THE UPGRADING OF HLS LINAC MODULATORS *

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Abstract

The existing five klystron modulators of HLS 200 MeV Linac use 50Hz high voltage power supplies and adopt resonant charging scheme with De-Qing circuit. The stability of the output high voltage is not satisfactory especially when the AC line voltage fluctuations. The control of the modulators is old manual method. In order to increase the stability, operating reliability and comply with the EPICS based new control system of HLS, a upgrading project is now in progress. The project includes two major parts. One is the replacing of old HV powers with five EMI 40kV constant-current charging powers. The other is the addition of PLC in each modulator as local controller.

1 INTRODUCTION

The existing modulators of HLS 200MeV LINAC began operation from 1989[1]. The main components of high voltage charging power consists of a motorized 3-phase variable transformer, a high voltage step-up transformer, a rectifier assembly and charging inductance as shown in Fig.1. After more than ten years' operation, some components are no longer in good condition and circuit failure occurred often. The stability of the output high voltage is not satisfactory especially when the AC line voltage fluctuations. The control of the modulators is based on manual method and there is no computerized controller in the modulators and therefore can not meet the requirement of new EPICS control system of HLS.

The specifications of the klystron modulators are shown in Table 1 and circuit schematic is illustrated in Fig.1.

The Phase Two Construction Project of HLS began in end of 1997[2]. In 2001, the plan of upgrading modulators was approved and be added to the Project.

The upgrading includes two major parts. One is the replacing of old HV powers with five EMI 40kV constant-current charging powers. The other is the addition of PLC in each modulator as local machine controller. The old control and monitor system all totally abandoned. In the new control system, PLC achieves command control, status-monitor, safety interlock and real-time communication with the IOC.

Table 1: Specifications of HLS klystron modulators

Klystron	KMF-1017A
Modulator Peak power	50 MW
Maximum average power	12 kW
Klystron Beam voltage	250KV
Klystron Beam Current	240A
RF output power	15MW
Thyratron anode voltage	40kV
Thratron current	2.9kA
Pulse flat top width	2us
Repetition rate	50pps
PFN impedance	8.8 ohm
Pulse to pulse stability	<0.5%

2 NEW HIGH VOLTAGE CONSTANT-CURRENT CHARGING POWER SUPPLY

Five EMI LC1202/40kV constant-current charging powers are employed. The specifications of the power are listed in Table 2.

Table 2 Specification of LC1202/40kV power supply

Average charging rate	**12kJ/s**
Peak charging rate	13.5kJ/s
Linearity	±1% of full scale
accuracy	±1% of rated output
power factor	>0.9
Efficiency	>90%
Stability	<0.2%/hr after 1 hour warmup
Pulse repeatability	±0.1%

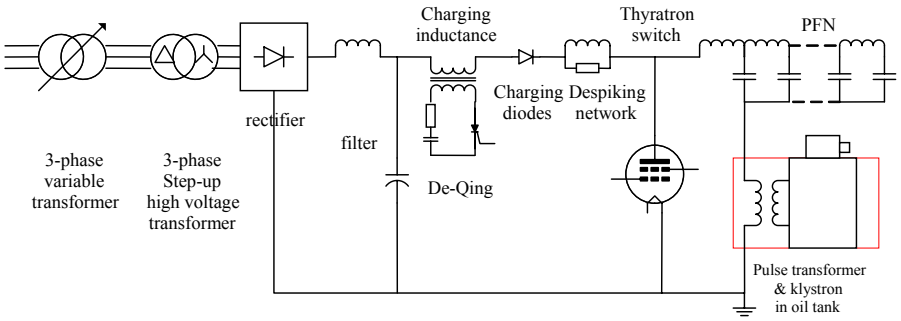

Figure 1 schematic of existing modulators

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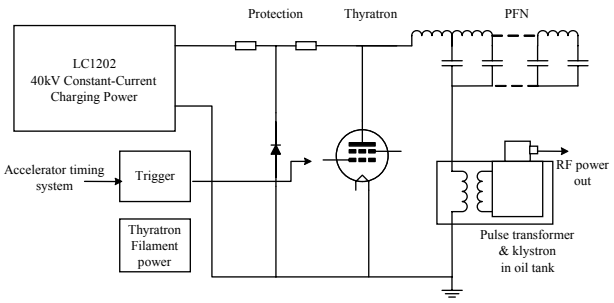

Figure 2 New klystron modulator structure

The power uses a parallel resonant topology and the working switching frequency is higher than that of resonant frequency to achieve constant current charging. PFN charging parameters can be calculated as:

- Charging time $(1/2)*C*U^2/13.5=12.4$ ms.
- Dewell time 20-12.4=8.6 m.
- Average charging rate $(1/2)*C*U^2/20=8.8$ kJ/s
- The maximum repetition rate that can be achieved 1/12.4ms=80.6 Hz

Water cooling method is adopted by LC1202/40kV and power supply is very compact. Much space in the modulator cabinet is free out.

3 TEST RESULTS

Three of five modulators have been fully tested and they perform quite well. Fig. 3 shows the PFN was charged to about 33kV. After discharging, the HV power is given a INHIBIT signal of 4ms width to avoid thyratron continual conducting. Fig. 2b is the load voltage waveform sampled from a high voltage capacitor divider which is installed in the oil tank.

A initial measurement shows that the Pulse to Pulse Repeatability of the modulators is less than 0.1%.

4 KLYSTRON CONTROL

The new control system of NSRL is built upon EPICS and following the standard model. The klystron modulator system control will be a subsystem as shown in Fig. 5. In each modulator, a OMRON PLC C200HE is employed as the local device controller. Command control, status-monitor, safety interlock and real-time communication with the IOC are achieved by the PLC. The protocol between the IOC and PLC is HOSLINK protocol which is a vendor protocol. The relevant drivers in IOC were developed. Several modules are adopted in each PLC including a 16-point Digital Input (DI) module, a 16-point Digital Output (DO), a 8-channel AD/DA module and a communication module. All the digital in/out signals are optically insulated. Strong electromagnetic interference, which was caused by the large pulse current in the modulator, was restrained. The program is written in the form of Relay Logic Ladder. PLC will make the operation of the modulator more stable and reliable.

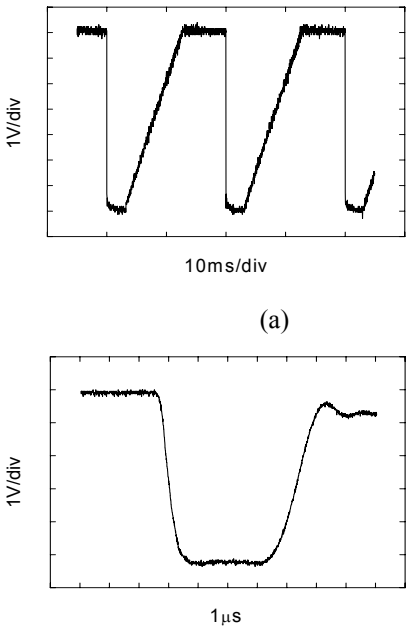

Fig.3 Measure waveforms of PFN charging and discharging

5 ACKNOWLEDGEMENT

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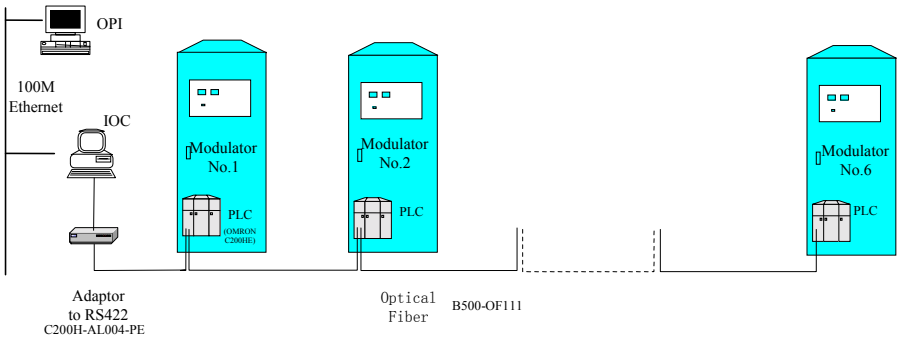

Figure 4 Klystron modulators control

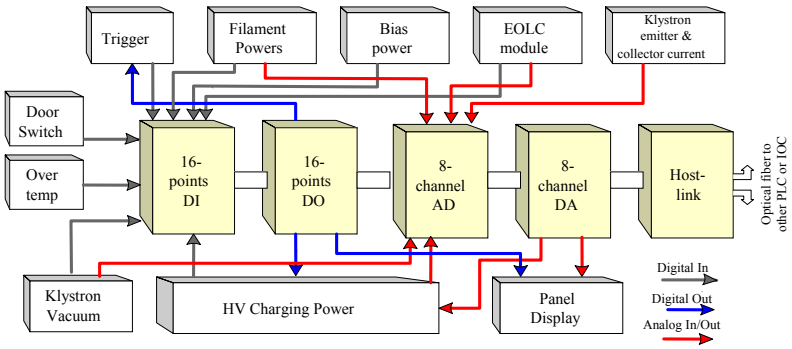

Figure 5 Control signals flow

6 REFERENCES

[1] G. S. Zhao, S. T. Sun, X. F. Luo, et. al, 250KV high voltage pulse modulator, Journal of China University of Sci. & Tech., 12(2),1982,128~132

[2] Design Report of Phase Two Project of NSRL,1997.