Design of constant gradient TW linac tubes for the Iranian Light Source Facility (ILSF)

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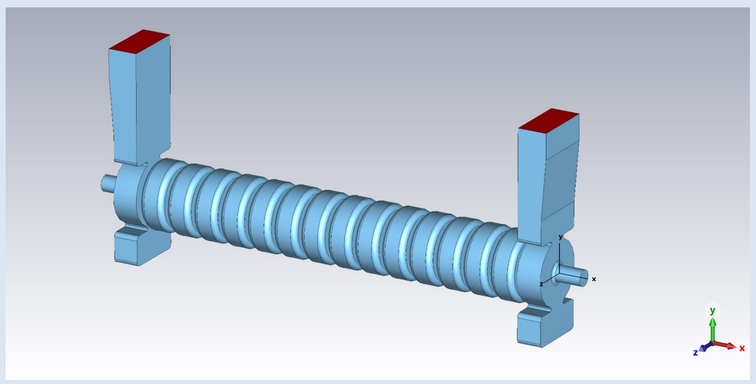
Abstract

The Iranian Light Source Facility (ILSF) is a 3 GeV low-emittance synchrotron light source laboratory for scientific research with very bright X-ray sources in various applications. ILSF's pre-injection system consists of a 2~3 MeV thermionic RF gun with an alpha compressor magnet and five Constant Gradient (CG) TW linac tubes. Each linac tube is 3 meters long with a minimum field gradient of 10 MV/m. To evaluate the design method of the constant gradient linac tubes, a smaller section of such tubes is designed and tuned to the desired operating frequency. The design of this short tube is presented in this report.

Introduction

The ILSF linac operates in 2π/3 mode at the frequency of 2997.79 MHz. The period length of each cell is 33.33 mm. In order to evaluate the fabrication process and sensitivity with minimum costs, first, a Constant Impedance (CI) prototype with 16 cells (~0.5 m) is designed and is now under fabrication. The design parameters of this prototype, such as the magnitude and phase of the on-axis electric field and s-parameters of the tube, are presented in FIG 1.



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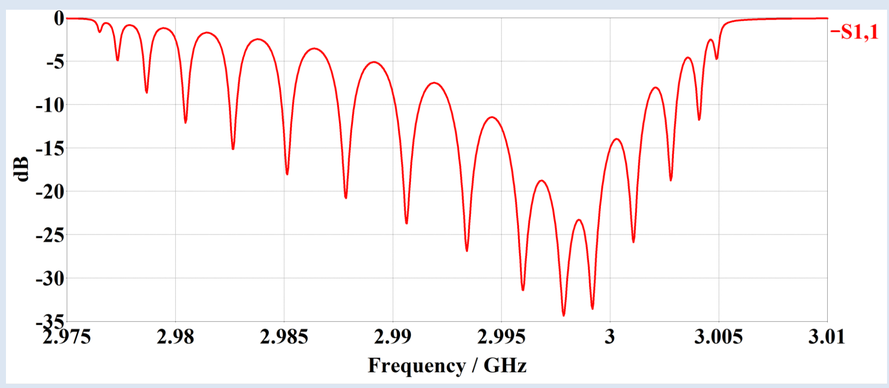

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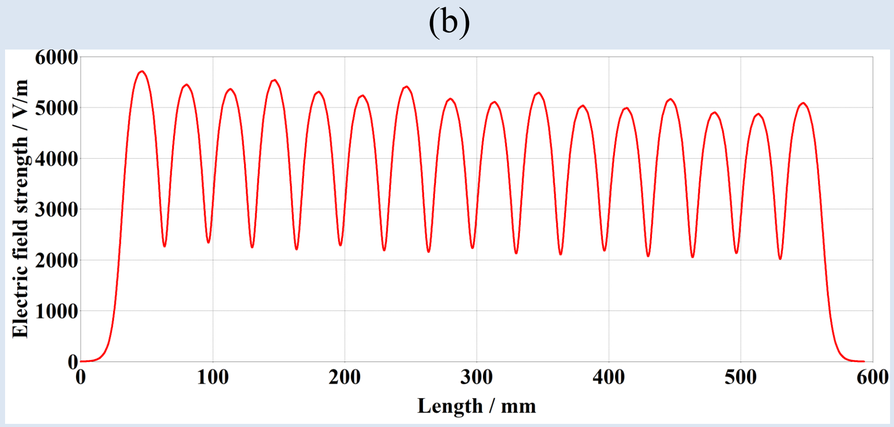

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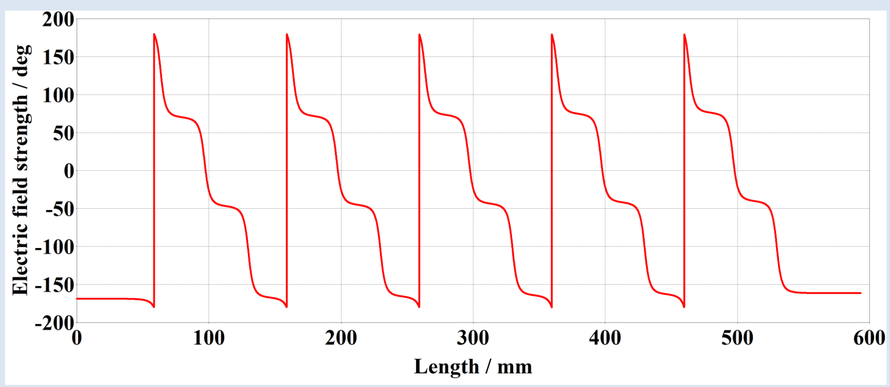


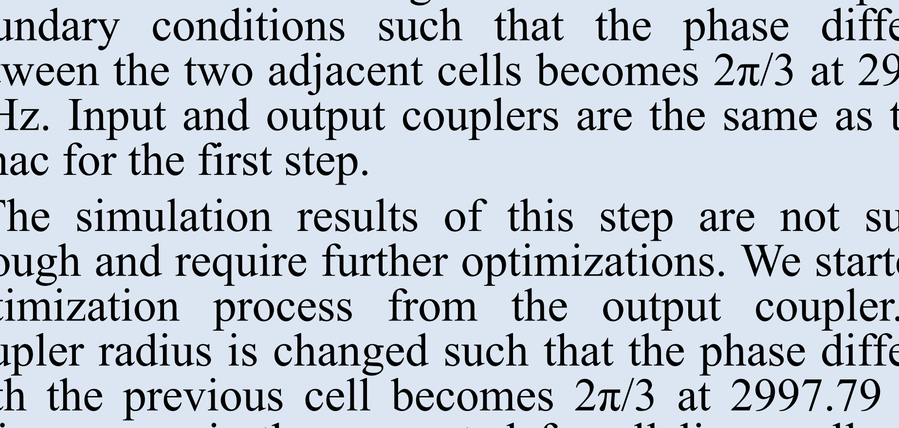
(d)

FIG 1. 3D model of designed CI Linac and its simulation results. a) Linac geometry, b) S-parameter, c) magnitude, and d) phase of electric field on axis.

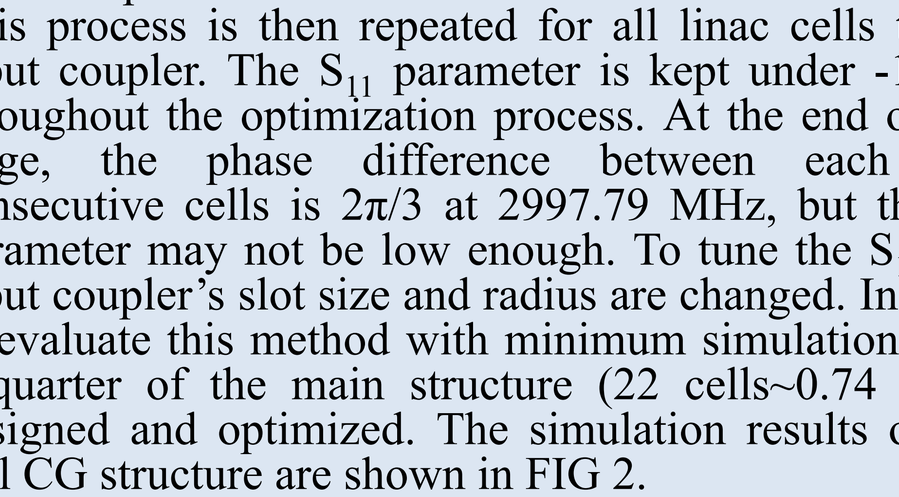
Design of CG Linac

To design a CG Linac, a curve is fitted on the aperture radius data of SLAC's Linac, and normalized to their maximum value. Then, these determined coefficients are multiplied by 11.5 mm. Then, each cell's radius is evaluated via CST's eigenmode solver with periodic boundary conditions such that the phase difference between the two adjacent cells becomes 2π/3 at 2997.79 MHz. Input and output couplers are the same as the CI Linac for the first step.

The simulation results of this step are not suitable enough and require further optimizations. We started the optimization process from the output coupler. The coupler radius is changed such that the phase difference with the previous cell becomes 2π/3 at 2997.79 MHz. This process is then repeated for all linac cells to the input coupler. The S_{11} parameter is kept under -10 dB throughout the optimization process. At the end of this stage, the phase difference between each two consecutive cells is 2π/3 at 2997.79 MHz, but the S_{11} parameter may not be low enough. To tune the S_{11}, the input coupler's slot size and radius are changed. In order to evaluate this method with minimum simulation time, a quarter of the main structure (22 cells~0.74 m) is designed and optimized. The simulation results of 22-cell CG structure are shown in FIG 2.



(a)



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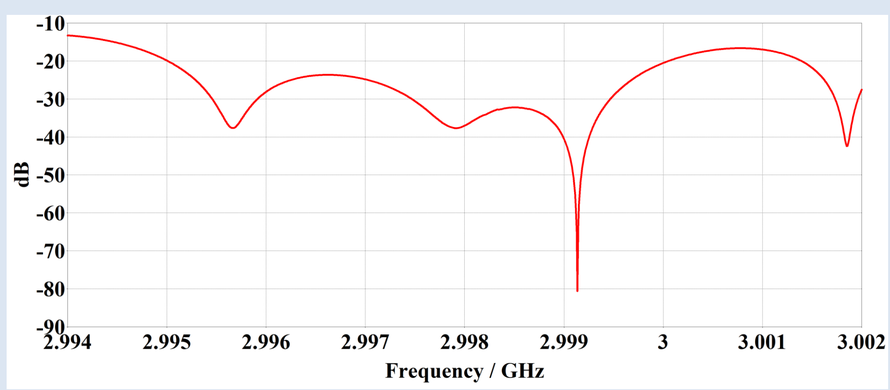

(c)

FIG 1. The simulation results the 22-cell CG structure ,a) S-parameter, b) magnitude, and c) phase of on-axis electric field.

We extrapolated a curve on the cells' radiuses to extend the 22-cell structure to the main structure (88 cells). Although the primary results of this extrapolation will not be optimal, it will be within the acceptable range. The final results of the design will be published when finalized.