IMPROVEMENT OF THE RF SYSTEM FOR THE PEFP 100MeV PROTON LINAC*

Kyung-Tae Seol#, Hyeok-Jung Kwon, Han-Sung Kim, Young-Gi Song, and Yong-Sub Cho
PEFP/KAERI, Daejeon, Korea

Abstract

The 100MeV proton linear accelerator of the Proton Engineering Frontier Project (PEFP) has been developed and will be installed in Gyeong-ju site. The 20MeV accelerator operated in Korea Atomic Energy Research Institute (KAERI) site will be also moved and re-installed. The LLRF control systems for the 20MeV Linac were improved and have been operated within the stability of ±1 % in RF amplitude and ±1 degree in RF phase. 7 sets of the extra LLRF control system will be installed with a RF reference system for the 100MeV accelerator. The waveguide layout was also fixed to install HPRF systems for the 100MeV Linac. Some of the HPRF components including klystrons, circulators, and RF windows are under purchase. The waveguide sections penetrating into the tunnel, which are fixed in the concrete floor with the bending structure for radiation shielding, were fabricated into a piece of waveguide to prevent the moisture and any foreign debris inside the concrete block. The details of the RF system improvement are presented.

INTRODUCTION

The PEFP 100MeV proton linear accelerator has been developed and will be installed in Gyeong-ju site [1]. The 20MeV proton linac has been already operated in KAERI site [2], and will be moved and re-installed with the 100MeV Linac. The RF systems of the 100MeV Linac have been developed and improved. A waveguide layout was fixed to install the high power RF (HPRF) system, and waveguide penetration sections were fabricated and have been installed to the building construction. The low-level RF (LLRF) system of the 20MeV Linac was improved [3]. The new commercial FPGA board was adopted and the LLRF analogue chassis were modified. The improved LLRF system has been operated with EPICS operator interface (OPI) for the 20MeV Linac.

HPRF SYSTEM

Total 11 sets of RF systems are required for the 100MeV accelerator, and the specifications of the RF system were summarized in Table 1. Waveguide layout was fixed to the 100MeV Linac, and some of the RF components are under construction.

Waveguide layout

The 100MeV waveguide layout is shown in Figure 1.

* This work is supported by MEST of the Korean government.
#ktseol@kaeri.re.kr

Table 1: Specifications of the RF system

Parameters	**Specifications**
Operating frequency	350MHz
RF power (peak)	1.6MW
RF Duty	9%
Pulse width / rep. rate	1.5ms / 60Hz
Transmission line	WR2300 waveguide
Stability of RF field	±1% in RF amplitude, ±1deg. in RF phase

The waveguide layout is relatively simple, and the waveguide layout varies with a 3MeV RFQ, a 20MeV DTL, and a 100MeV DTL. In the case of the 20MeV DTL, One klystron drives 4 tanks, so RF power from a klystron is split by magic Ts and each waveguide runs in 4 ways. The waveguide penetration sections have the bending structure for radiation shielding. The waveguides in the tunnel have the straight section to adjust the waveguide for an installation.

Waveguide penetration

The waveguide section penetrating into the concrete floor of 2.5m was fabricated into the bending structure of WR2300 half height, and was made into a piece of waveguide to prevent the moisture and any foreign debris inside concrete block. Figure 2 shows the fabricated waveguide penetration sections.

Figure 2: Waveguide penetration section.

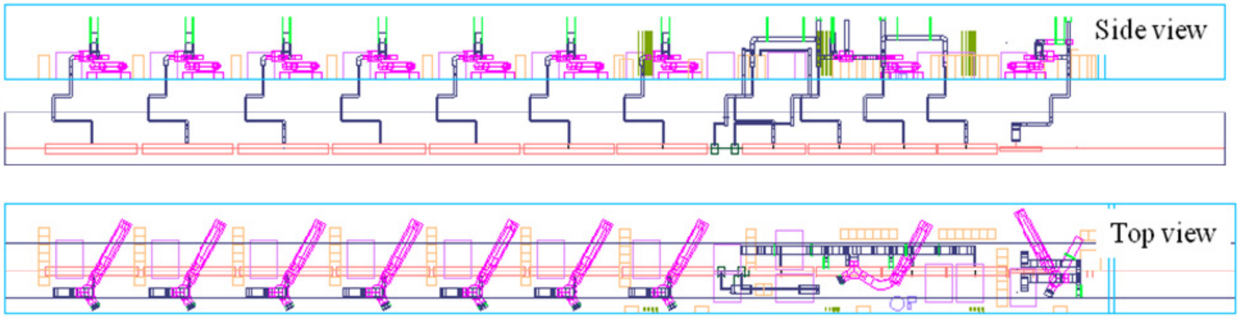

Figure 1: HPRF system and waveguide layout for the 100MeV Linac.

Leakage from the penetration waveguide was inspected with the pressure of 0.25 psig. VSWR was also measured within 1.2. After the fabrication and the measurements, the waveguide penetration sections have been installed within the sleeve of the building construction structure. Figure 3 shows the installation of the penetration section.

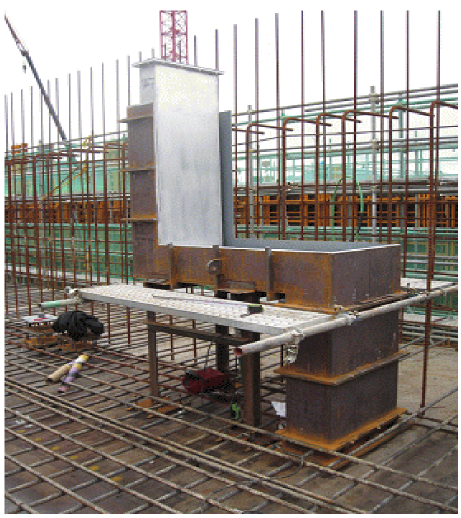

Figure 3: Installation of waveguide penetration section.

LLRF SYSTEM

The low-level RF (LLRF) system of the 20MeV Linac was improved. The main characteristic of the improved system is to produce the synchronized phase IF signal from the FPGA board at every trigger. Therefore, the IQ modulator installed in the former analogue chassis and other auxiliary components for the IQ modulator could be eliminated. The block diagram of the modified LLRF system is shown in Figure 4. RF of 350MHz, LO of 300MHz, IF of 50MHz, and clock of 40MHz could be chosen. We are going to use the LO signal of 300MHz as a RF reference. The RF reference line will be installed in the klystron gallery with the temperature-controlled equipment.

A commercial high-speed FPGA module (Pentek 7142) was adopted as a new digital control board. The adopted FPGA board is shown in Figure 5, and its specifications are as follows.

- ADC : 125MHz max. sampling rate
  : 4 ch., 14bit resolution
- DAC : 320MHz max. converting rate
  : 1 ch., 16bit resolution
  : dc to 160MHz IF output
- FPGA : Xilinx Virtex4 XC4VSX55
- Memory : DDR2 SDRAM (64M×32)
- Clock : external or internal
- Gate : internal or external

The LLRF analogue chassis was also modified to accommodate the IF signal directly from the digital control module. Figure 6 shows the newly manufactured LLRF analogue chassis for the 100MeV Linac. It performs the reference signal distribution, clock generation, up-down conversion, and RF interlock for the HPRF system protection.

An EPICS control system based on the VME was newly developed, and an EPICS OPI was also adopted [4].

The digital control system adopted general PI control algorithm using I/Q signal. After the test with a dummy cavity, the LLRF system has been operated with the 20MeV Linac. The latency of the control system was 1us. The RF amplitude and RF phase measured during the 20MeV operation is shown in Figure 7 and Figure 8 respectively. The amplitude and phase of the cavity could be controlled within 1% and 1 degree respectively as shown in the Figure.

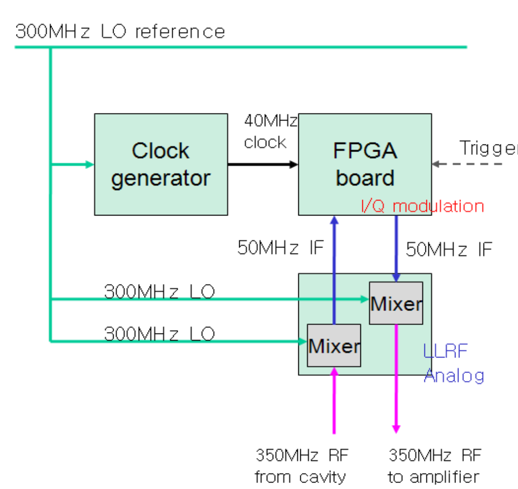

Figure 4: Block diagram of the improved LLRF system.


Figure 5: New commercial FPGA board (Pentek 7142).

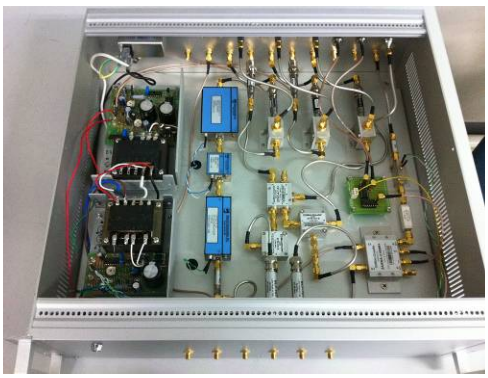
Figure 6: LLRF analogue chassis.

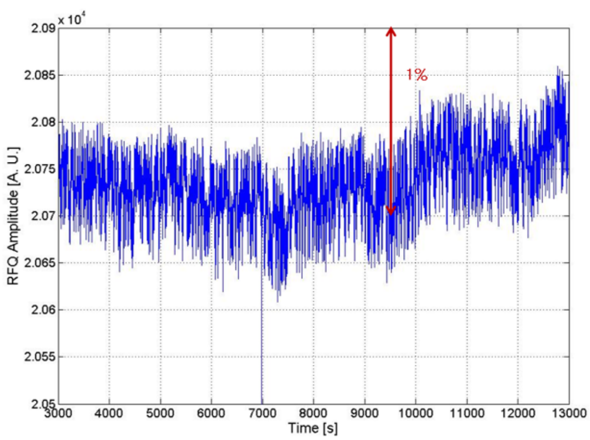

Figure 7: RF amplitude during 20MeV Linac .

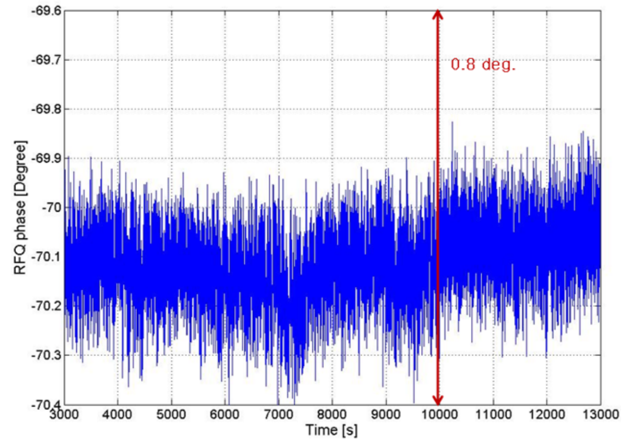

Figure 8: RF phase during 20MeV Linac .

CONCLUSION

For the construction of the 100MeV accelerator, the RF system has been developed and improved. The HPRF system and waveguide layout was fixed to install the RF components. The waveguide penetration sections were fabricated and have been installed with the building construction. The LLRF control system was improved. It adopted a new digital control board and an new EPICS OPI, and showed the test results within 1 % in RF amplitude and 1 degree in RF phase. The RF systems will be installed and be operated for the 100MeV Linac.

REFERENCES

[1] Y. S. Cho, et al.,"Status of 100-MeV Proton Linac Development for PEFP", in these proceedings.

[2] H. J. Kwon, et al., "Improvement of the 20MeV Proton Accelerator at KAERI", in these proceedings.

[3] Kyung-Tae Seol, Hyeok-Jung Kwon, Han-Sung Kim, Young-Gi Song, and Yong-Sub Cho, J. Korean Phys. Soc. **59**, 627 (2011).

[4] Young-Gi Song, Han-Sung Kim, Kyung-Tae Seol, Hyeok-Jung Kwon, and Yong-Sub Cho, J. Korean Phys. Soc. **59**, 577 (2010).