Beam Commissioning Plan and Result of KOMAC Linac

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1. Introduction

The beam commissioning of the KOMAC (Korea Multi-Purpose Accelerator Complex) 100-MeV proton linear accelerator is in progress [1]. The linac includes a 50-keV ion source, a 3-MeV RFQ (radio frequency quadrupole), a 100-MeV DTL (drift tube linac). The final goal of the beam commissioning is accelerating 100-MeV proton beams to the beam dump in the accelerator tunnel and into a target room. This work summarized the present status and near-future plan of the beam commissioning.

2. Beam Commissioning

2.1 Beam Commissioning Plan [2]

The beam commissioning consists of two stages, one up to the 20-MeV and the MEBT, the other for 100-MeV beams. For 20-MeV beam commissioning, we prepared a beam stop in MEBT which is designed both for 20-MeV beam extraction and for beam matching into the next DTL tank. The 1-kW beam bump was installed at the end of the 100-MeV linac for the 100-MeV beam commissioning. The initial goal is accelerating 100-MeV proton beams into the beam dump after finishing the 20-MeV beam study. The layout of the beam diagnostic equipment is summarized in Figure 1. The beam position monitors are designed to measure the beam position and the beam phase which is used to determine the RF set point of DTL tanks.

In the initial commissioning of the 50-keV injector including a microwave ion source and LEBT (low energy beam transport), we will use the operating conditions of the machine at Daejeon site. The RFQ commissioning is based on the comparison of the beam transmission between in the calculation by using PARMTEQ [3] and in experimental result. A 1-MW klystron drives 4 DTL tanks which accelerate proton beams up to 20-MeV. The RF set point of tanks should be determined by the same procedure as that for a DTL tank.

2.2 Determination of the RF set point [4]

The phase scan signature method [5] is well known for determining the RF set-point, the amplitude and the phase, of a DTL tank. In our case, the beam phase is measured by a beam position monitor which is installed downstream of each DTL tank as shown in Figure 1. The schematic plot of the beam phase measurement of a DTL tank is shown in Figure 2 where the phase can be measured by using BPM1. When the set-point is properly determined, the output energy of each tank becomes the design value which is given in Table 1.

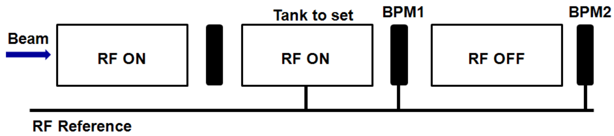

Fig. 2. Schematic plot for beam phase measurement of a DTL tank.

Table 1. RFQ design requirement.

DTL	Input energy	Output energy
DTL101	20.0	33.1
DTL102	33.1	45.3
DTL103	45.3	57.3
DTL104	57.3	69.1
DTL105	69.1	80.4
DTL106	80.4	92.0
DTL107	92.0	102.6

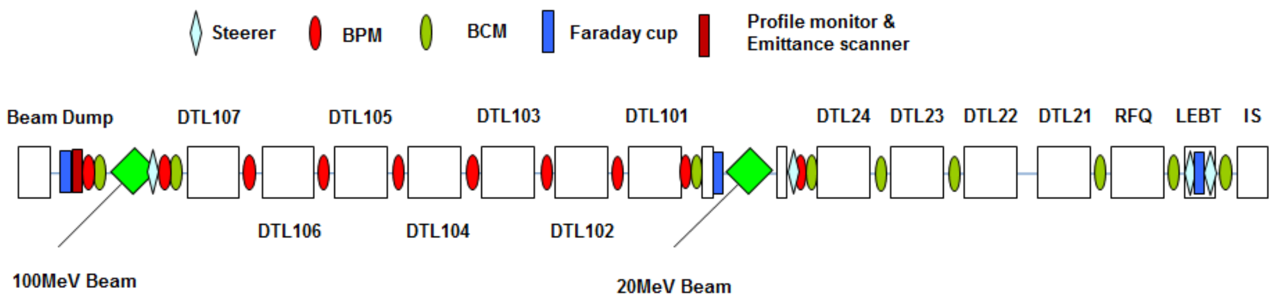

Fig. 1. Layout of beam diagnostic equipment used for beam commissioning.

2.3 Program for RF set point [5]

First of all, we calculated the beam phase as a function of RF phase for each DTL tank by using PARMILA code [6]. The result for DTL101 is given in Figure 3 where A/A_{design} of 1.02 represents 2% larger value of the RF amplitude than the design value.

The measurement result is compared with simulation results for several cases of amplitude values. From the minimization condition of χ^2, we can determine the amplitude and phase. The χ^2 value is defined as

$$\chi^2 = \frac{1}{N}\sum_{i=1}^{N}\left[f_{ex}(\phi_i) - (b + f(\phi_i - a))\right]^2 ,$$

where N is the number of the experimental data and ϕ_i is the RF phase of each datum. The $f_{ex}(\phi_i)$ is the experimental beam phase at the RF phase of ϕ_i.

We also developed an RF set-point program based on MATLAB with a nonlinear optimization routine, LEVMAR. The main screen of the RF set-point program is shown in Figure 4. The amplitude and phase calculation results are shown in Figure 5 and Figure 6 whose results are respectively given in (D) and (C) of Figure 4.

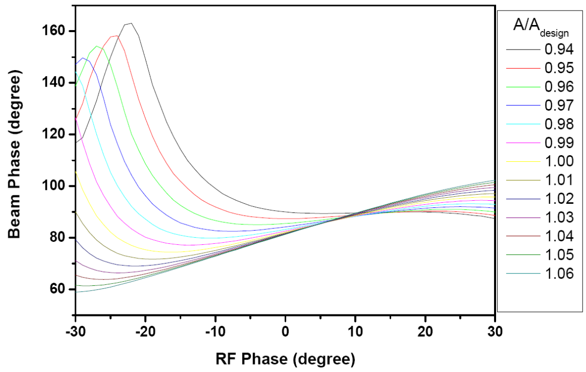

Fig. 3. Beam phase as a function RF phase for DTL101.

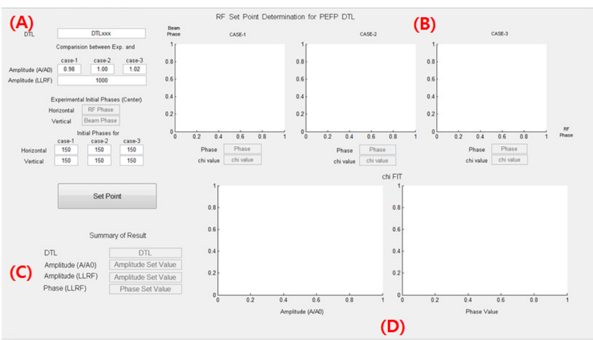

Fig. 4. Screen for beam commissioning program: (a) input parameters (b) χ^2 calculation by comparing an experimental result with 3 simulations (c) determined RF amplitude and phase by quadratic fittings in (d).

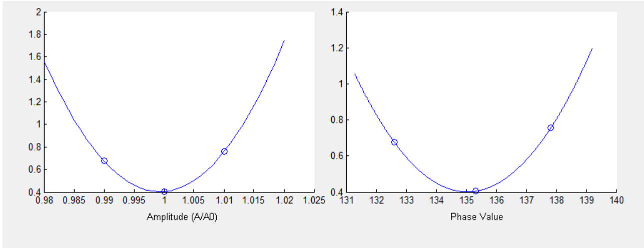

Fig. 5. Quadratic fitting of χ^2 values for 3 different cases of the relative amplitudes and phases.

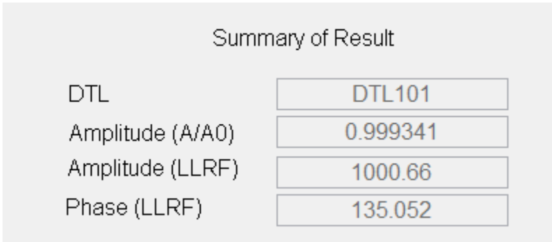

Fig. 6. Determination of the RF set point, amplitude and phase.

3. Conclusions

The development and installation of the 100-MeV proton linac were finished. Beam commissioning is scheduled in May 2013. Hence we hope we can report the initial beam commissioning result in the spring meeting of Korea Nuclear Society

ACKNOWLEDGEMENT

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