Klystron High Power Operation for KOMAC 100-MeV Proton Linac

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1. Introduction

A 100-MeV proton linac of the Korea multi-purpose accelerator complex (KOMAC) has been operated for beam service to users from July in 2013. The KOMAC accelerator facility has a 100-MeV proton linac, five beam lines for 20-MeV beam utilization, and another five beam lines for 100-MeV beam utilization [1]. The 100-MeV linac consists of a 50-keV proton injector based on a microwave ion source, a 3-MeV RFQ with a four-vane structure, and a 100-MeV DTL [2-3]. Nine sets of 1MW klystrons have been operated for the 100-MeV proton linac. The klystron filament heating time was approximately 5700 hours in 2014, and RF operation time was 2863.4 hours. During the high power operation of the klystron, unstable RF waveforms appeared at the klystron output, and we have checked and performed cavity frequency adjustments, magnet and heater current, reflection from a circulator, klystron test without a circulator, and the frequency spectrum measurement.

2. Klystron Operation

The specifications of the klystron for 100-MeV proton linac are summarized in the followings.

- Klystron : TH2089K (Thales)
- Operating frequency : 350 MHz
- Beam voltage (max) : 107 kV
- Beam current (max) : 26 A
- Mod. Anode voltage (max) : 71 kV
- Heater voltage (max) : 30 V
- Heater current (max) : 30 A
- Peak RF power (min) : 1.6 MW
- Gain (min) : 41 dB
- Efficiency (min) : 58 %
- Ion pump current (max) : 10 uA
- Electromagnet current (max) 12 A
- Electromagnet voltage (max) : 300 V

Figure 1 shows a klystron installed for a RFQ cavity, and Figure 2 shows klystrons installed at the gallery for the 100-MeV proton linac.

RF operation time was 2863.4 hours for beam service and accelerator study, and the klystron filament heating time was 5700 hours in 2014. Figure 3 shows the klystron filament heating times accumulated up to December in 2014. Two klystrons for a 20-MeV accelerator had been operated on Daejeon site, so the heating time is high as shown in Figure 3.

Figure 1: Installed klystron (for RFQ)

Figure 2: HPRF installation

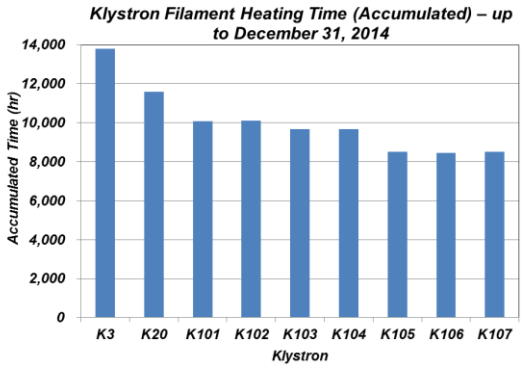

Figure 3: Klystron heating time accumulated up to 2014

3. High Power Operation Results

Nine sets of the klystrons have been operated for the 100-MeV proton linac. During the high power operation, some klystrons have unstable RF waveforms at a

specific power level. Figure 4 shows the unstable RF waveform at the klystron for a DTL105. We have performed a cavity frequency adjustment to solve it, and we checked a reflection from a circulator as shown in Figure 5. We also measured a frequency spectrum at the unstable RF waveform as shown in Figure 6. We performed klystron high power test without a circulator to know if the unstable RF is caused by the klystron or not. The test results show that the klystron output signal is not normal.

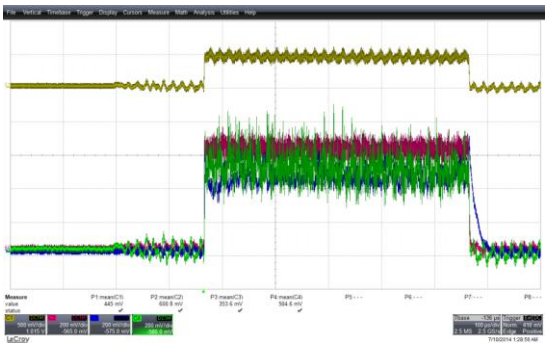

Figure 4: Unstable RF waveform at klystron operation (Yellow: klystron drive, Red: klystron output, Blue: circulator output, Green: reflection to klystron)

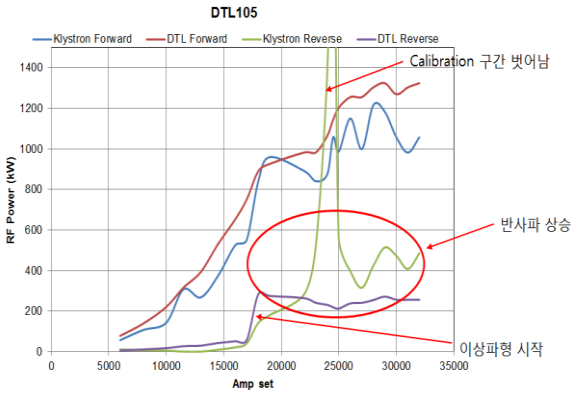

Figure 5: Reflection measurement of klystron

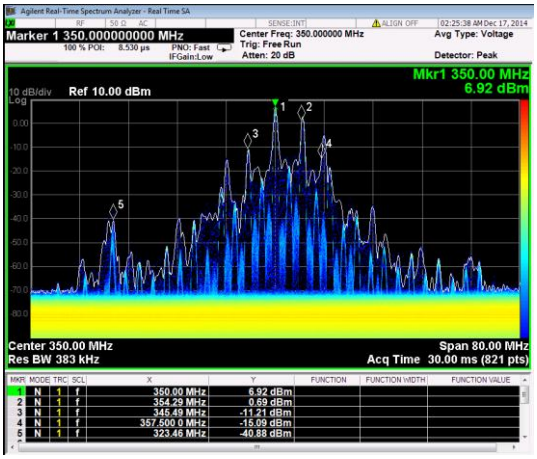

Figure 6: Frequency spectrum at klystron output

Figure 7 shows the radiation from the klystrons during the operation, and we installed a radiation (X-ray) shielding block from the klystron for DTL101, which consists of a lead plate of 2 mm thickness and two SUS plates of 1 mm thickness based on the calculation for the radiation reduction.

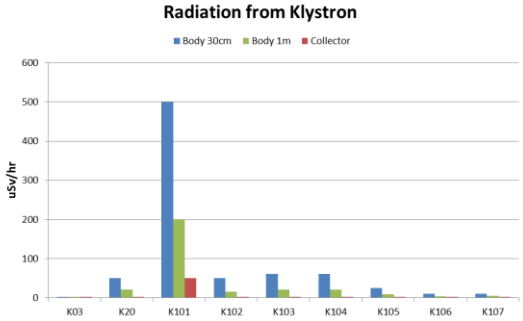

Figure 7: Radiation measurements from klystrons

4. Conclusions

Nine sets of the klystrons have been operated for the KOMAC 100-MeV proton linac. The klystron filament heating time was 5700 hours and RF operation time was 2863.4 hours during the operation in 2014. Some klystrons have unstable RF waveforms at specific power level. We have checked and tested the cavity frequency adjustment, reflection from a circulator, high power test without a circulator, and frequency spectrum at the unstable RF. We have discussed the problem with Thales (manufacturer) to solve them.

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REFERENCES

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