PA05

Pulse Response of Y-796 Electron Gun and Space Charge Effects

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Abstract

For the purpose of the estimation of the characteristics of low energy short pulse in an injector, the peak currents and the pulse duration were measured by co-axial beam catcher at the distance of 25mm, 225mm and 475mm from the anode plane of Y-796 electron gun. The 200 ps duration pulse with the peak current of 13A and the energy of 90 keV lengthened until 390 ps time duration at the 225 mm measurement point. The computer simulation almost agreed with experiment a results.

1. Introduction

The X-band linear accelerator, which can generate a ultra short single pulse in the femtosecond domain, is under design at Nuclear Engineering Research Laboratory, the University of Tokyo[1]. We planed the construction of the X-band linac, which consists of thermionic gun, a subharmonic buncher (SHB), two accelerating tubes and achromatic magnetic pulse compression system[2]. In order to generate a single pulse in X-band linac whose electron source is a thermionic gun, a shorter emission is required, because an electron beam from the electron gun must be compressed within one period of the X-band RF (87.5 ps), which is 1/4 period of S-band RF (350 ps). In order to determine a frequency of SHB, it is important to evaluate pulse response of a thermionic electron gun and space charge effects of high current short pulse in low energy region. In this paper, the pulse response of a thermionic electron gun and lengthening of its emission in the drift space are discussed.

2. Experimental

A test bench for measurement of waveform of an emission from a thermionic electron gun was constructed as shown in Fig. 1. It consists of an thermionic electron gun and a d-c biased grid-cathode pulse generator placed on a -90 kV high potential deck, focusing system and so on. Y-796 electron gun (EIMAC) was used as a thermionic electron gun. The accelerating potential of the electron gun is provided by 90 kV pulses of 8 μs duration. The duration of flat top

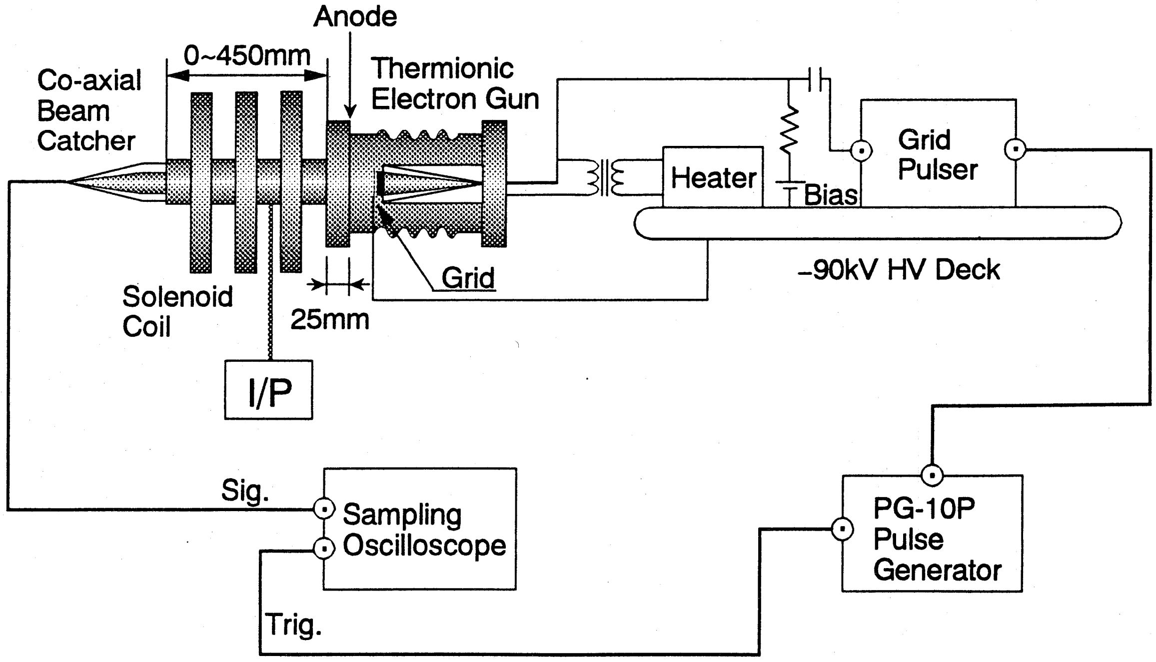

Fig. 1. Test bench for an thermionic electron gun.

is 4 μs. The beam sizes in the transverse direction was controlled by solenoid coils. We used two kinds of grid pulsers (Pulser I and Pulser II). Pulser I have presently been used for normal operation of the UTNL linac. Pulser II was purchased from Kentech Corporation. Peak output voltages of each pulser are 300 V (Pulser I) and 1.7 kV (Pulser II), respectively. Their rise times are 1.2 ns and 100 ps, respectively. Their pulse width (FWHM) are 1.6 ns and 130 ps, respectively.

The waveform and total charge of emission from the electron gun were measured by using co-axial beam catcher. The diameter of the beam catcher is ϕ14 mm. The signals passing through semirigid cable were measured by sampling oscilloscope (S-4, Tectronix) and DC microvolt ammeter (PM-18R, TOA Electronics Ltd.). The time resolution of the co-axial beam catcher is less than 50 ps. Measurement of the emission was carried out at the distance of 25 mm, 225 mm and 475 mm from the anode.

3. Results and Discussion

3-1. Pulse response of Y-796 electron gun

Typical output waveforms of Pulser I and of the emission measured at the distance of 25 mm are shown in Fig. 2. Figure 3 shows the relation between grid bias and emission current. The peak current was 800 mA. On the other hand, typical output waveforms of Pulser II and of the emission at the distance of 25 mm are shown in Fig. 4. Figure 5 shows the relation between grid bias and emission current. The peak current was 8 A. If enough voltage is applied, Y-796 respond to the trigger with the pulse length less than 1 ns.

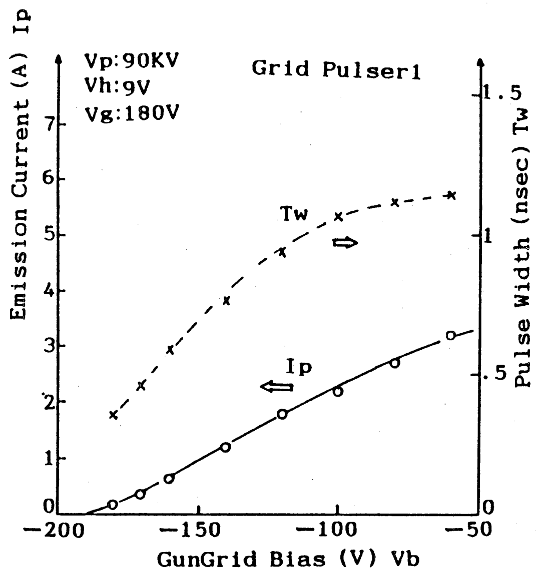

Fig. 3. Relation between grid bias and emission current (Pulser I).

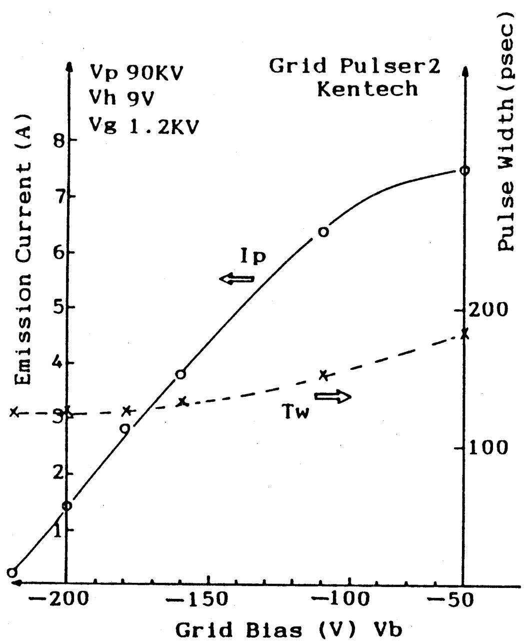

Fig. 5. Relation between grid bias and emission current (Pulser II)

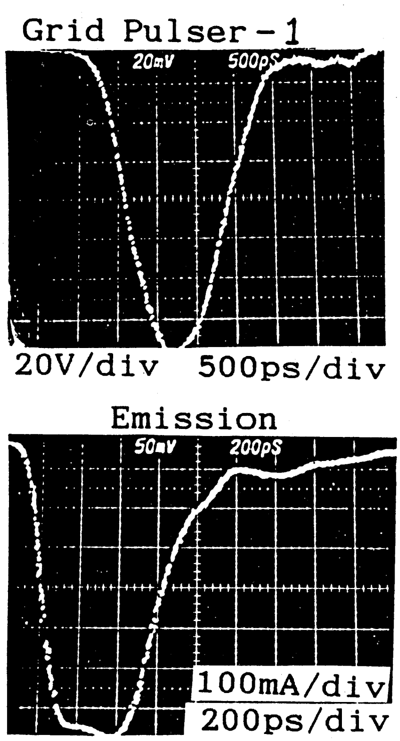

Fig. 2. Typical output waveforms of Pulser I and of the emission measured at the distance of 25 mm.

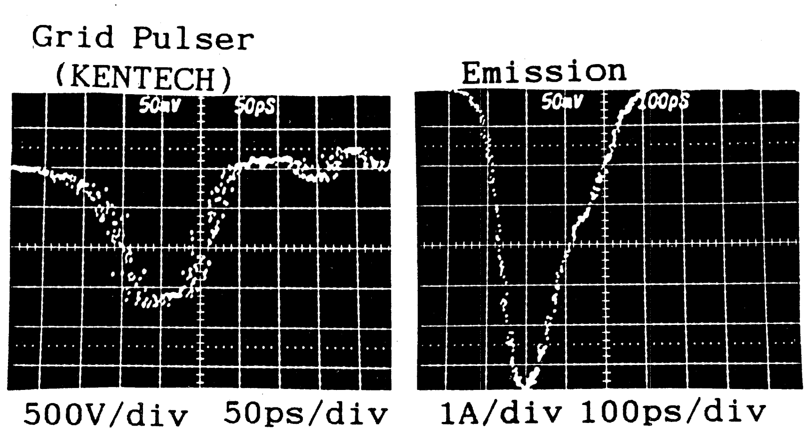

Fig. 4. Typical output waveforms of Pulser II and of the emission at the distance of 25 mm.

3-2. Space charge effects

Lengthening process of the emission from the electron gun were measured in the drift space as shown in Fig. 6. It is found that the pulse was lengthened by the space charge effects. Lengthening by the space charge effects are calculated based on the disk model[3]. The results are shown in Fig. 7. The pulse widths almost agree with the experimental results. However, peak current does not. This is because beam loss is ignored in this simulation. Figure. 8 shows dependence of bunch lengthening on accelerating voltage. It is found that the bunch lengthening of 200 keV beam by the space charge effects is little at the distance of 225 mm from the anode. This distance is enough long to locate subharmonic buncher.

4. Conclusion

From the experimental results, it is found that Y-796 have pulse response was less than 1 ns. The longitudinal lengthening of low energy short pulse was evaluated.

Reference

[1] M. Uesaka, T.Kozawa et al., proc. 20th linear accelerator meeting in Japan, 1995, p. 121.
[2] A. Takeshita, T.Kozawa et al., proc. 20th linear accelerator meeting in Japan, 1995, p. 145.
[3] G. Mavrogenes et al., IEEE Trans. Nucl. Sci. NS-20, 1973, p.919

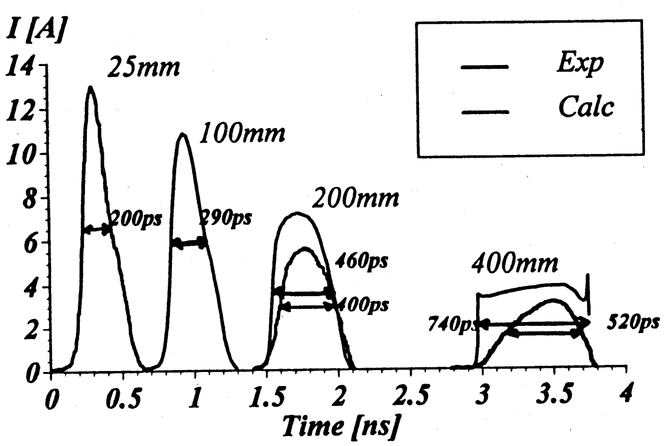

Fig. 7. Bunch lengthening calculated based on the disk model.

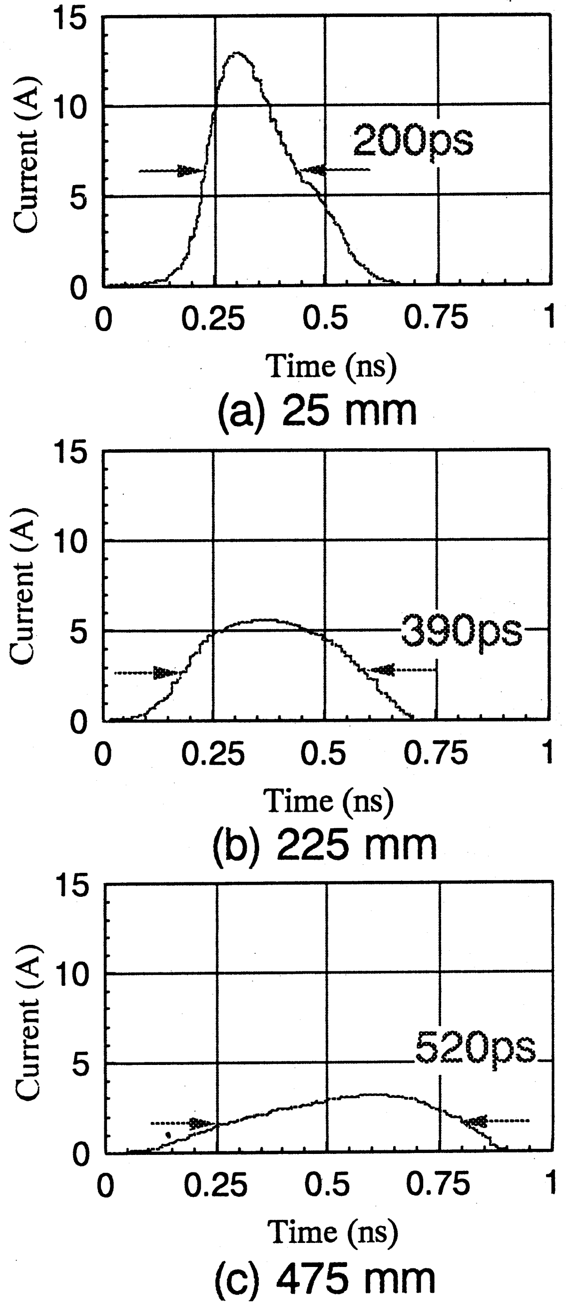

Fig. 6. Pulse shapes of 90 keV electron beam measured at the distance of 25 mm, 225 mm and 475 mm form the anode.

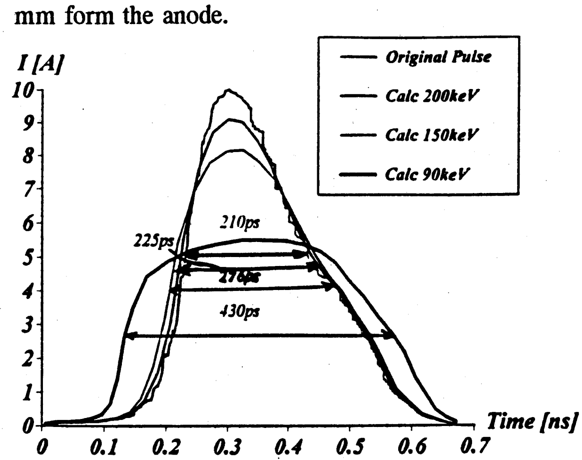

Fig. 8. Dependence of bunch lengthening on accelerating voltage.