Power-balance control by Slug Tuner for the 175MHz RFQ linac in IFMIF project

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International Fusion Materials Irradiation Facility (IFMIF) is an accelerator-based neutron irradiation facility employing deuteron-Lithium (D-Li) stripping reaction, to produce neutron field similar to the D-T Fusion reactor (2MW/m^2, 20 dpa/year for Fe). In the IFMIF, 40 MeV deuteron beam with a current of 250 mA is injected into the liquid lithium flow with a velocity of 20 m/s. The required current of 250 mA is realized by two beam lines of 125mA, and the output energies at injector, radio-frequency quadrupole (RFQ) linac and drift tube linac (DTL) are designed to be 0.1,5 and 40 MeV, respectively.

The operation frequency of 175MHz was selected for linacs to accelerate the large current of 125mA. For this low frequency, the transmission line using rectangular waveguide is needs to be as large as 1.0 x 0.5m, and accordingly the RF-Input coupler using Iris type also becomes large to inject RF power into RF cavities. Therefore, an RF-Input coupler using a loop antenna with co-axial transmission line has been developed. A multi-drive configuration is necessary to inject a total RF power of 2.3 MW for the RFQ.

For tuning the RFQ, the RF power-balance control by slug tuner is indispensable because the loop antennas and pick-up coils are to be installed into the RFQ cavity, and the RF power-balance in each cavity for quadrupole operation mode (TE_{210}) will be affected by the insertion of these elements. In this study, RF power-balance effects by slug tuners have been measured by using an aluminum low power test module of 175MHz RFQ mock-up with a total length of 1.1m.

The test module consists of a central piece and two end-plate pieces, and several types of loop antennas with different shapes were tried to obtain the optimal insertion depth, 3cm, for realizing appropriate phase differences of TE_{210} mode. Under this condition, cylindrical slug tuners having the various diameters, 3 to 5 cm, were inserted, and S_{21} parameters in each cavity were measured. As a typical result, RF power-balance control less than 20% error can be achieved in case of ϕ3 cm tuner up to 3cm insertion. The obtained results will be a good technical base for RF power-balance control in the IFMIF 175MHz RFQ.