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THE RF PARAMETERS OF HEAVY IONS LINAC

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Abstract

The new linac for A/Z = 8, output energy 4 MeV/u and 3 mA current is under development at NRC "Kurchatov Institute" - ITEP. The linac consists of Radio-Frequency Quadrupole (RFQ) with operating frequency 40 MHz and two sections of Drift Tube Linac (DTL) with operating frequency 80 and 160 MHz, correspondently. Both DTL have a modular structure and consists of separated individually phased resonators with focusing magnetic quadrupoles located between the cavities. The DTL_1 is based on the quarter-wave resonators meanwhile DTL_2 is based on IH 5-gap resonators. The 6D beam matching between RFQ and DTLs is provided by magnetic quadrupole lenses and 2-gaps RF-bunchers.

The paper presents results of the radio-frequency (RF) design of linac accelerating structures.

INTRODUCTION

The heavy ions linac consists of ≈ 11 m long RFQ with operating frequency 40.625 MHz, two DTLs with operating frequency 81.25 and 162.5 MHz, correspondently. The first DTL consists of 12 separated individual phased cavities based on quarter-wave resonator (QWR). Each DTL_1 cavity has the same longitudinal dimension. The second DTL consists of 28 separated individual phased cavities and bases on IH-cavity.

The accelerating structures connecting by beam transport channels – two medium energy between RFQ-DTL_1 and DTL_1-DTL_2 (MEBT_1, MEBT_2, correspondently) and one high energy after DTL2 (HEBT). The MEBT_1 bunchers operates at resonant frequency f_0 = 81.25 MHz, the MEBT_2 and HEBT bunchers operate at resonant frequency f_0 = 162.5 MHz.

RFQ DESIGN

According to particles dynamics simulation the RFQ's vanes length should equals to 10998 mm, average aperture radius R_0 = 12.5 mm, vane tip radius R_e = 0.8 mm R_0 = 10 mm and operates at f_0 = 40.625 MHz. The RFQ cavity consists of 1222 mm long 9 identical sections and input/output flanges. The best RF parameters of RFQ cavity could be achieved by using a 4-vane structure [1, 2] and would require a bigger diameter of the cavity compared to shifted windows structure. The last one structure was chosen. The windows areas were chosen as bigger as possible in order to minimized the cavity's inner diameter. The regular RFQ section is shown at Fig. 1. The main dimensions and RF RFQ parameters are presented at Tables 1 and 2, correspondently.

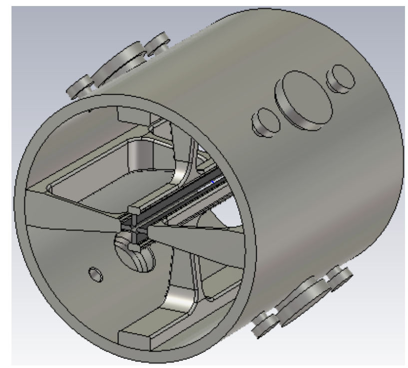

Figure 1: The regular RFQ section.

From Fig. 1 one can see that RFQ section has a 4 CF200 flanges and 8 CF63 flanges. It would be used for RF power feeders, RF signal antennas, motorized and stationary plungers, vacuum pumps and detectors.

Table 1: The Main Dimensions of RFQ

Parameter	Value (mm)
Cavity inner diameter	1025
Cavity length	1222
Vane base width	150
Vane base height	65
Vane top width	60
Vane window length	780
Vane window height	352.5
Vane tip height	30

Table 2: The main RF RFQ parameters

Parameter	Value
Resonant frequency, MHz	40.625
Resonant frequency of the dipole mode, MHz	46.5
Inter-vane voltage, kV	170
Self quality factor	13000
RF power losses, kW/m	46
Full RF power losses, kW	506

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DTL_1 DESIGN

DTL_1 section consists of 12 identical separated individual phased 2-gaps cavities based on quarter-wave resonator (QWR) operate at resonant frequency $f_0 = 81.25$ MHz (see Fig. 2) [3]. The accelerating gap increases from cavity to cavity with beam energy growth. In order to simplify DTL_1 construction the cavities length was taken constant while gap variation was achieved by varying the front/end tubes length. Each DTL_1 cavity consists of accelerating section where drift tubes are located and base where central drift tube's stem is fixed. The aperture radius is equal to 21 mm in each cavity.

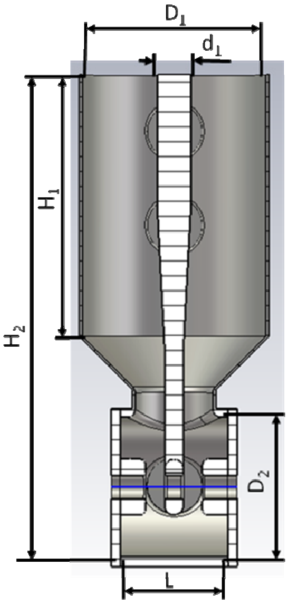

Figure 2: The DTL_1 cavity.

The base diameter was chosen in order to minimize the distance between cavities which is required by particles dynamics simulation. It should be mentioned that the RF power losses of QWR depends on cavity's base. Each DTL_1 cavity has a 6 CF100 flanges for the same purpose as RFQ.

The main dimensions parameters and RF parameters of DTL_1 are presented at Tables 3 and 4, correspondently.

Table 3: The Main Dimensions of DTL_1

Parameter	**Value (mm)**
Full height	865
Base height	470
Length of accelerating section	194
Accelerating section diameter	250
Base diameter	330
Stem diameter	60
Gap length	34 ÷ 48

Table 4: The Main RF DTL_1 Parameters

Parameter	**Value**
Resonant frequency, MHz	81.25
Accelerating field intensity, kV/cm	80
Shunt impedance, MΩ/m	20
Self quality factor	9600
RF power losses, kW/cavity	60 ÷ 95

From Table 4 one can found that full RF power loss for DTL_1 section is equal to 0.9 MW.

DTL_2 DESIGN

The DTL_2 section consists of 28 separated individual phased IH 5-gaps cavities and operates at resonant frequency $f_0 = 162.5$ MHz (see Fig. 3) [3]. The DTL_2 cavities length is increasing from cavity to cavity with beam energy growth. The aperture radius is equal to 25 mm in each cavity.

From Fig. 3 one can see that tubes stems have the various diameters. Different stems diameters were taken for requested field distribution required by particles dynamics simulation. Each DTL_2 cavity has a 2 CF100 flanges and 4 CF63 flanges. The main purpose for flanges is the same as for RFQ and DTL_1.

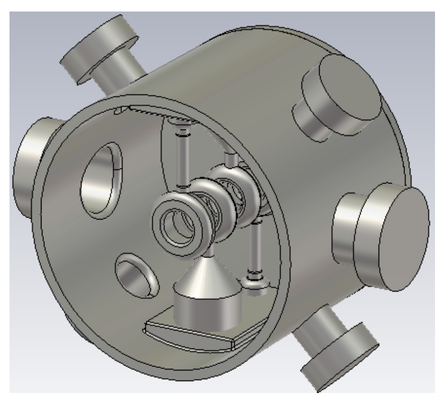

Figure 3: The DTL_2 cavity.

The main dimensions parameters and RF parameters of DTL_2 are presented at Tables 5 and 6, correspondently.

Table 5: The Main Dimensions of DTL_2

Parameter	**Value (mm)**
Cavity inner diameter	420
Cavity length	280 ÷ 442
Central stem diameter	97
Side stem diameter	41
Gap length	24 ÷ 42

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Table 6: The Main RF DTL_2 Parameters

Parameter	Value
Resonant frequency, MHz	162.5
Accelerating field intensity, kV/cm	77 ÷ 107
Shunt impedance, MΩ/m	12 ÷ 27
Self quality factor	7200 ÷ 10800
RF power losses, kW/cavity	150 ÷ 200

From Table 5 one can see that every DTL_2 cavity has the same inner diameter in order to unify DTL_2 cavity's construction. It should be mentioned that various accelerating gaps lead to different RF parameters (especially f_0) of the cavities while cavities inner diameter is constant. The resonant frequency was tuned by varying the drift tubes diameters not taking into account the cavities shunt impedance. The full RF power loss for DTL_2 section is equal to 4.3 MW.

CONCLUSION

The new linac for A/Z = 8, output energy 4 MeV/u and 10 mA current is under development at NRC "Kurchatov Institute"-ITEP. The linac consists of RFQ with operating frequency 40.625 MHz and two sections of DTLs with operating frequency 81.25 and 162.5 MHz, correspondently.

The main RF parameters and accelerators geometry are presented in this paper. The total RF power for the linac's feeding is equal to ≈ 5.7 MW.

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