ELECTRON GUN FOR SSRF

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Abstract

A 100kV triode-electron-gun has been designed and manufactured for the Linac of Shanghai Synchrotron Radiation Facility (SSRF). This gun is able to generate two different electron beams, the 1ns (FWHM), 2A (peak) single bunch and the 300nsec (macro-pulse width), 300mA(average) multi-bunch train modulated by 500MHz, to meet the requirement of two operating modes of SSRF, single-bunch mode and multi-bunch mode. In this paper the performance of the gun and some key components are described.

1 INTRODUCTION

A 300MeV Linac is designed for the injector of the booster of Shanghai Synchrotron Radiation Facility (SSRF) and the proposed DUV FEL facility. In the first phase, a thermo-electronic triode electron gun, which has been designed and manufactured during the R&D of SSRF, a pre-buncher and a buncher are used to be the injector of the Linac. At this time, the whole electron gun system will be described in the following text, with the design, fabrication, assembling and the measurement of electron beam.

2 ELECTRON GUN

This gun is a conventional triode electron gun, which is a classic Pierce gridded gun with a thermo-electronic cathode. The gun structure is designed to fit the cathode grid assembly Y646B manufactured by EIMAC, which has a circular cathode area of 0.5cm^2 equivalent to 10mm in diameter and a grid cathode spacing of 0.15mm. The gun structure is shown in fig. 1. At this time, we use the cathode grid assembly YH01, which has a circular cathode area of 0.75cm^2 equivalent to 10mm in diameter and a grid cathode spacing of 0.15mm.

The main different between the two cathode grid assemblies is that the former one has a dispenser cathode, while the latter one has an oxide cathode. In our case, though the peak current is high, the repetition is low, so the oxide cathode is a good choice. After activation, keeping the filament voltage and current at the nominal values 6.3V and 1.5A, the peak pulsed current can reach to 4A. Because we only need 1.2A to 2A, this cathode is sufficient.

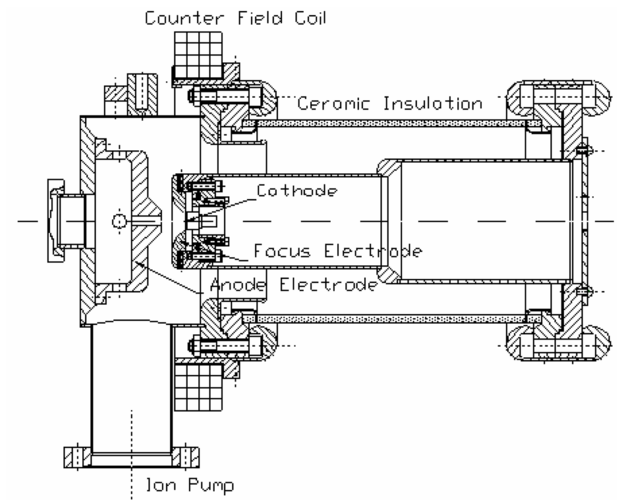

Fig.1: Structure of gun assembly

The gun cathode and anode shape, the gap between the cathode and anode and the gun focus was designed using the code EGUN [1]. The optimum of gun geometry was determined to obtain small emittance for 100kV and 2A. The normalized emittance is equal to 4mm mrad for 100kV and 2A. The gap between the cathode and anode is 28mm and the anode hole is 8.8mm in diameter. The waist of the beam is 2.5mm in diameter. Fig. 2 shows the calculated beam trajectories.

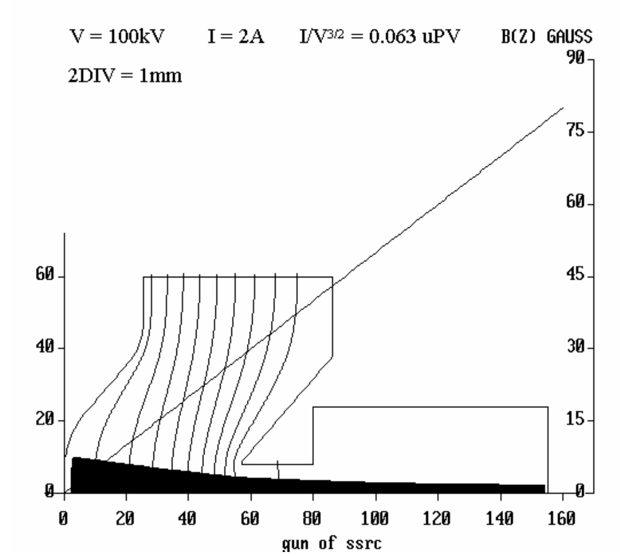

Fig.2: Computed electron beam trajectories

The ceramic isolator is made of 99 ceramics. Two Ti flanges are brazed onto both side of the ceramic isolator. After mechanical processing, the alignment error of two flange centers is less than or equal to 10 μ m. Two anti-corona rings are assembled onto the flanges to withstand up to 100kVDC at least.

A 50 l/s ion pump directly under the cathode anode space pumps the high voltage region of the gun. A vacuum gauge monitors the pressure at the entrance of the ion pump. The pressure is about 3×10^{-8} Torr while the gun is running. AT the exit of the gun, a gate valve manufactured by VAT is used to separate the vacuum of gun from the vacuum of the downstream parts.

Before assembling, all the parts under vacuum have been cleaned by ultrasonic cleaning equipment. After assembling, the whole gun has been baked at 150℃ for more than 16 hours. During process of cathode activation, the vacuum pressure was kept under 10^{-5} Torr.

The high voltage conditioning was performed up to 110kVDC with a grid cathode negative bias of 70V to protect the cathode from damage.

A counter field coil is assembled in the cathode plane to cancel the background magnetic field of the Linac. The magnetic field inside the gun is zero at the cathode surface and increase with a gradient of 1kG/m.

3 PUSLER SYSTEM

The triode gun is driven by the grid pulse. To meet the requirement of two operating modes, two different pulser systems are used to generate the grid pulses. The block diagram of the pusler system is shown in Fig 3.

In single bunch operating mode, a single bunch with a current of 2A and a pulse width of 1ns (FWHM) must be generated by the gun. Considering the attenuation and distortion in the transmission and connection, a single pulse with a voltage of 300V on a 50Ω load and a pulse width of 1ns (FWHM) is needed. An array of avalanche transistors with a very fast ECL trigger is used to generate a single pulse with a negative voltage of 300V on a 50Ω load. The falling time of the single pulse is about 600ps, the rising time is about 800ps and the pulse width is less than 1ns (FWHM).

In multi-bunch operating mode, a bunch trains with an average current of 300mA and a macro-pulse length of 300ns (FWHM) must be generated by the gun. As discussed above, a 300ns macro-pulse modulated by 500MHz with a peak power of 500W is needed. A 500MHz CW signal from the local oscillator is modulated with a trigged square wave signal by the PIN diode. Then, two broadband solid-state amplifiers are used to amplify the signal up to 500W. The rising time of the macro-pulse is about 50ns, while the falling time is about 30ns. The pulse width can be adjusted from 100ns to 1000ns.

A special coaxial transmission line is used to supply the grid pulse, filament power and grid bias to the cathode grid assembly. A TEK TDS784A oscilloscope with 1GHz bandwidth is used to measure the power attenuation through the transmission line. In case of single pulse the attenuation is –2dB, while in case of multi-pulse the attenuation is –3.7dB.

Two operating modes can be switched from one to the other by switching the output coaxial RF switch. Another two more switches will begin to work when the gun is triggered by the synchronous signal from the main control system.

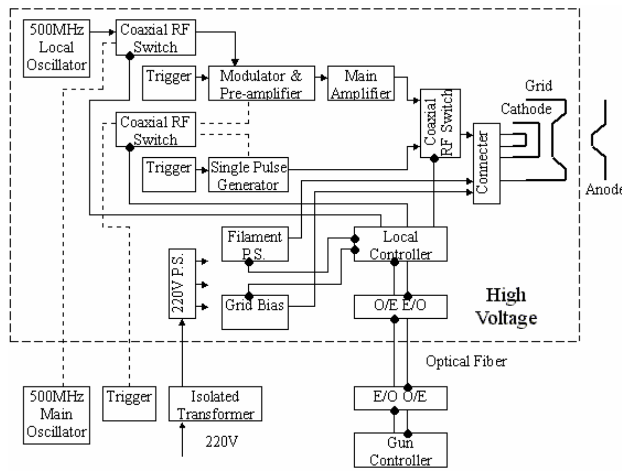

Fig. 3: Block diagram of the pulser system

4 CONTROL SYSTEM

A remote control system running on a PC is connected to a local control system in the high voltage deck via an optical fiber. Switching of the operating mode and adjusting of the filament power and the grid bias can be operating from the control room easily.

5 BEAM DIAGNOSTIC SYSTEM

A beam diagnostic system is designed to measure the beam parameter. A coaxial faraday cup with a response of nanosecond is used to get the longitudinal structure of the beam. A profiler is used to observe the beam profile and together with a quadrupole magnet the transverse emittance can be measured.

6 PERFORMANCE OF ELECTRON GUN

The beam signal is picked up by the coaxial faraday cup and measured by an oscilloscope through a set of attenuators. A TEK TDS694C oscilloscope with a bandwidth of 3GHz and a rising time of 200ps is used. The total power attenuation between the faraday cup and the oscilloscope is 50.5dB.

The peak current of the single bunch is 2.0A and the bunch length is 1.2ns. The single bunch signal is shown in Fig. 4. The small overcharge on the right side of the main pulse is related to the distributed inductance.

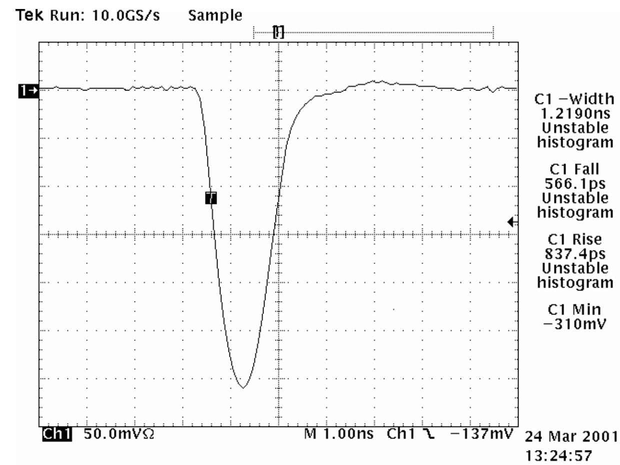

Fig. 4: Single bunch (1.2ns, 2A)

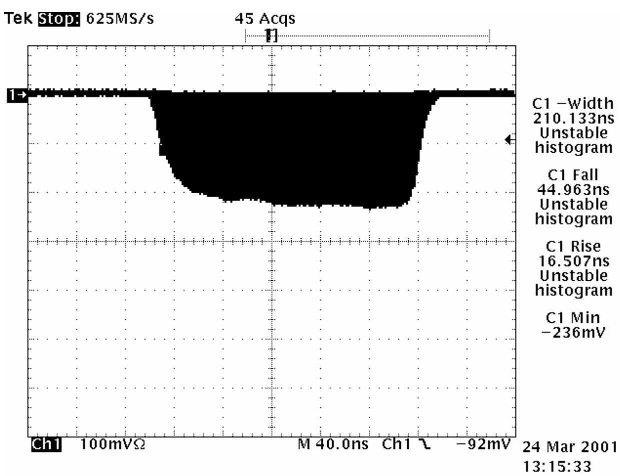

Fig.5: Envelope of the multi-bunch (200ns, 0.375A)

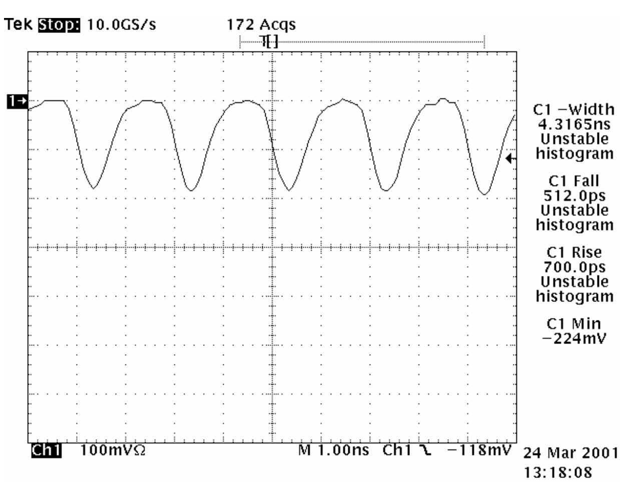

Fig. 6: Micro bunches in multi-bunch (0.65ns, 1.5A)

The full multi-bunch signal recorded by the oscilloscope is shown in Fig. 5. The fall time is less than 50ns, the fall time is less than 20ns and the flat top fluctuation is less than 10%. The detail of the multi-bunch is shown in Fig. 6. The peak current is 375mA, the micro bunch length is 0.65ns and the repetition frequency of the micro bunch is 500MHz.

7 CONCLUSION

This electron gun can meet the request of SSRF basically. Further experiments and studies will be done on this electron gun to find the best operating parameters for SSRF operating.

8 ACKNOWLEDGEMENTS

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9 REFERENCE

[1] W. B. HERRMANNSFELDT, “Electron Trajectory Program” SLAC report 226, November 1979.