Development of the Modulator auto start at KOMAC

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1. Introduction

In KOMAC(Korea Multi-purpose Accelerator Complex), we operate a 100 MeV proton accelerator. To provide a stable proton beam, a High Power Radio Frequency (HPRF) system operates 24 hours on weekdays. Since the equipment continues running after working hours, in case of any equipment shutdown, the equipment manager will handle the restarting equipment upon returning to work. Even after restarting the equipment, there is a required stabilization period, which can adversely affect operational efficiency and the provision of a stable beam.

To improve this process, an automatic operation of the HPRF equipment is proposed. This aims to automatically assess the equipment's status when it stops due to an interlock, enabling the normalization of the equipment without the presence of the equipment manager. The application of automatic operation to the HPRF system is expected to enhance equipment operational efficiency, ensure a stable beam, and reduce fatigue for both operators and equipment managers. In this presentation, our focus will be on the development and implementation of the auto-start feature for the system corresponding to the modulator

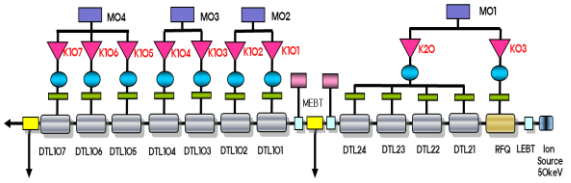

Figure 1. HPRF system at KOMAC. [1]

2. HPRF auto start system

HPRF system is divided into three subsystems: Klystron, Modulator, and RF System. We aim to implement auto-start systems for each of these systems and integrate them for unified operation.

The concept of HPRF auto start is as follows: in the event of an interlock in the HPRF system, a latch for the interlock is engaged. Simultaneously, the auto start is activated according to the predefined scenario. The determinants for auto start activation are as follows:

1. If the interlock latch is reset by the interlock latch reset command, assuming an engineer-independent automatic recovery sequence is possible, auto start is activated. This allows for automatic recovery even in the absence of an engineer.
2. If the reset is unsuccessful, disabling automatic recovery, on-site verification by an engineer and manual recovery is inevitable. In this case, auto start remains inactive, highlighting the necessity of engineer inspection for resolution.

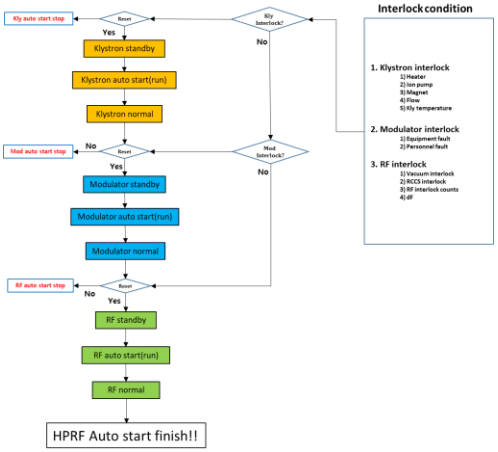

Figure 2. HPRF auto start scenario.

2.1 Control system

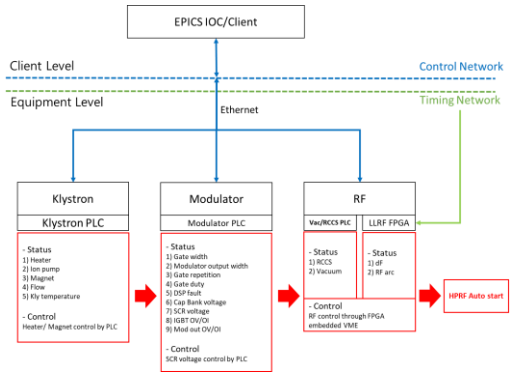

Figure 3. Control system of HPRF auto start.

The HPRF auto start control system is illustrated above(Figure 3). At each Equipment level, the hard-wired system detects interlocks initially and proceeds to shut down the equipment. Secondly, at the client level

corresponding to the EPICS IOC server, the auto start system is activated according to predefined scenarios.

In the case of Klystron and Modulator, each system's PLC detects interlocks, initiates equipment shutdown, and simultaneously transmits the interlock signal to the client level, which is the EPICS IOC. Subsequently, upon receiving the auto start command signal, the auto start sequence is activated.

For the RF system, except for the fact that the Equipment level is FPGA, the auto start scenario is the same as the previously mentioned scenarios for Klystron and Modulator.

2.2 Modulator auto start

The Modulator, a component of the HPRF system, already features an implemented Hardwire interlock system, ensuring stability from an equipment perspective. Consequently, it was the first to undergo both trial and normal operation.

The Modulator auto start system is activated through the following sequence. The Modulator's auto start sequence mirrors the actual operational steps performed by engineers. Additionally, to enhance the stability of the automatic recovery sequence, a checking sequence is added to iteratively monitor the Modulator's output parameters.

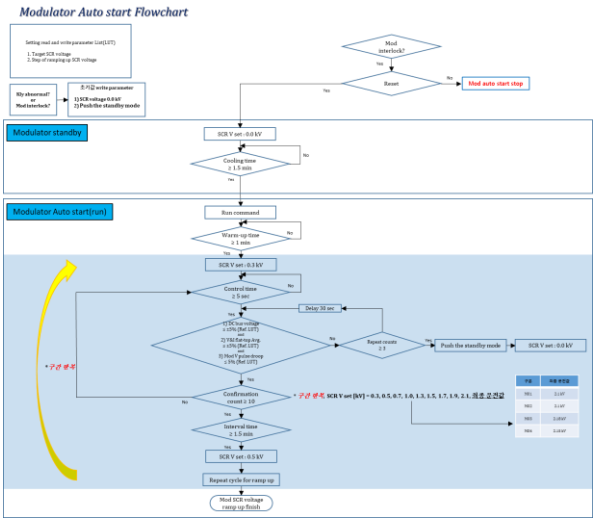

Figure 4. Modulator auto start flow chart.

The Figure 5 represents the interface for the Modulator auto start currently in normal operation at KOMAC. The above sequence has been implemented through an EPICS sequence script, featuring real-time setting and monitoring values. Additionally, the text log function has been applied to track the sequence progress status over time.

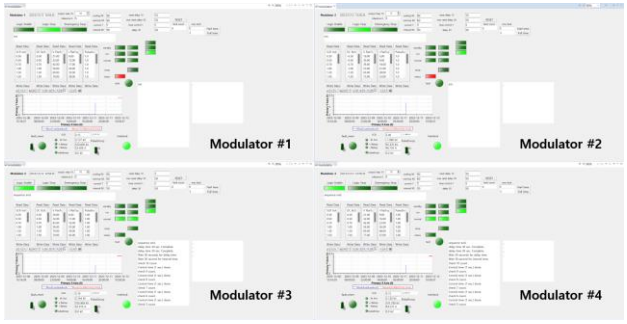

Figure 5. Modulator auto start system GUI.

Figure 6 is the actual activation of auto start on Modulator #04. The red data represents the interlock flag signal, while the yellow data indicates the output voltage of the modulator. The interlock flag changes in the sequence 1−>0−>1, demonstrating the reset of the interlock latch. The yellow data, it is evident that the modulator output voltage automatically boosts according to the configured steps.

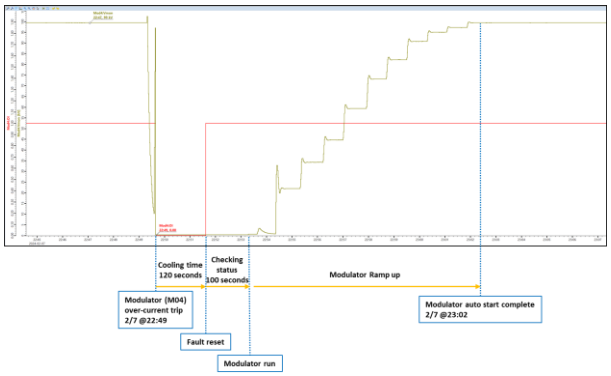

Figure 6. Operation of the Modulator auto start.

3. Conclusions

The current HPRF auto start system is officially operational only for the Modulator. We plan to implement the Klystron - RF auto start system by next year and integrate it into the entire HPRF system. This is anticipated to contribute to reducing unnecessary fatigue for personnel and enhancing equipment operational efficiency.

ACKNOWLEDGMENT

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[1]H. S. Kim, H. J. Kwon, Y. S. Cho, Operation of KOMAC 100-MeV LINAC, 28th Linear Accelerator Conference, 29 Sep, 2016