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Design, construction and tuning of S-band coupler for institute for research in fundamental sciences electron linear accelerator (IPM E-linac)

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ABSTRACT

Design and construction of an electron linear accelerator by Institute for Research in Fundamental Science (IPM) is considered as Iran's first attempt to construct such an accelerator. In order to design a linear accelerating tube, after defining the accelerating tube and buncher geometries, RF input and output couplers must be designed. In this article, firstly, a brief report on the specifications of an S-band electron linear accelerator which is in progress in the school of particles and accelerators is presented and then, the design process and construction reports of the couplers required for this accelerator are described. Through performing necessary calculations and tuning the coupling factor and resonant frequency, couplers with desired specification have been fabricated by shrinking method. The final obtained coupling factor and resonant frequency have been respectively 1.05 and 2997 MHz for the first coupler, and 0.98 and 2996.9 MHz for the second one that are close to calculation results.

1. Introduction

Since the very first electron linear accelerator, there has been a significant progress in constructing various types of such accelerators. Nowadays electron linear accelerators are widely used in industries, cancer therapy, cargo inspection, food irradiation, and sterilization of medical equipment [1–3].

One of the most important applications of electron linear accelerators is using them as injectors for synchrotron radiation accelerators. In Iran, a national project has been started in Institute for Research in Fundamental Sciences to build a synchrotron light source facility [4]. Simultaneously, Iran's first attempt to construct electron linear accelerator is ongoing in IPM. A layout of this accelerator is given in Fig. 1. Main specifications of this accelerator are also given in Table 1 [5].

As it is illustrated on Fig. 1, this accelerator is a traveling wave type. Appropriate shunt impedance, easy cavity construction method, and simplicity of increasing the accelerating tube longitude for higher energy are the main reasons why this type of linear accelerator has been selected [6–7].

Fig. 2 shows the applied flowchart for the design of accelerator main parameters. As long as it is determined that all the components to be constructed in Iran, RF frequency and power have been defined based on the specification of the klystron built in Iran.

As it is shown on Fig. 2, the accelerator couplers should be designed followed by buncher and main accelerating tube design. Careful calculations and precise couplers construction and tuning are very important for buncher and tube specification measurement [8]. Each coupler consists of a single cavity. Cavities have been designed based on the geometrical dimensions of the first buncher cavity and the last accelerating tube cavity. The design procedure will be discussed in “coupler design” section.

Fig. 3 shows the final layout of IPM's Linac accelerating tube, and Figs. 4 and 5 show the buncher and one of the constructed accelerating tubes, respectively [9]. The cavities are assembled using shrinking method. This method is similar to the one used for MARK(III) accelerating tubes [10]. In this project, klystron specification is similar to KS37 model.

Fig. 3 shows the coupler used for transmission of RF wave from klystron to the buncher and main waveguide. On the design of couplers at frequency of 2997.9 MHz, it is should be notified that at the input coupler, there must be minimum wave reflection toward klystron and at the output coupler, there must be minimum wave reflection toward accelerating tube. Minimum wave reflection depends on the coupler shape and size. The coupler also converts the TE mode of rectangular waveguide to a TM mode of circular cavities such as buncher and accelerating tube [11]. Coupler design will be discussed in detail in Section 2.

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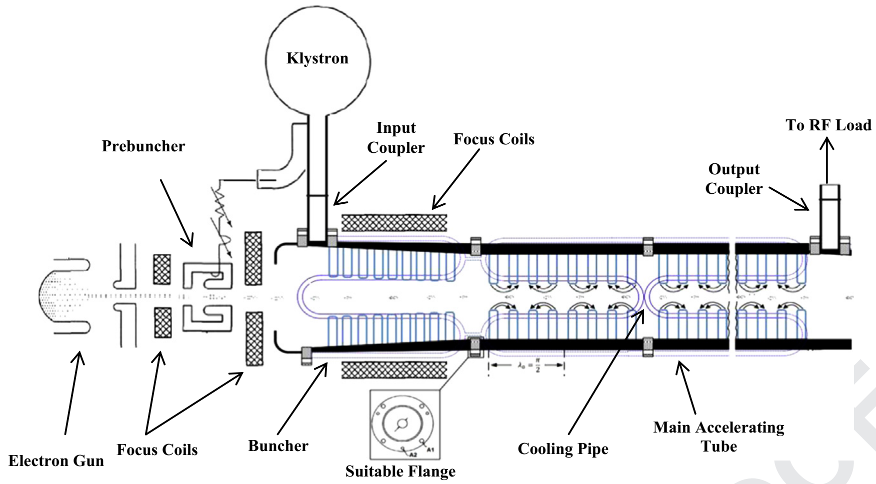

Fig. 1. The layout of IPM's electron linac.

Table 1
The main specification of IPM's electron linac.

Parameter	Unit	Value
Output E-Gun energy	keV	45
Output E-Gun current	mA	10
Frequency	MHz	2997.92
RF peak power	MW	2.5
PRF maximum	Hz	250
RF pulse length	sμ	4–10
Output buncher energy	MeV	2
Bunching factor	–	16
Buncher length	cm	30
Output energy	MeV	15
Operational mode	–	π/2-TWπ
Acceleration tube Length	cm	120

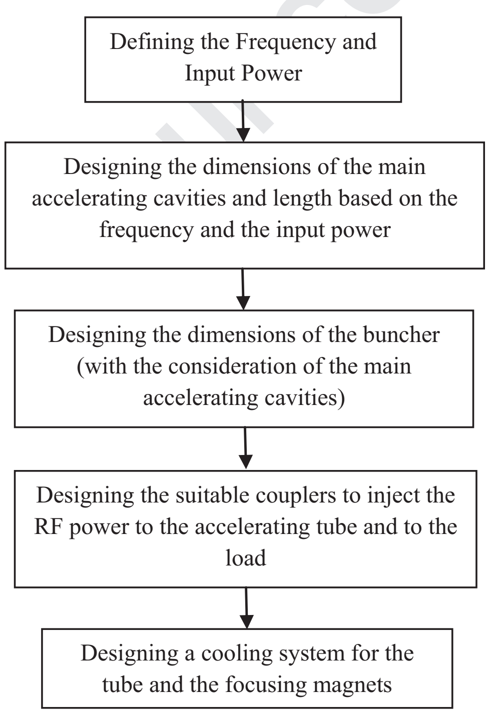

Fig. 2. The design process of an accelerating tube.

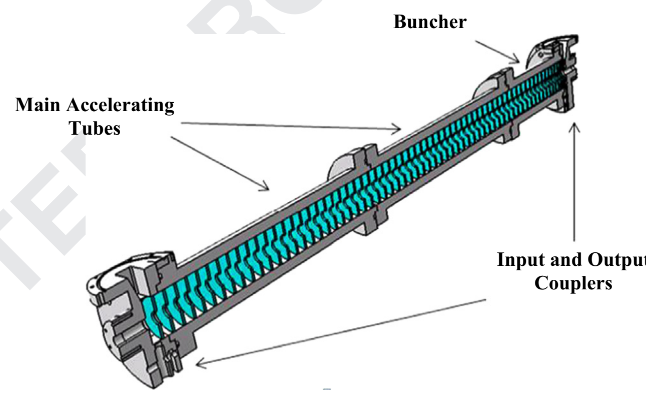

Fig. 3. The final layout of IPM's electron linear accelerator.

Fig. 4. Constructed buncher.

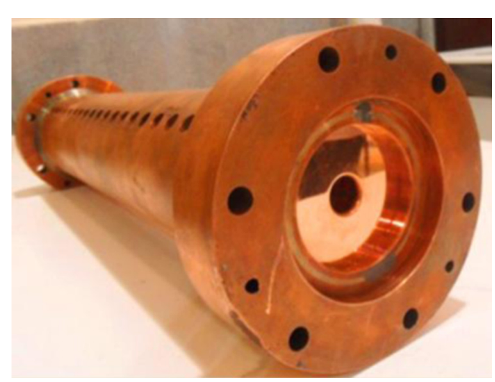

Fig. 5. One of the constructed accelerating tube.

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