Single Bunched Beam Generation using Conventional Electron Gun for JLC Injector

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Abstract

For the electron source of JLC(Japan linear collider), high-current, low-emittance and multi-bunch beam is required. In order to generate the beam, we are developing a conventional gun with a fast grid pulser and sub-harmonic buncher(SHB) system. We have tried to generate a high current beam with fast rise and fall time. At the present, we can generate short pulse beam, peak current over 5A, full pulse width less than 2ns. An amorphous core CT is used for monitoring the beam. The beam will be able to ride on single bucket phase of SHB. And 14ns flat-top beam will be generated for 10 bunches mode.

I. INTRODUCTION

High-current, low-emittance and multi-bunch beam is required for JLC. The parameters of the beam are summarized in Table 1 and the beam structure of the bunch is shown in Fig.1.[1)] In order to realize these parameters, we are trying the development of two apparatus. The one is RF gun using laser triggered photo-chathode and the other is thermionic gun and SHB system. The development of the RF gun is very difficult and the R&D study more than several years is required. This paper describes the performance of the second apparatus. The hardware scheme and each waveform are shown in Fig.2. In this scheme, the thermionic gun emits high current 14ns width beam with fast rise and fall time. The beam is cut and compressed by 714MHz SHB. Thus 10 bunched beam with 1.4ns interval are generated at downstream of SHB. The thermionic gun is required to have 1)fast rise and fall time (less than 700ps), 2)14ns pulse width, 3)high-current(over 4A). At the ATF (Accelerator Test Facility), high-current and low emittance thermionic gun using EIMAC Y-796 cathode-grid assembly had been constructed.[2)] For generating the beam which has fast rise and fall time, we installed a fast grid pulser to the ATF thermionic gun. The beam was monitored by using amorphous core CT which has fast pulse response.

Table 1 Beam parameters of JLC

Number of particles per bunch	1.0×10^{10}
Number of bunches per rf pulse	10
Repetition rate of rf pulse	200
Bunch spacing	1.4 ns
Flatness	< +/- 2 %

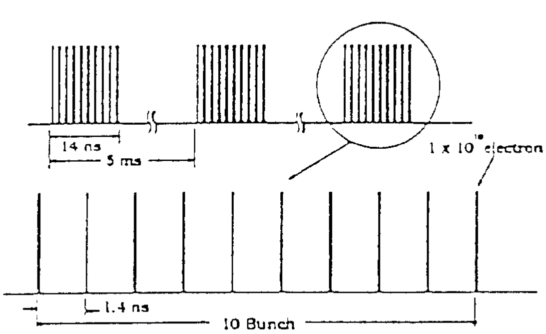

Figure 1. Beam structure of JLC

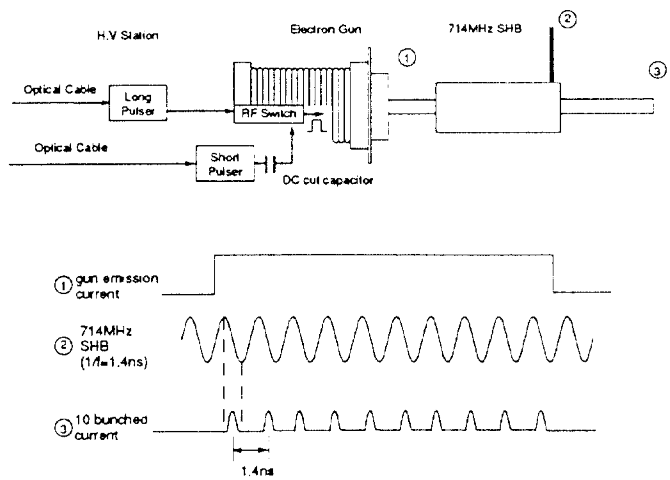

Fig. 2 Hardware scheme for 10 bunches beam
The thermionic gun emits ①high current 14ns width beam with fast rise and fall time. ②The beam is cut and compressed by 714MHz SHB. Thus ③10 bunches beam with 1.4ns interval is generated at downstream of SHB.

II. FIRST GRID PULSER AND AMORPHOUS CORE CT

The fast grid pulser is provided by Kentech Instruments Ltd.,. The rise and fall time of the pulse are less than 200ps. We ordered it for our specification. The pulser is operated at the following three modes: (1)200ps width for test and calibration, (2)1ns width for a single bunched beam and (3)14ns width for 10 bunches. The amplitude is over 500V. The output impedance is 50Ω.

For monitoring the fast beam, an amorphous core CT is tested. Amorphous core which has high μ characteristics is good material as CT. The amorphous core CT can reduce winding coil and consequently can respond more fast pulse beam.[3)] In order to improve the characteristics for more fast beam response, we measured the response of the amorphous core CT to which the grid pulser output has been fed using tapered pipe and inner conductor. The winding of the CT is arranged for matching the fast pulse. Consequently, 1 turn pick-up coil is used. The output of grid pulser and the response of the amorphous core CT is shown in Fig. 3.

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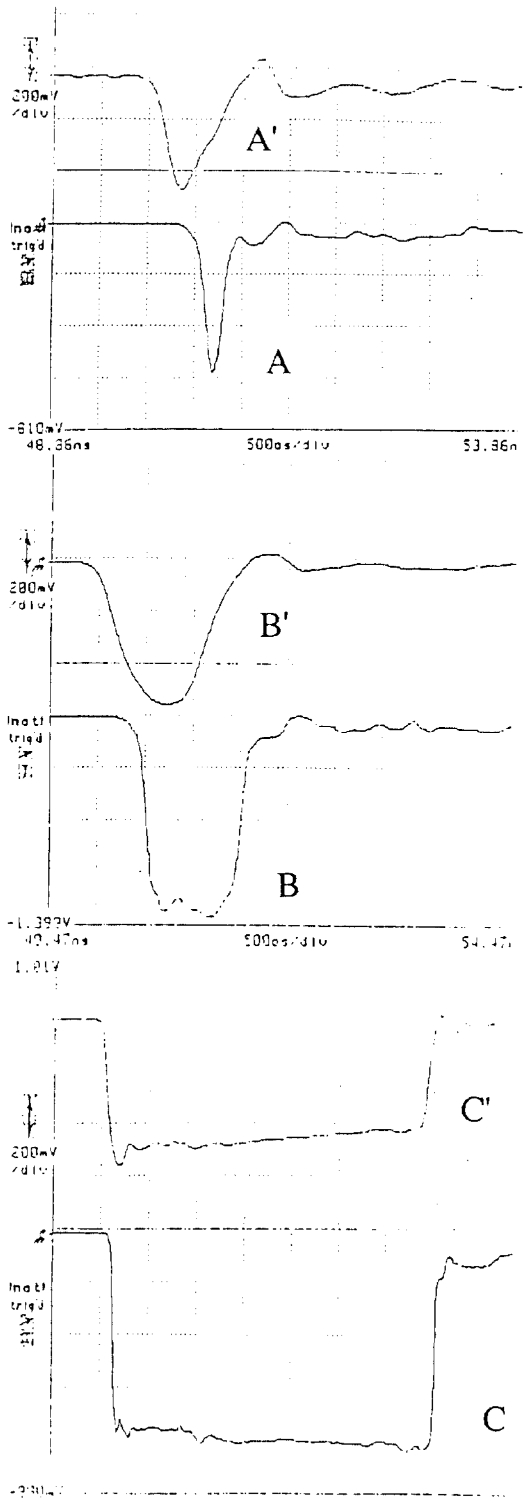

Fig. 3 The output of grid pulser and the response of amorphous core CT
Grid pulser has three pulse width mode-- A:200ps width, B:1ns width, C:14ns width. Amorphous core CT responds 200ps width(A'), but not sufficient. At 1ns width, the CT responds sufficiently. It has about 500ps rise time(B'). At 14ns width, we can see the droop (about 20%). It's caused by 1 turn pick-up coil(C').

III. CATHODE RESPONSE

The EIMAC Y-796 cathode-grid assembly is suitable for high current beam emission[4] but not adequate for fast pulse response to sub-nanosecond rise and fall time. It has large capacitor about 27pF. Using the parameter, the cathode response simulated by SPICE is shown in Fig.4. The rise time of the output signal is over 500 ps. This simulation involves quiescent parameter only, and ignores variation of impedance, space charge effect, etc.. They enlarge the rise time.

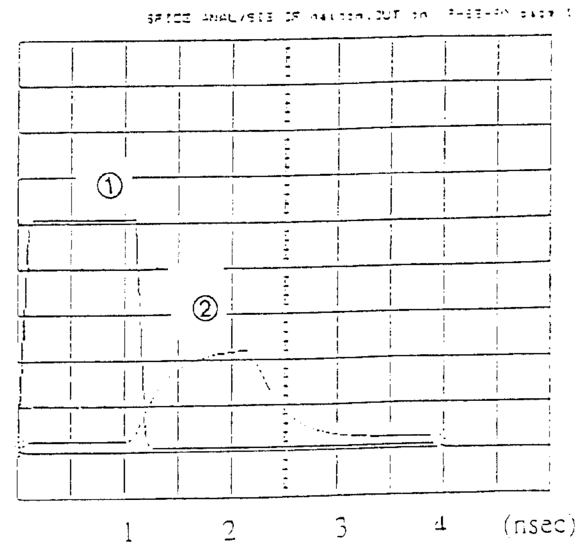

Fig. 4 SPICE analysis of pulse response of Y-796
At 1ns pulse input with 200ps rise and fall time, Y-796 responds over 500ps. In the figure, ① is input signal and ② is output signal.

IV. CHARACTERISTICS OF THE BEAM EMISSION

The waveform of the emission current at 1 ns pulse width is shown in Fig. 5. The gun parameters are follows: anode voltage 150kV, heater voltage 6.0V and grid net drive voltage 360V. And the pressure level of the gun is kept in the range of 10^{-8} Torr. The peak current is about 5.8 A. The full width of the pulse is less than 2 ns. The value of pulse width involves the response of the amorphous core CT(~500 ps). The pulse width of the beam is calculated from

$$Tr = \sqrt{Tm^2 + Tb^2}$$

,where Tr: rise time of observation, Tm: rise time of monitor, Tb: rise time of beam. When Tr=1 ns and Tm=~500 ps, Tb is estimated to be ~800 ps. The value agreed with SPICE simulation. The emission characteristics versus heater voltage, grid net drive voltage and anode voltage are shown in Fig. 7,8,9. We expect that these characteristics will be improved by processing the cathode and operating in lower pressure environment.

The waveform of emission current at 14 ns pulse width is also shown in Fig.6. The gun parameters are same as 1 ns pulse width. The peak current is over 8A. The decay of the waveform is caused by droop of the amorphous core CT. The flat-topped bunched beam with the width of 14ns is expected from the waveform of the beam current.

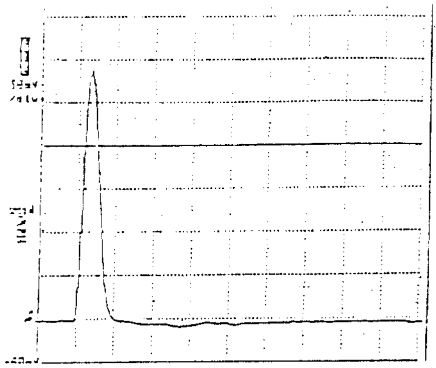

Fig. 5 The emission current at 1 ns pulse width
The gun parameters are as follows: anode voltage 150kV, heater voltage 6.0V and grid net drive voltage 360V. (V: 1A/div., H: 2ns/div.)

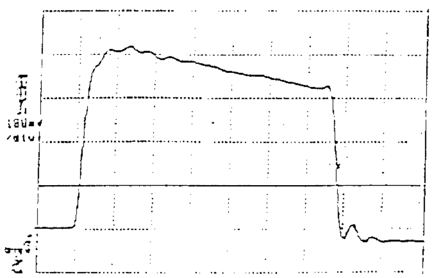

Fig. 6 The emission current at 14 ns pulse width
The gun parameters are same as 1ns pulse width. (V: 2A/div., H: 2ns/div.)

V. SUMMARY

We have generated the high current beam emission with the fast rise and fall time using fast grid pulser (provided by Kentech Instruments Ltd.). The fast beam is measured using the amorphous core CT. And also the pulse response of Y-796 cathode-grid assembly is measured. The response is determined by capacitance among the grid-cathode distance, mainly. The emission current at 14 ns pulse width will be able to use as beam of 10 bunched beam injector with 4th SHB of 2856MHz.

VI. ACKNOWLEDGEMENTS

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VII. REFERENCES

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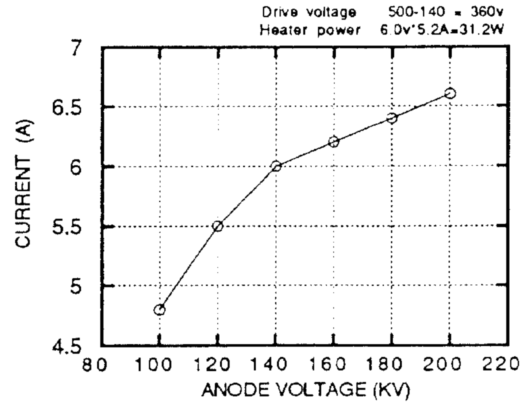

Fig.7 Emission current characteristics versus anode voltage

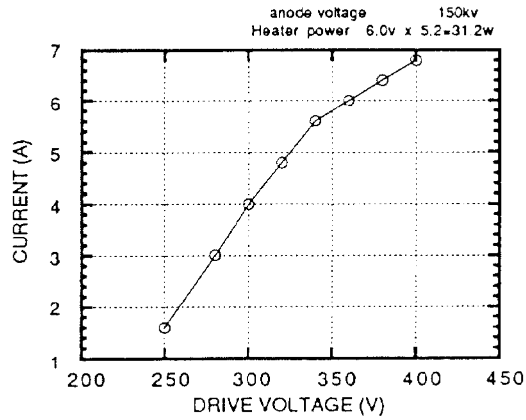

Fig.8 Emission current characteristics versus drive voltage

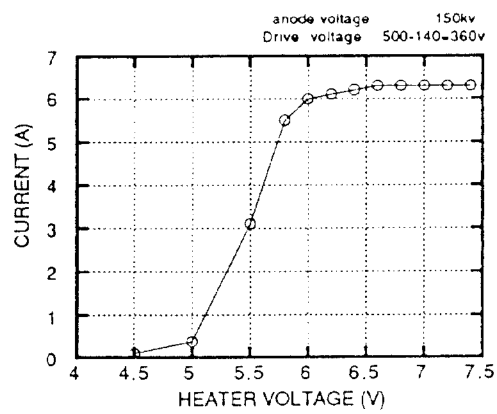

Fig.9 Emission current characteristics versus heater voltage