

## Long Term Behavior of the Modulator Voltage and Klystron Perveance Measurement

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### 1. Introduction

A modulator developed for the 100 MeV proton linear accelerator was installed and tested in the 20 MeV linac. The modulator drives two klystrons simultaneously, one for the RFQ, the other for the DTL. These klystrons were triode type with mod-anode [1]. The typical operation parameters of the modulator during the operation of the 20 MeV proton linac are 85 kV of the pick voltage, 34 A of the peak current, 1 ms of the pulse width, 4 Hz of the pulse repetition. In this paper, the results of the long term behavior of the modulator voltage and klystron perveance measurement are presented [2].

### 2. Modulator Operation

#### 2.1 Long Pulse Operation

To prepare the long pulse operation of the modulator, 500 us of the pulse width was extended to 1 ms. The results in the long pulse operation is shown in the Fig. 1 and Fig. 2.

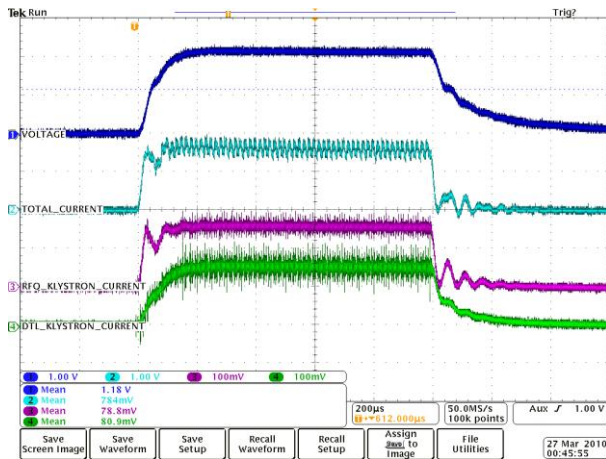


Fig. 1. Voltage and current profile of the modulator. (Ch 1: Voltage (40kV/V), Ch 2: Total current (20A/V), Ch 3: RFQ klystron current (1A/10mV), Ch 4: DTL klystron current (1A/10mV), Horizontal scale: 200us/div.)

The voltage droop was 1.8% for the 1ms pulse and the flat top average voltage was 86.8kV. The voltage droop during the machine operation will be solved to apply the droop compensation.

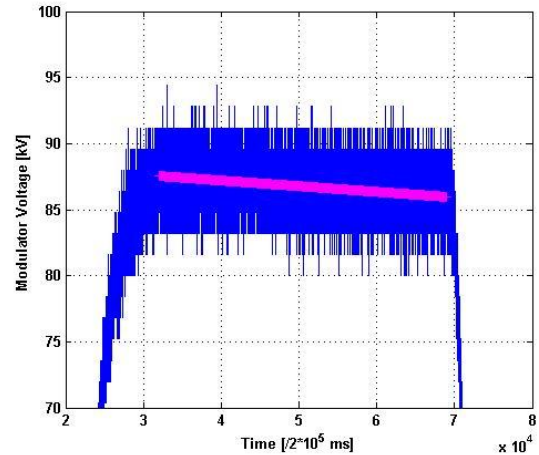


Fig. 2. Voltage droop in long pulse operation

#### 2.2 Long Term Operation

The average number of pulse of the modulator during the test was about 140,000 for 8 hours operation. The example of the modulator voltage during test was shown in Fig. 3 and the results of the long term operation are summarized in the Table I. In this case, the operation condition of the modulator was 87 kV of the output voltage, 8 hours of the operation time, 2 and 4 Hz repetition rate, 0.5 and 1 ms of the pulse width, 2.8 MW of the peak power.

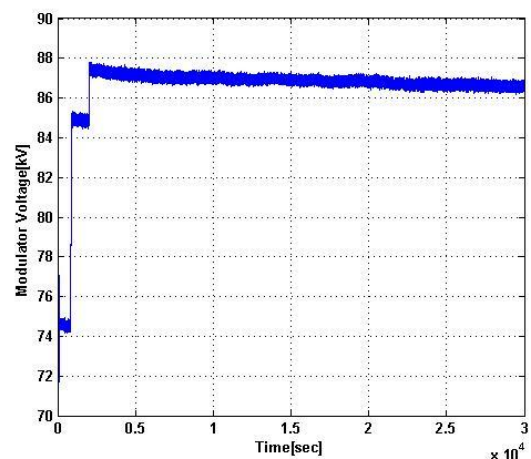


Fig. 3. Modulator voltage deviation during operation

The voltage decreases about 0.8% from initial value. The reason of the voltage decrease is assumed that modulator average power is much lower than design

value that is 520 kW. The voltage fluctuation along the average was less than 0.2%.

Table 1: Results of the long term operation

	1st	2nd	3rd	4th
Average voltage[kV]	86.9	87.2	87.0	86.1
Voltage droop[kV]	0.7	0.59	0.81	0.6
Voltage fluctuation std.[kV]	0.14	0.16	0.16	0.16

### 3. Klystron Perveance Measurement

The specifications of the klystron (TH2089F, THALES) for DTL of the 20 MeV Linac are 350 MHz of the frequency, 1.1MW of the maximum average RF power, less than 95 kV of the beam voltage, triode type electron gun. The values measured at the factory were such that 0.68 uperv. in beam perveance, 1.44 uperv. in gun perveance [1].

The layout of the klystron perveance measurement is shown in the Fig.4. The output voltage of the modulator and mod-anode voltage are measured using the output voltage port of the modulator control rack and high voltage probe (VD-150, NORTH STAR) which is shown in the Fig.5. The klystron perveance measurement is summarized in the Tabel 2.

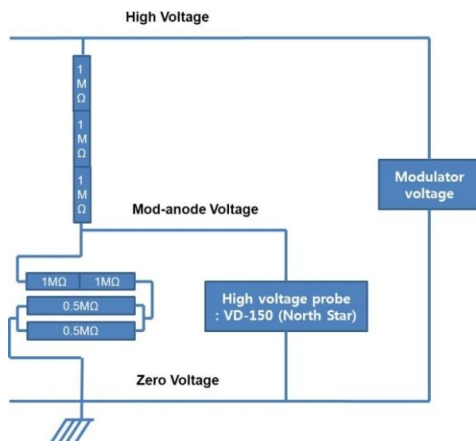


Fig. 4. Layout for klystron perveance measurement



Fig. 5. Installation for measurement of the mod-anode voltage

The beam perveance was similar to the value measured at factory, but the gun perveance was higher that measured at factory.

Table 2: Summarized the klystron perveance measurement

	1st	2nd	3rd	4th
Output voltage[kV]	86.6	85.2	85.2	85.2
Mod-anode voltage[kV]	47.9	46.6	45.9	45.8
Output current[A]	16.8	16.8	16.8	17.1
Beam perveance[uperv.]	0.66	0.67	0.67	0.69
Gun perveance[uperv.]	1.6	1.67	1.7	1.74

### 4. Conclusion

In this paper, the long pulse and long term operation of the modulator were summarized. The voltage droop in the long pulse operation was 1.8% which will be compensated by proper droop compensation method. The voltage decrease for 8 hours operation was 0.8% which is probably due to the low average power operation. The klystron perveance was measured and the higher value in gun perveance should be checked.

### ACKNOWLEDGMENT

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### REFERENCES

- [1] Hyeok-Jung Kwon, et al., Test of the 20-MeV Proton Accelerator Using Modulator, Transactions of the Korean Nuclear Society Spring Meeting, Pyeongchang, Korea, May 27-28, 2010
- [2] Dae-Il Kim, et al., Installation and Test of High Voltage Converter Modulator for PEFP Proton accelerator, The 13<sup>th</sup> International Conference on Accelerator and Beam Utilization, October 13-14, 2009