A HIGH STABILITY MODULATOR FOR THE SDUV-FEL LINAC

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Abstract

A 150 MeV electron linac for the SDUV-FEL is being constructed at Shanghai Institute of Applied Physics (SINAP). As the crucial component to meet the performance specifications of the SDUV-FEL Linac, a modulator with high amplitude stability is under development. The peak power of the modulator and its 2856MHz klystron are 110MW and 45MW respectively. A capacitor charging power supply and 20 sections PFN are used to obtain 0.1% amplitude stability and ±0.25% flat-top ripple within 3 microsecond pulse width. The pulse repetition rate can be adjusted from 1 Hz to 50 Hz without amplitude excursion. The design concept, performance results and present status of this modulator will be described in this paper.

INTRODUCTION

The SDUV-FEL Linac is a 150MeV electron linac, which serves for the development of deep ultraviolet – free electron laser. A pulsed klystron operating at 2856MHz with a nominal output power of 45MW is installed to power the electron beam. The 1.5µS duration power pulse with ±0.25% voltage flat-top and ±0.1% repeatability is required to achieve that less than 1° of the phase variation of the klystron RF output. In order to generate the microwave power of 45MW, a 110MW high stability modulator should be required to provide 314kV and 350A pulse on the klystron. Main parameters of the high stability modulator for the SDUV-FEL Linac are defined in Table 1.

Table 1: Parameters of The modulator

Peak output power	110 MW
Output pulse current	350A
Output pulse voltage	314 kV
Voltage flat top duration	> 1.5µs(<±0.25%)
Pulse repetition rate	1 Hz - 50 Hz
Pulse voltage repeatability	< ±0.1%
Klystron (2856MHz)	TH2128C (45MW)

THE MODULATOR LAYOUT

Figure 1 shows the basic circuit diagram of the modulator and its associated parameters. The pulse forming network (PFN) consists of 20 sections of LC unit. The PFN is charged by a capacitor charging power supply with constant current of 1.4A. It is discharged by a thyratron, CX1536A, via the pulse transformer into the klystron. Two resistors and an inductor in series and a reverse diode in parallel are used to protected power supply from negative voltage shock.

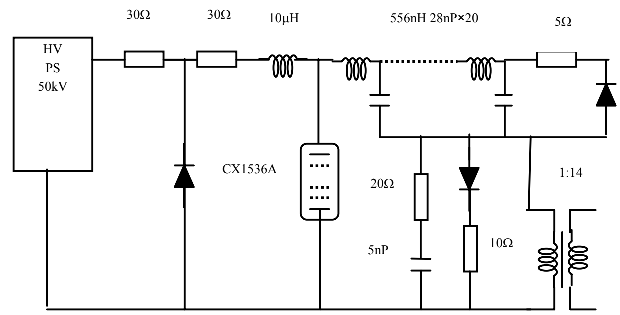


Figure 1: Diagram of The modulator

Figure 2: The PFN cabinet

The Model 303L capacitor charging power supply made by EMI Inc. is used. 303L is a switching mode power supply. It has good regulation properties, 0.2% stability. It is also powerful: average and peak charging rate are 30k J/s and 37.5kJ /s at rated output voltage. It can support the modulator to operate at 50Hz. To using the switching mode power supply for the modulator has a great benefit. The stored energy of power supply is extremely low. In case of a high-voltage breakdown in the klystron or the thyratron, the dissipation energy in the output section is limited and the fatal damages on the circuit components will be avoided. Figure 2. shows the PFN cabinet of modulator.

A SLC-503 PLC based controller (Figure.3) is developed to take charge of the interlock, trigger and the remote operation of the 303L. The controller also monitors the charging reverse current, end-of-line clipper current, as well as status of the PFN cabinet door and so on. The operating timing scheme will seriously affect the stability and lifetime of the thyratron tube. The controller is designed to generate two pulses with constant interval (see Figure 4), one is for starting power supply to charge PFN and another is for firing the thyratron, so that the PFN holding time keeps constant. In this case, the voltage of PFN at the time of discharging will be constant while repetition rate changed. The fire is synchronized with thyratron heating power at the crest or valley.

Figure 3: Controller of the modulator

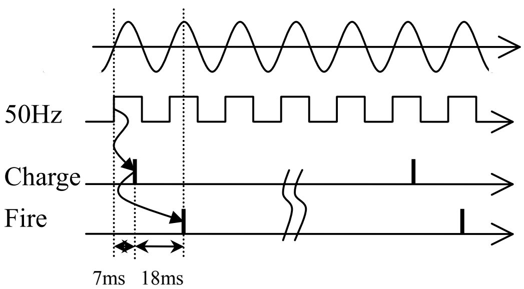


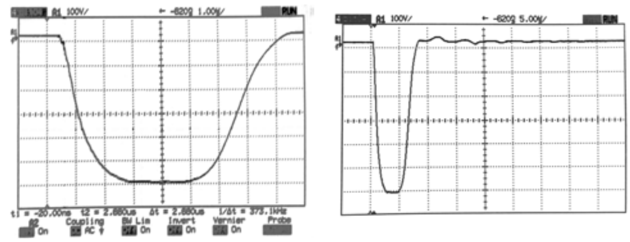
Figure 4: The time scheme for charging and firing

EXPERIMENTAL RESULTS

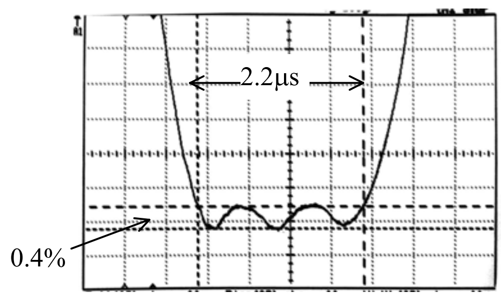
The completed modulator was firstly tested with a resistor as a matched load. The PFN was charged to a maximum value of 42kV, and the transformer output voltage reached 309kV. The trigger frequency was varied from 1Hz to 25Hz. The pulse waveform and its flat-top are presented in Fig.5. It can be seen that the fluctuation of the pulse flat-top is ±0.25% within 2.2μs. That result was achieved by fine tuning the PFN inductance and modifying the layout of discharge loop line. The pulse to pulse repeatability is mainly depends on the stability of power supply which is cooled by constant temperature water. The fall-time and rise-time seems somewhat slow (1.3μs and 1.9μs) that decrease the flat-top duration but can reduce the electromagnetic noise.

CONCLUSIONS

This modulator has just been tested. Further testing with full power will soon be performed. The modulator will be used for the SDUV-FEL linac.



(a) Transformer output voltage waveform (309kV)



(b) Expanded view of pulse top

Figure 5: Output waveform

ACKNOWLEDGEMENT

We would like to thank Prof. H. Baba and Prof. H. Matsumoto for their effective advices and assistance in the collaboration between KEK and SSRF. We would like to thank Prof. P. Pearce, Prof. S. H. Nam and Prof. Y.L.Chi for their useful discussions and encouragement .

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