OPTIMIZATION OF BUNCHER SECTION IN RFQ LINACS

S. Yamada

Institute for Nuclear Study, University of Tokyo,
Tanashi, Tokyo 188, Japan

Abstract

A design procedure of RFQ linacs has been developed. The length of the designed linacs can be shorter than those using the LASL prescription. The calculated transmission efficiencies of more than 90% are easily obtained.

1. Introduction

The beam dynamic design of RFQ linacs has been extensively studied by LASL group[1] especially for high intensity beam acceleration. According to the proposed design procedure[2], the overall linac is divided into four sections: radial matching, shaping, gentle bunching and accelerating sections. In the gentle buncher, the injected continuous beam is designed to have a bunch structure during several periods of longitudinal phase oscillations. Both of the longitudinal small oscillation frequency and the spatial length of the separatrix are held almost constant in this section.

2. Design Procedure of Buncher Section

According to the newly proposed design procedure, the gentle bunching section is divided into two sections: prebunching and bunching sections. Another section, booster, is introduced as a buffer between buncher and accelerator sections.

As far as the longitudinal motions are concerned, the fast beam compression can be realized without any reduction of capture efficiencies. The fast beam bunching, however, results large values of rf-defocusing force, and therefore, the bunching time is affected strongly by transverse beam motions.

In the prebuncher, the synchronous phase changes from almost -90° to -60° during about a half period of small angle longitudinal phase oscillations. The rf-defocusing parameter increases from almost zero to its maximum value maintaining a constant longitudinal acceptance. An increase of the longitudinal acceptance during the fast bunching process is important in forming good beam bunches especially under a strong influence of space-charge forces. However, it is found that a constant longitudinal acceptance gives faster beam bunching with sufficiently high transmission for low intensity RFQ linacs.

In the buncher, both of the rf-defocusing parameter and the longitudinal acceptance are kept constant. The spatial length of separatrix for the longitudinal motions is automatically kept constant. This section is essentially same as the gentle bunching section proposed by LASL.

The more detailed discussions are described in reference 3.

3. Design Example

A 200 MHz Ne(5+) RFQ linac is designed and shown in the table comparing with LASL results[4]. The basic parameters for this example are as follows:

Ion species ;	up to Ne^{5+} (q/A > 0.25)
Frequency ;	200 MHz
Maximum surface field ;	1.95 × (Kilpatrick's limit)
Normalized beam emittance ;	0.05 π cm.mrad
Input energy ;	12.5 keV/u
Output energy ;	1.0 MeV/u

It can be recognized that the length of accelerator is relatively shorter than the LASL design. The current limit, however, is slightly lower than LASL data.

Table
Ne^{5+} RFQ linac design parameters.

	LASL	INS
Focusing strength	3.43	3.60
Synchronous phase (deg)		
at the entrance	-90	-90
exit	-27	-30
Modulation parameter		
at the entrance	1.00	1.00
maximum	1.90	2.54
Radius parameter (cm)		
at the entrance	0.37	0.35
minimum	0.24	0.19
Transmission (%)		
for I = 0 emA	97	95
I = 10 emA	90	79
Vane length (m)	4.23	3.33

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References

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