THE DESIGN STUDY OF A FREE ELECTRON LASER BASED ON THE INJECTION LINAC OF THE TAIWAN LIGHT SOURCE

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Abstract

A preliminary design study for a free electron laser system based on the 50 Mev injection Linac of the Taiwan Light Source of Synchrotron Radiation Research Center at Taiwan was presented. A steady-state amplifier code (TDA3D) is used to simulate lasing conditions. The results shown that using the parameters of Linac and U-10P undulater of SRRC, if the Linac output peak current can reach 20A combined with some modification of the undulator, it is possible to lasing.

1. INTRODUCTION

In recent years, there has been an increasing interest in the generation of coherent radiation through the use of relativistic electron beams. The Free Electron Laser (FEL) is a device which amplifies radiation by stimulated emission, using a beam of relativistic electrons. There were more and more free electron lasers operating and proposed For example, there were 28 existing short wavelength FELs, and 25 proposed short wavelength FELs worldwide in 1996. [1]

The main goal of this paper was to study a preliminary design of a free electron laser system based on the 50 Mev injection Linac of the Taiwan Light Source (TLS) of Synchrotron Radiation Research Center (SRRC) at Taiwan. We reported numerical simulations results (using the TDA3D code [2]). The study including electron beam parameters of energy, energy spread, beam current, beam size, as well as the Linac and undulator parameters, and the laser gain.

2. LINAC

The preinjector system of SRRC consists of a 140kV gun, SLAC type, and a 50MeV Linac structure delivered by HRC [3]. Table 1 summarizes the specification for the Linac system.

3. BEAM TRANSPORT

Figure 1 shows the overall layout of the Linac and the 1.3 GeV electron booster at SRRC. In the left part of the figure, the line represents the beam transport line for the FEL system. At the end of the line, a rectangle means the location which we hope to host the FEL device. Of course, a series of bending and focusing magnets are needed. We will design magnets to transport the beam to the FEL undulators, with appropriate conditions to optimize the FEL performance, this was not included in this paper.

Table 1

General specifications for the Linac

Energy	50 MeV
Steady state operation (multibunch mode)	
Linac operational frequency	2997.9 MHz
Maximum pulse repetition frequency	10 Hz
Normalized geometric emittance	100 mm-mrad
Pulse length	1.5 s
Accelerated pulse current	24 mA
Peak current	≈ 5 A
Energy spread, less than	± 0.4 %
Stored energy operation (five bunch mode)	
Linac beam pulse	1.8 ns
Energy spread, less than	± 0.3 %

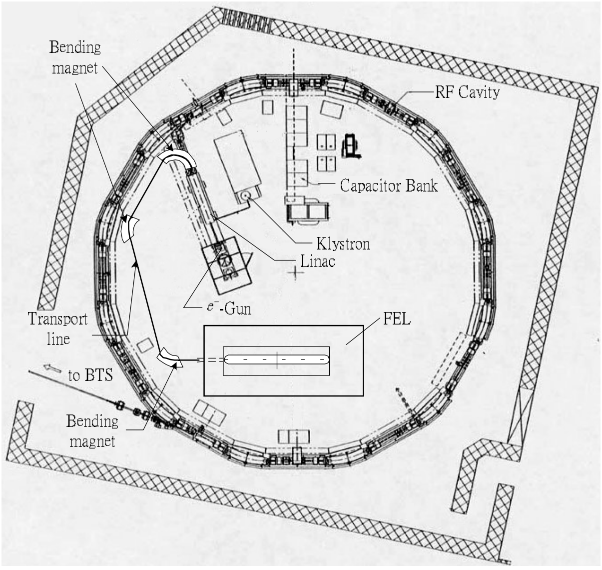

Fig. 1 Layout of the Linac, synchrotron booster and the FEL.

4. UNDULATORS

We will use the parameters based on the U-10P undulator in SRRC to simulate the performance of the free electron laser in this preliminary study. Table 2 lists the undulator parameters. The U-10P undulator was manufactured by SRRC in house for the study of new type of undulator sources.

However, for the results showing in the next section, we have modified the undulator length to be 1 m, the undulator period length to be 0.05 m, and the undulator peak field to be 0.5 Tesla as the input parameters of TDA3D.

Table 2
Main parameters of the U-10P undulators

Type	Planer
Undulator length	2 m
Undulator period length	0.1 m
Number of periods	20
Undulator peak field	1 T
Number of sections	1
K parameter	9.34
Minimum gap	22 mm

5. SIMULATION RESULTS

For this preliminary study, we have used the parameters (the charge distribution, emittance, batatron phase…etc) of the electron beams in the input of the undulator be the same as in the output of the Linac, and neglect the transport process.

Table 3 lists some of the simulation results by using TDA3D. In this preliminary study, we focused on the electron beam current of the Linac. The main input parameters are given in Table 1 and Table 2, except some modified parameters mention in the previous section.

6. CONCLUSIONS

From the simulation results, the accelerated peak current (5 A) of the Linac of the TLS is too small to lasing. We had ran several different λ, including 100 μm, 250 μm, 70 nm…etc, but the results is the same as Table 3. If we improve the system, it seems it is possible to lasing. About improve the free electron system, such as, for example, how to modified the undulator, how to increase the electron beam current. The detail methods need be further studied. The design of the electron transport line will be studied in the next stage.

Table 3 Simulation results by using TDA3D
λ = 10 μm (λ: radiation wavelength at which the simulation is to be performed)

e^- Beam peak current (A)	Beam Energy (GeV)	Laser Beam Power (TW)	Eff. Energy Spread	Gain
0.024	0.05	0.00	13.679	1.0005
0.1	0.05	0.00	5.283	1.0005
1	0.05	0.00	1.138	1.0005
10	0.05	0.00	0.245	1.0005
20	0.05	0.001	0.154	1.0004
30	0.05	0.001	0.118	1.0004
100	0.05	0.005	0.053	1.0004
200	0.05	0.01	0.033	1.0004

REFERENCE

[1] W.B. Colson, *Short wavelength free electron lasers in 1996*, Nucl. Instr. and Meth. A 393 (1997) 6.

[2] T.-M. Tran and J.S. Wurtele, *TDA - A Three-Dimensional Axisymmetric Code For Free-Electron-Laser (Fel) Simulation*, Computer Physics Comm. 54 (1989) 263.

[3] J. Modeer, project manager, Scanditronix AB, *1.3 GeV Electron Synchrotron*, report of the Pac 1993 conference.