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Operational Parameters Stability of KOMAC Proton Linac

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1. Introduction

A 100-MeV proton linac installed at KOMAC (Korea Multi-purpose Accelerator Complex) has been operated and provided accelerated proton beams to beam users from various fields since 2013 [1]. Beam stability is critical and important issues for some of proton beam applications such as detector experiments and nuclear data evaluation. The stability of accelerated beam depends on and is affected by various factors including, for example, RF power stability, ion source stability, magnet system stability and cavity resonance stability. In addition, those factors having influence on the accelerated beam stability are affected by several other factors. To be specific, RF power stability is heavily dependent on klystron stability, modulator stability and LLRF system stability.

To provide more stable beam to users, we investigated stabilities of several operational parameters such as RF power stability and temperature related parameters. In fact, the stability can be divided into two categories: one is pulse-to-pulse stability and the other is stability during a period of a single beam pulse. We focused on pulse-to-pulse stabilities, which show long term variation of the major operational parameters. The measured stabilities and impacts on the accelerated beam stability are given in detail.

2. Parameter Dependence Model

The proton accelerator at KOMAC consists of various parts and nearly all of them have some effects on the final stability of the accelerated beam [2]. A simplified diagram, which reveals the inter-dependency of main operational parameters, is shown in Fig. 1. The accelerated beam stability is directly affected by RF power stability, cavity resonance stability, magnet system stability and an ion source extraction current stability as shown in Fig. 1.

The RF power stability is dependent on several factors such as transmission line including RF dummy load and circulator, LLRF system and HVCM (high voltage converter modulator) stability [3]. For example, the high voltage output from HVCM to klystron may have some droop and this droop is translated to phase shift and power droop in the klystron output. A rough estimation shows that 9 degree phase change in the output occurs if the high voltage varies to 1%. This amount of phase change is absolutely not acceptable for the accelerator and should be taken care of by feedback control action in LLRF system.

The resonant frequency of an accelerating cavity depends heavily on the temperature of the coolant, which is supplied by RCCS (resonance control cooling system). The sensitivity is about 4 kHz variation of the resonant frequency per 1 degree temperature change. Therefore, the coolant temperature should be control better than 0.1 degree to maintain resonant condition. This can be done by PID control of three-way mixing valve in the RCCS system.

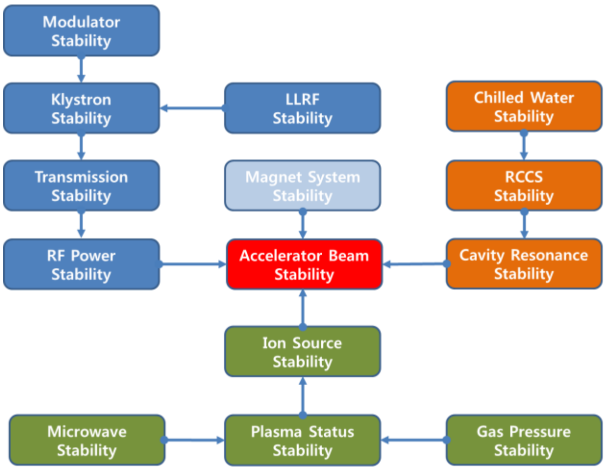

Figure 1: Operational parameter dependency

If there are some variations in the magnet system, the beam transport along the accelerator and beamline is greatly affected. The magnet system, however, is considered to be stable enough compared with other operational parameters due to its large inductance.

The ion source stability, which has direct impact on the accelerated beam stability, is related with the plasma status inside the ion source and the gas pressure and microwave power are important factors having effect on the plasma stability. The extracted beam current also heavily depends on the extraction high voltage stability.

In summary, many factors are related and have some effects on the accelerated beam stability and should be carefully considered and monitored to result in stable beam operation

3. Measurement of Stability

Among various factors, we measured the stability of some major operation parameters such as the modulator output voltage (Fig. 2), RF power and phase (Fig. 3 and

4), the RCCS temperature (Fig. 5) and the ion source current (Fig. 6). The measured data were plotted as a function of time from 9 AM to 6 PM on one specific day. The RF system was operated in open loop control mode purposely to see the variation clearly. From the measurement results, the overall stability of the modulator and RF amplitude is reasonably good. However, it is clear that the RF phase and RCCS needs to be enhanced in stability aspect.

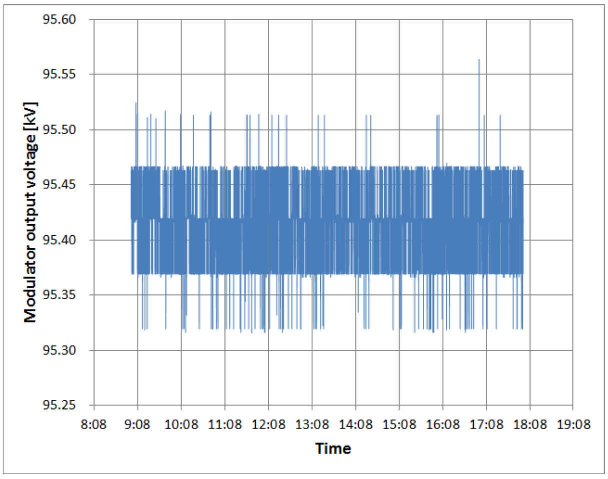

Figure 2: Modulator voltage output

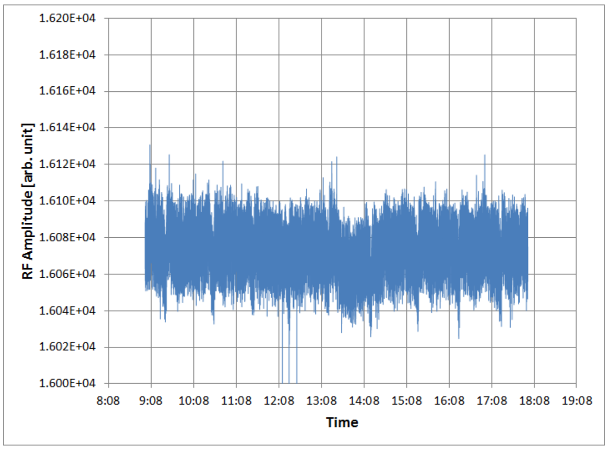

Figure 3: DTL102 RF Amplitude

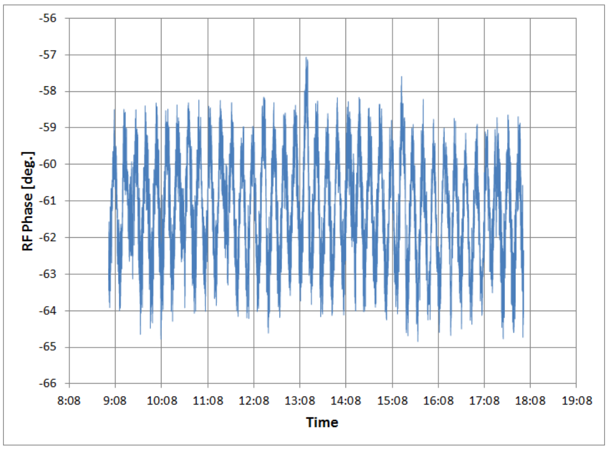

Figure 4: DTL102 RF Phase

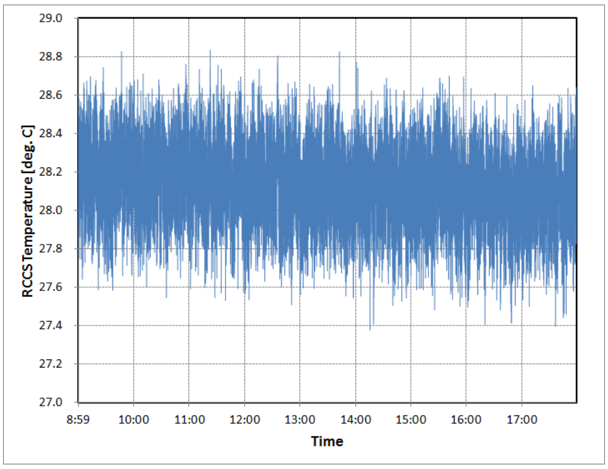

Figure 5: RCCS102 Temperature

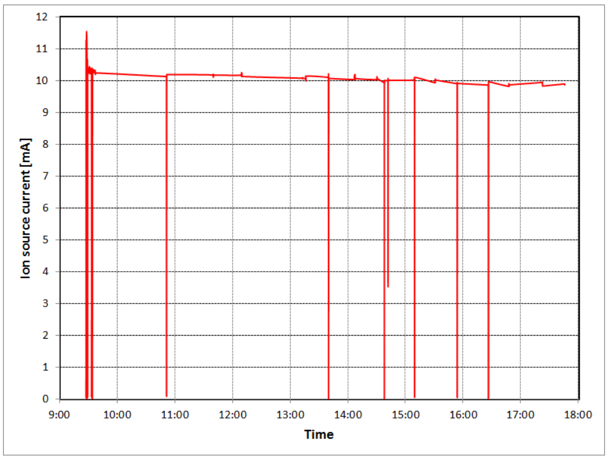

Figure 6: Ion source current

Acknowledgment

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