circulator TCU, 5-minute time delay, external interlock are normal or not. If everything is normal status, we can select next step “High Voltage” status”. Besides, it goes back “Standby” status if we select “Standby” of “High Voltage” status. We can select “High Voltage” status if “Standby” status is normal status. If VCB check & ON, setting operating beam voltage & current, klystron ready, klystron window arc, forward/reflect RF power, circulator arc work normally, we can turn on Low Level RF System (LLRF) which is a final step. If status of “OFF”, “Black Heater”, “Standby” is selected, it goes back according to status which is selected.



TOUCH SCREEN

Figure 5: Configuration of touch screen.

CONCLUSION

We had a lot of difficulties in experiment because the condition of experiment shut as sequence control system of 1-MW CW klystron was executed using simulator which was made simulator with real condition. We think that we can solve problems to manage well and expect that real site experiments is made in consideration of environment factors such as klystron, power supplies in the field of proton accelerator.

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