MULTI-BUNCH BEAM WITH THERMIONIC GUN FOR ATF

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Abstract

A thermionic gun of Accelerator Test Facility(ATF) which is required to generate high current (2×10^{10} electrons/bunch) and multi-bunch beam (20 bunches with 2.8 ns spacing). The gun uses triode cathode(EIMAC Y-646E) and operates up to 240 kV. In order to obtain the bunch structure, we have been developed a new grid pulser system. The pulser system consists of a low level pulse train generator, a pair of optical signal transmitter/receiver system and a high power RF amplifier. In this paper, the pulser system and the operating characteristics of the electron gun are described.

Introduction

The Accelerator Test Facility(ATF) consists of a 1.5 GeV Linac and a Damping ring. The ATF is under construction for development of accelerator components to realize future Japan Linear Collider(JLC)[1]. The main purpose of this facility is to accelerate multi-bunch beam and to make a low emittance beam. An 80 MeV injector linac of the ATF consists of a thermionic gun, two SHBs(357MHz), two pre-bunchers, seven cells of buncher following to a 3m long S-band(2856MHz) accelerating structure(fig.1). The pre-bunchers and buncher will be changed to four single cells of low R/Q bunchers to reduce the beam loading effect. The beam acceleration test is in progress[2].

The thermionic gun need to generate the beam of 20 bunches of 2×10^{10} electrons with 2.8ns spacing. The thermionic gun uses a triode cathode(EIMAC Y-646E) which has $1cm^2$ cathode area and operates up to 240 kV of pulsed high voltage. The development of a grid pulser system is key issue of the gun. We already generated single bunch and double bunches beam using avalanche pulsers[3,4]. The other type of grid pulser system is required to generate the 20 or more bunches of beam. The new grid pulser for multi-bunch beam consists of a fast ECL circuit, a pair of optical signal transmitter/receiver system and an RF power amplifier. This paper describes the new grid pulser system, the emission characteristics and the beam test of a deflector for shaping of the multi-bunch shape.

Grid Pulser System

Pulse Train Generator

The grid pulser system is shown in fig.2. A 357MHz RF signal which is synchronized with the frequency of the accelerating structure is used as a clock signal to the ECL circuit. The circuit is started by the system trigger signal(25Hz). The system trigger also hits other components of the linac through synchronizing and delay circuits[5]. The required number of pulses are formed by counting and gating the clock in the circuit. The number of pulses can be set from a computer. A fast operational amplifier convert and amplify the pulses of ECL level to RF signal. The output signal is shown in fig.3.a.

Optical signal transmitter/receiver

To transmit the pulse train signal into high voltage potential, we used the optical signal transmitter(E/O) /receiver(O/E) system(ORTEL 3510A/4511A). The same

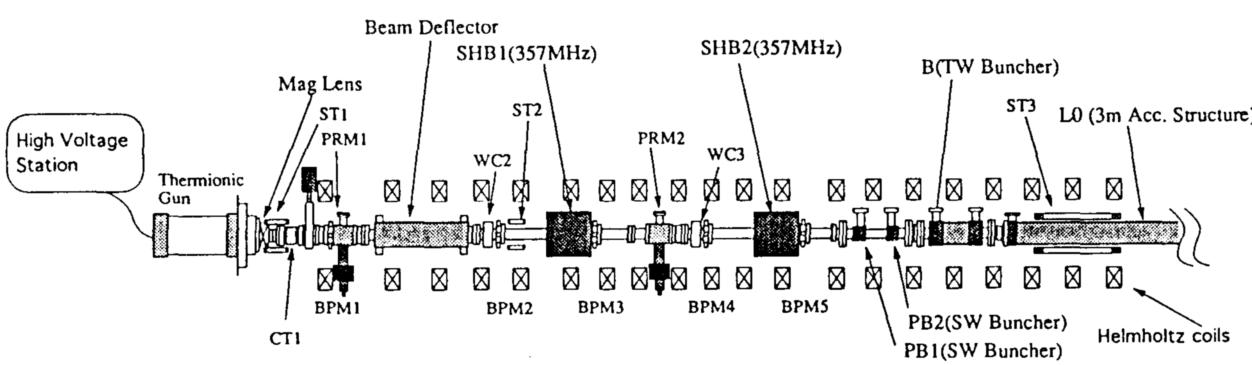

Figure 1. Schematic drawing of ATF injector linac.

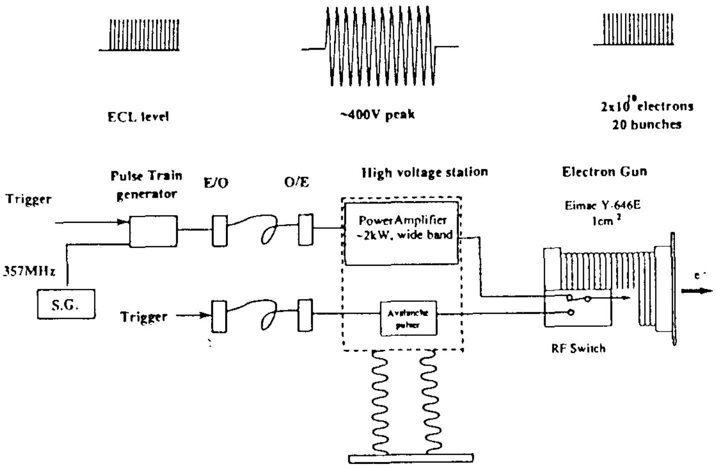

Figure 2. Block diagram of grid pulser system.

system is used for the reference signal transmission to klystrons. The parameters of this system are summarized in table 1. This system can transmit the pulse train without any serious distortion. The time jitter of the input to the output is less than 50 ps.

Table 1
parameters of E/O,O/E system

Optical wavelength	1310+/-30nm
3510A(E/O)	
Band width	.01 - 3GHz
Input power(max.)	100mW
S/N	105dB
4511A(O/E)	
Band width	.01 - 2GHz
Output power(1dBcompression)	14dBm
NF	<5dB

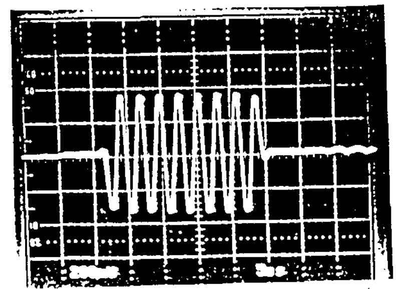

Figure 3.a Output of pulse train generator.

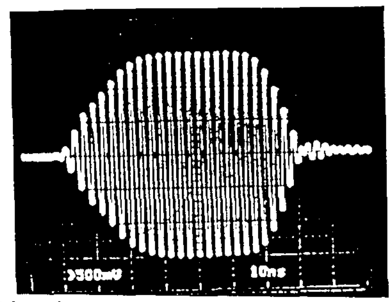

Figure 3.b Output of RF power amplifier.

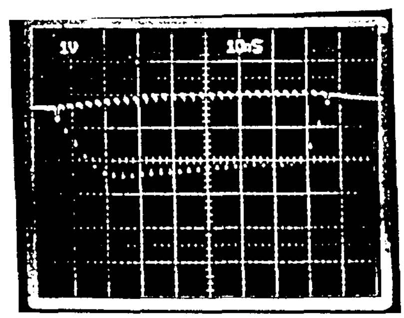

Figure 3.c Emission current monitored by C.T. just down stream of the thermionic gun.

RF power Amplifier

This amplifier has been developed for the grid pulser by NEC Co.,. Since the amplifier is used on high voltage potential, the size, weight, and plug power is limited. From this reason, the peak power and the band width are sacrificed. In order to reduce the power consumption, we chose the class AB type of amplifier. The wave form of output is shown in fig. 3.b. The slow rise/fall time of the envelope is caused by the narrow band width.

Table 2
parameters of RF power amplifier

Output power	2 kW
Frequency	357 MHz
Band width	50 MHz
Power gain	45 dB
Class of operation	AB
rise/fall time	30/20 ns
Flatness of flattop	2 %

Beam emission characteristics

The beam emission of the gun driven by this grid pulser was measured by current transformer(C.T.) located just down stream of the gun. The C.T. using a amorphous core has ~1ns pulse response. At the early stage of the experiment, the intensity of the emission current had distortion caused by reflection from the DC bias circuit and the miss-matched grid impedance. The reflection from the DC bias circuit was cured by inserting a large inductance. The reflection from the miss-matched grid impedance was cured by using a 10 m long cable. The cable used as a delay line so that the reflection return after drive signal come through. After these improvement, we could get the emission current in proportion to the wave shape of the grid pulser. The emission current is shown in fig.3.c. The peak current is 3.8A(2.1x 10^{10} electrons/bunch) and flatness of each bunch except for rise/fall several pulses is about 2% peak to peak.

Beam deflector test

To get the mult-bunch which have the same population of square burst, we tested the beam deflector.

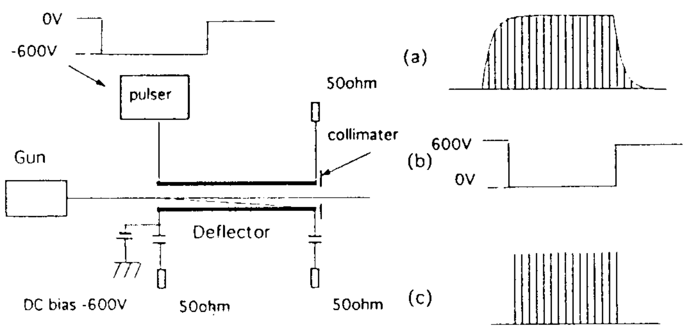

Figure 4. Schematic drawing of beam deflector system.

The block diagram of the beam deflector system is shown in fig.4. The gun emits much larger number of bunches of beam than required number of bunches(fig.5.a). The two electrodes are set at downstream of the gun and a collimator is installed at the end point of electrodes. The one electrode is applied a DC voltage and the other electrode is applied a rectangular pulse which have the same amplitude and the same polarity of the DC voltage(fig.5.b). When the beam goes through both electrodes, the beam feels a transverse electric field and kicked out to the collimator except for the time when the rectangular pulse goes through. At the downstream of the collimator, we will get the required number of bunches with flat beam envelope(fig.5.c).

The setup of the beam line is shown in fig1. The electrodes have the length of 600mm long, 30mm of gap width. The DC voltage is 600V and the rectangular pulse has 600V of the amplitude, 1.4ns of the rise/fall time and 4% of the flatness(this pulser is made by Kentech Instr. Ltd.,). The current of the input and output of the deflector were observed by the amorphous core CT(CT1) and a wall current monitor(WC2) at just downstream of the deflector. The wave shapes of the input current, the rectangular pulse and the output current are shown in fig.6. We confirmed that the system can work, however the transmission rate of the beam was only about 50%. The deflector could not kick out effectively because of solenoid field effect. We reduced the solenoid field ,however, the size of the beam blew up by the space charge effect.

Summary

We could generate multi-bunch beam. The intensity of each bunch has over 2 x 10^{10} electrons and the flatness of each bunch were about 2% peak to peak. The acceleration test carried out using this beam.

A beam deflector for shaping multi-bunch beam is also tested. The system worked in principle, however some improvement is required to get good transmission rate.

Acknowledgment

We would like to express our thanks to Professors Y.Kimura and K.Takata for their encouragement. We also thank other members of JLC R&D group and Mrs. T.Matsui and S.Morita of ATC Corporation for their support.

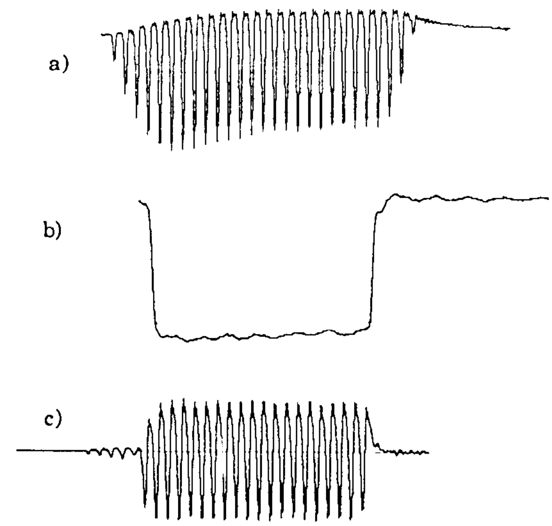

Figure 5. a)gun emitted beam. b)rectangular pulse fed to deflector. c)transmitted beam after the collimator.

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