KLYSTRON AND MODULATOR UPGRADE FOR BEPCII LINAC

Y.L.Chi*, D.Dong, L.Shen, G.Y.Li, Q.M.Dai, S.M.Tian, X.W.Yang, Y.W.Chen, and G.X.Pei
Institute of High Energy Physics, Chinese Academy of Sciences
P. O. Box 918, Beijing 100039, China

Abstract

An upgrade of the RF power source is now processing at the BEPC Linac in order to increase the acceleration energy from the present 1.3Gev up to the1.89Gev required for the BEPCII. It was decided that most of the existing klystron and all modulators should be reinforced so as to be capable of producing pulses with 110MW peak power and 6.3μs pulse duration. This paper describes the detailed concerning of the klystron and modulator upgrade.

1 INTRODUCTION

BEPC Linac RF power source consists of 16 units of Klystron and Modulator, including 13 units of Hk-1 30MW klystrons and 2 units of SLAC 5045 65MW klystrons. Unit 2 and from unit 5 to unit 16 are running with SLAC type energy doublers. Figure 1 shows lay out of BEPC Linac RF power source configuration. BEPCII requires injection Linac to upgrade energy from 1.3GeV to 1.89GeV. There for we will use new higher peak output power klystrons and upgrade modulators to increase Linac energy and positron injection rate.

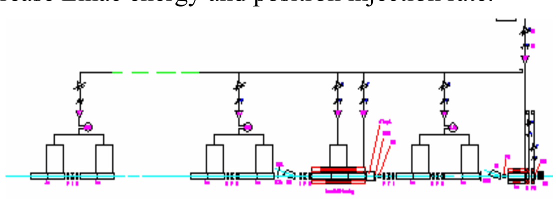

Fig.1 Lay out of BEPC Linac RF source Configuration

2 KLYSTRONS

BEPC Linac operating 2units SLAC 5045 65MW peak output power klystrons and 14 units HK-1 30MW peak output power klystrons to injection 1.3Gev e-/e+ beams to ring. In order to upgrade injection energy, we will adopt 14 units of Thomson TH2128C 45MW klystrons instead of HK-1 30MW klystron and keep to use two units of SLAC 5045 klystron. K2 will use 65MW SLAC 5045(working at 50MW) primary electron beam energy to 240MeV for positron production. K_{12} has already used SLAC 5045 and will keep working at 45MW. Main parameters of klystrons are shown in table 1. Down stream of positron production, there are 12 such regular acceleration sections. For the SLAC type RF structure, the energy gain for each regular section driven by one klystron can be expressed as: $\Delta E = 20M[P]^{1/2}$, Where M is the multiplication factor of SLAC type Energy Doublers, P the output power of the klystron. If TH2128C klystron works at 35~40MW, the total energy gain is $\Delta E = 20\times1.5\times\sqrt{45} + 11\times20\times1.5\times\sqrt{35} = 2.15GeV$. Considering the initial energy of 80MeV at DC solenoid exit, the positron beam energy at Linac end will be about 2.2GeV, 16% higher than the design specification. The extra gain will be used for one klystron standby in case of failure, and energy tuning. Figure1 and figure 2 is picture of TH2128C and SLAC 5045 klystron respectively.

Table1. Specifications of BEPCII klystrons

PARAMETER	Unit	TH2128C	5045
Center Frequency	MHz	2856	2856
Peak output power	MW	45	65
Peak average power	KW	10	90
RF pulse width	μs	4.5	3.5
Peak beam voltage	kV	320	350
Peak beam current	A	360	414
Microperveance	μA/V3/2	2.0	2.0
Heater voltage	V	20~30	15
Heater current	A	20~28	35
Focusing currents	A	40	15
Peak driver power	W	200	350
Gain	dB	54	53
Efficiency	%	43	45
Pulse repetition rate	Hz	50	120

The window is usually weak link in klystron. From operating experience of klystron, found that even small amounts of dust or foreign particles on the ceramic surface can act as arc centers. As figure. 1 shows that output waveguide of TH2128C klystron is horizontal and output window is vertical. In this way any foreign materials introduced into the output waveguide will deposit itself harmlessly in low-field region of waveguide that can avoid arcing in the ceramic window effectively during operating with accelerator.

3 MODULATOR UPGRADE

In order to operating Linac in 50Hz and operating 14 units of new TH2128C klystrons, we need to upgrade modulators with new specifications. Table 2 is Specifications of BEPC and BEPCII Modulators. Since klystron need higher beam voltage and average current

* chiyl@mail.ihep.ac.cn

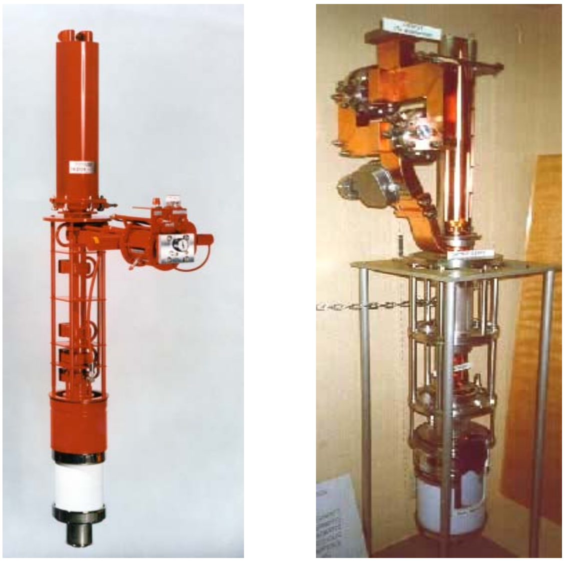

Fig.2 TH2128C Klystron and 5045 Klystron

will be increased by 50Hz repetition rate, most of main components are redesigned and replaced, such as pulse transformer and oil tank, PFN and thyratron, etc. but will remain original cabinet to save budget.

3.1 Pulse transformer oil tank and pulse cable

The previous pulse transformer tank had performed well over the 20 years it had been in use, so the basic concept will not changed but almost components need to redesign due to the handle increased high voltage and long pulse and pulse repetition rate. An efficient tank cooling system will required to deal with the increased pulse transformer losses and increased filament dissipation. The circuitry of pulse transformer tank is shown in figure 3. New pulse transformer specifications is, pulse transformer ratio is 1:15, peak pulse voltage and pulse current are 320kV and 360A, pulse flat top is 4.5µs, pulse repetition ratio is 50Hz. The pulse transformer tank, and therefore the klystron, is connected to the modulator by short flexible triaxial cable with a plug at the tank end to allow convenient disconnection for klystron changes. BEPCII Will use SLAC type cable, with carry pulse current of over 6.5 kA at over 25 kV with low characteristic impedance.

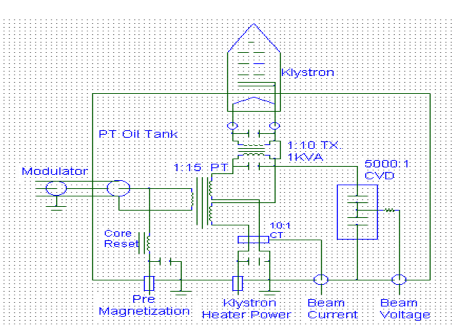

Fig.3 Circuitry of pulse transformer tank assembly

Table 2. Specifications of BEPC and BEPCII Modulators

PARAMETER			
Klystron	HK-1	5045	TH2128C
PFN voltage pulse width(µs)	5	5	6.3
PFN Cell capacitance (nF)	14/22	45	32
PFN Cell inductance(Ω)	6	3.5	4
Pulse transformer ratio	1:12 / 1:14	1:15	1:15
Thyratron peak current (A)	3500/3900	6200	5400
Thyratron Peak voltage (kV)	47/40	47	43
Beam voltage flat top(µs)	3~3.5	3.5	4.5
Pulse rise time（10%-90%）(µs)	0.7	0.8	0.7
Pulse fall time（10%-90%）(µs)	1.2	1.2	1.2
Pulse voltage variation (%)	±0.1	±0.1	±0.1
Pulse repetition rate (Hz)	12.5	12.5	50
Modulator charging time (ms)	6.5	12	10

3.2 PFN and Thyratron

The increase in pulse width and decrease in load impedance means that the total replacement of PFN. The new klystrons will also operate into the SLED cavities, which don’t demand perfect flattops, but some applications will still require modest flattop smoothness. Total 26 capacitors will used for new PFN. The total PFN capacitance will increased to 0.832µF to increase pulse width and decrease characteristic impedance. Figure 4 is PSPICE simulation waveform of Modulator high voltage pulse output. Pulse requirement of the new modulator changed to 43kV, 5400A, 6.3µs ESW, that peak anode current is high than 5000A of original CX1525A peak anode current. For the new modulator operation will use CX1536A thyratrons, which has 10kA peak anode current. Thyratron driver will adopt twin pulse generator that pulse voltage for grid 1and grid 2. Apply pulsed voltage to grid 1 helps thyratron operating with longer lifetime.

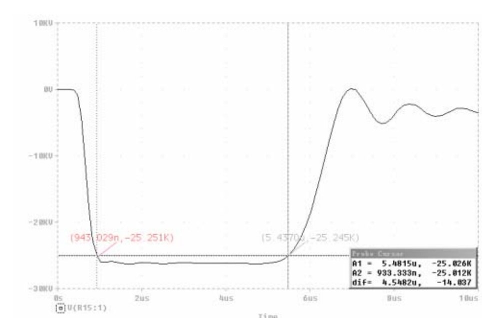

Fig.4 Simulation Waveform of Modulator Pulse output

3.3 Resonant Charging circuit

The resonant charging system consists of a charging transformer, De-Qing circuit and charging diodes. Conventional SLAC type de-Qing circuit in the secondary of charging transformer regulates the voltage applied to the PFN. The increase in PFN capacitance and the increase of pulse repetition rate dictated the charging transformer specifications. The charging time was chosen to be 10ms which half of the repetition period. Therefore, the primary inductance of the charging transformer is 12H. Expected PFN voltage regulation is ±0.1%.

3.4 High Voltage DC Power Supply

HV DC power supply consists of SCR voltage controller, rectifier transformer, rectifier and filter. The new klystron requires a 50% increase in average power for 50 Hz operations. The 50% average power increase would require the replacement of rectifier transformer, rectifier, filter choke, and capacitors. Keep to use original SCR voltage controller with modification of interface to modulator controller that enable to remote DCHV control.

4 M/K CONTROLLER UPGRADE

The BEPC Klystron-Modulator controller is more than 10 years old and does not satisfactory for BEPCII. In order to operating K&M with more reliably and more stably we will upgrade Klystron-Modulator controller for BEPCII with more robust interface. The new controller will base on the industrial PC platform and setup in each K&M station, with analog and digital input and output signals that handles the changes of the equipment. Additionally, to enable acquisition and interlock fast signals with short duration (μS) that are also present in the modulators, a fast signal conditioning module are to be developed. BEPCII main control system communicate with K&M controller via Ethernet and provide remote control of the K&M by setting operating points and remote permits. Figure.5 is control layout of BEPCII klystron and modulator. All operation data of the klystron and modulator can be acquired and saved in real time. The industrial PC platform will function as an IOC of the EPICS BEPCII control system.

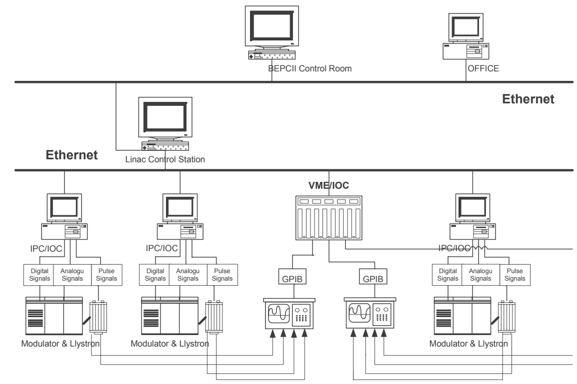

Fig.5 Control layout of BEPCII klystron and modulator.

5 CONCLUSION

The upgrade work is now under going. As to the full energy injection of1.89GeV, we will adopt 2 Units of SLAC 5045 klystrons and 14 Units of Thomson TH2128C klystrons as of BEPCII Linac RF power source. We will upgrade Modulators for operating TH2128C klystrons at 50 Hz and to improve operating stability and reliability. We also upgrade klystron and modulator controller with more robust interface. The new controller will communication with main control system via Ethernet that enable to remote control and will function as an IOC of the EPICS BEPCII control system.

6 REFERENCES

[1] R.B.Neal, ed. “The Stanford Two-Mile Accelerator”, W.A.Benjamin, 1968,N. Y.

[2] “Design Report on PF Injector Linac Upgrade for KEKB”, March 1996, KEK Report 95-18.

[3] “The Second Generation SLAC Modulator”, June 1986, SLAC-PUB- 3993.

[4] “Upgrade of the PF 2.5Gev Linac Klystron Modulator for the KEKB”, November 1994, KEK Preprint 94-146.

[5] S.H.Nam, “PLS Linac status”.

[6] Specification of TH2128C, Thomson Tubes Electronique