STATUS AND TEST RESULTS OF HPRF SYSTEM FOR PEFP *

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Abstract

The PEFP 20MeV proton accelerator is composed of 3 MeV RFQ and 20MeV DTL and two sets of 1 MW, 350 MHz RF system are required for each accelerating structure. The high power RF system for 3 MeV RFQ was already installed and operated to drive the RFQ. The klystron was tested up to 600 kW itself and operated in pulse routinely. The HPRF system for 20 MeV DTL which consists of 4 tanks was installed, and the RF test for 4 tanks has been carried out. Four RF dummy loads for absorbing RF power reflected from each accelerating structure were designed and manufactured.

In this paper, the status and test results of the RF system for 20 MeV proton accelerator are discussed.

INTRODUCTION

The 100 MeV proton accelerator is under development for the Proton Engineering Frontier Project [1]. The low energy section of accelerator consists of ion source, LEBT, RFQ and DTL. The DTL accelerates 20 mA proton beam to 20 MeV for 1st phase of the project.

The HPRF system includes a klystron, a circulator, waveguide components, cooling system, high voltage supply system and so on. Two sets of HPRF system have been built to drive 3 MeV RFQ and 20 MeV DTL respectively, and RF test has been carried out. RF power from a klystron is split into each leg by magic tee and delivered to each accelerating structure. The RF dummy load of a magic tee for absorbing RF power reflected from the accelerating structure was manufactured.

The following sections include the status and test results of the RF system for PEFP 20 MeV proton accelerator.

HPRF SYSTEM FOR RFQ

The HPRF system for 3MeV RFQ is summarized in Table 1. The operating frequency is 350MHz and the required RF power is 460kW including the additional loss originated Q-degradation [2]. A 3MeV RFQ has two RF input ports and the RF power from a 1MW klystron is divided into two legs by magic tee to drive a cavity because of the power limitation of the RF window. To absorb asymmetry RF power reflected from RFQ, 100 kW dummy load of magic tee is required. The schematic of the RF power delivery system and the installed HPRF system for RFQ are shown in Figure 1, Figure 2 respectively.

Table 1: HPRF system summary for 3MeV RFQ.

Accelerating structure	RFQ
Frequency (MHz)	350
Energy range (MeV)	0.05~3
Beam current (mA)	20
Required RF power (kW)	460
No. of 1 MW klystron (ea.)	1
No. of couplers (ea.)	2

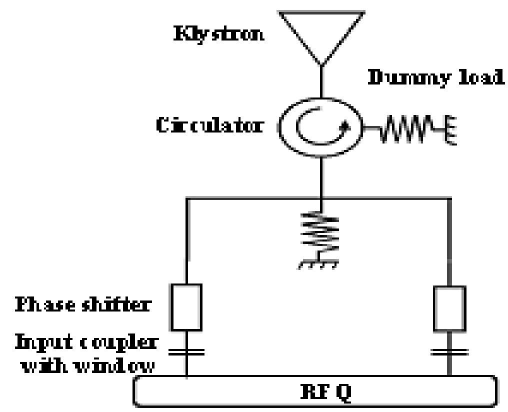

Figure 1: Schematic of the RF power delivery system for RFQ.

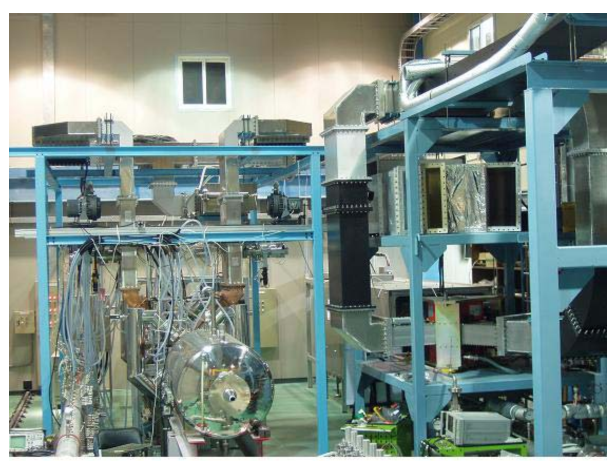

Figure 2: The installed HPRF system for RFQ.

The klystron was tested up to 600 kW itself in pulse operation. The pulse width, repetition rate are 50 μs, 10 Hz respectively. The klystron was operated up to 350 kW routinely. The forward RF power and cavity's RF power in HPRF test for the RFQ are shown in Figure 3. All of the RF components including RF window, input coupler, klystron power supply and cooling system have the capacity of operating at 600 kW average power level.

* This work is supported by the 21C Frontier R&D program in the Ministry of Science and Technology of the Korean government
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Therefore RF duty can be increased for higher average power operation.

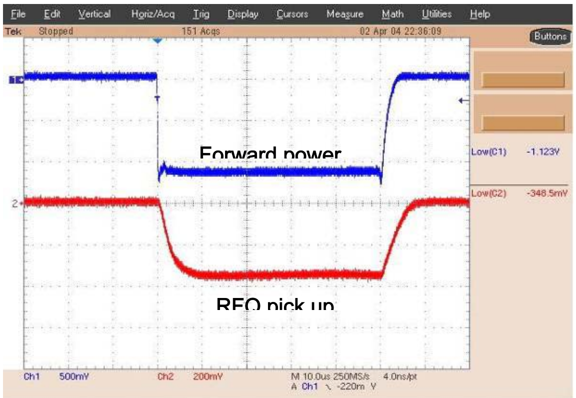

Figure 3: The measured RF signal in RF test for 3MeV RFQ.

HPRF SYSTEM FOR DTL

The HPRF system for 20 MeV DTL is summarized in Table 2. The DTL is composed of 4 independent tanks and driven by single RF source, which has a feature with regard to the way to control independent amplitude, phase and resonant frequency of each tank [3]. The RF power from a 1 MW klystron is split into four legs to drive 4 tanks of the DTL - that is one RF port per one tank - by magic tees which power balance is less than 1 %. Each leg has a phase shifter (+/-22.5°) to adjust the phase of the RF field in each tank. The schematic of the RF power delivery system for DTL is shown in Figure 4.

The HPRF system for DTL was installed as shown in Figure 5, and the klystron was tested up to 800 kW itself in pulse operation. The pulse width, repetition rate are 50 µs, 1 Hz respectively. The measured RF signal in RF test is shown in Figure 6.

Table 2: HPRF system summary for 20MeV DTL.

Accelerating structure	DTL
Frequency (MHz)	350
Energy range (MeV)	3~20
Beam current (mA)	20
Required RF power (kW)	895
Tank1	(225)
Tank2	(225)
Tank3	(224)
Tank4	(221)
No. of 1MW klystron (ea.)	1
No. of couplers (ea.)	4 (1ea./tank)

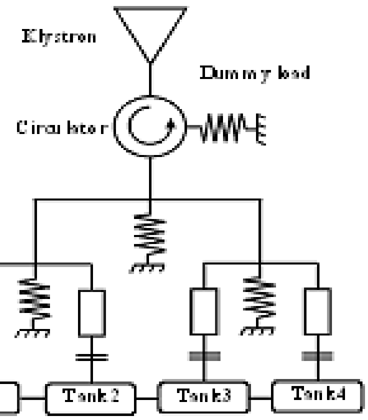

Figure 4: Schematics of RF power delivery system for 20MeV DTL.

Figure 5: The installed HPRF system for DTL

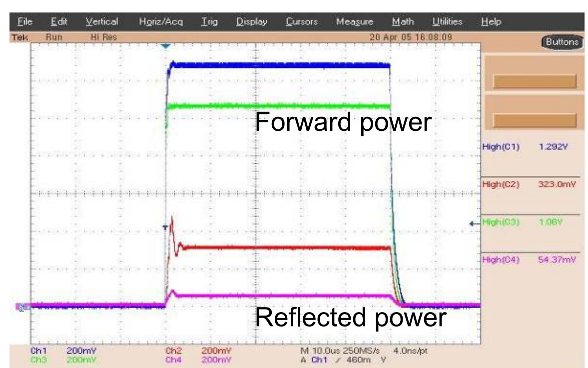

Figure 6: The measured RF signal in RF test for DTL klystron.

RF DUMMY LOAD

As presented in the previous sections, RF power is divided by magic tee and delivered to the accelerating structure. To absorb asymmetry RF power reflected from the accelerating structure, one dummy load of magic tee for RFQ and three dummy loads of magic tee for DTL were manufactured as shown in figure 7. It is 350 MHz, 100 kW load. The length and gradient of waveguide were determined for the constant dissipation per unit length of

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100 kW RF power. It uses mixture of water and MEG with additives (volume ratio 50:50) as a coolant.

Figure 7: external and internal shapes of manufactured 100kW magic tee dummy load.

It can be matched with two matching posts and given input coolant temperature. Height and position of two matching posts were determined to match the RF dummy load at given input coolant temperature. The required VSWR value is 1.05 below and the measured VSWR values of four loads were less than 1.02 at 45℃ coolant. Figure 8 shows the measured VSWR and Smith chart using Network Analyzer.

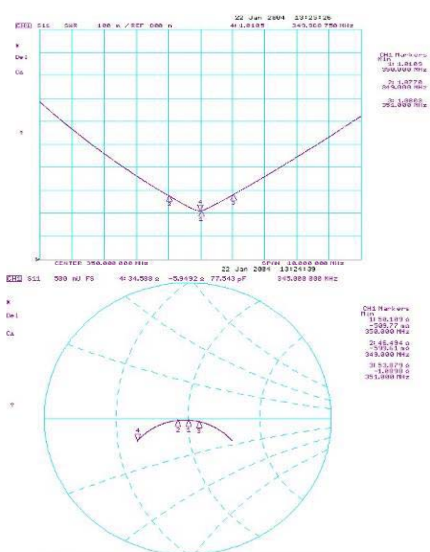

Figure 8: VSWR and Smith chart measured at 45℃ coolant.

SUMMARY

The high power RF system for PEFP 20 MeV proton accelerator composed of 3MeV RFQ and 20 MeV DTL has been installed. The klystron for RFQ was tested up to 600 kW itself and operated routinely to drive RFQ in pulse operation. The klystron for DTL which consists of 4 tanks tested up to 800 kW itself in pulse operation. The pulse width, repetition rate was 50 μs, 1 Hz respectively. RF dummy load for absorbing RF power reflected from each accelerating structure was manufactured and the measured VSWR was 1.02 below at 45℃ coolant. The HPRF system for 20 MeV accelerator has been operated to drive each accelerating structure.

REFERENCES

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