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The RF Interlock System for the KOMAC 100-MeV Proton Linac

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1. Introduction

The 100 MeV proton linear accelerator at KOMAC is driven by the high power RF system which is composed of a total of 9 RF subsystem. Each subsystem including digital LLRF system, high power klystron and RF transmission components such as directional coupler and circulator has an interlock system to protect equipment. Due to its high peak power and crucial role in accelerator operation, an RF interlock system is very important to protect the machine. In case of any fault event such as arcing in RF window or high VSWR, RF power should be shut off within a few micro-second. For that purpose, we developed an RF interlock box with VSWR detection function and auto-reset function. The interface for a remote control and monitoring is integrated into machine protection system.

2. KOMAC RF system overview

The RF system includes the low-level RF control system and the high power RF systems such as a solid state RF amplifier, wave guide, klystron, circulator, and RF window were installed in the klystron gallery and the accelerator tunnel. The RF duty is 9% (1.5 ms, 60 Hz). The operating frequency of the RF system is 350 MHz. In our system, an accelerating electric field stability of ± 1% in amplitude and ± 1° in phase is required for the RF system. Now a total of 9 RF systems are being operated. In the 20 MeV part of the linac, there are 2 klystrons, one for RFQ and the other for 4 DTL tanks of the 20 MeV linac. In the energy range between 20 MeV and 100 MeV, 7 klystrons are used and each one drives one DTL tank. The peak power of klystrons is 1.6 MW [1].

Fig. 1. Klystron gallery (klystron, circulator and LLRF system were installed in this place)

3. RF interlock system design

The RF interlock system has been designed to switch off the RF drive and to protect the high power RF equipment against RF arc and abnormal VSWR. The interlock system uses the status of the critical subsystems such as the high power RF components and VSWR measured from the forward and reverse RF power. The RF arc signals are detected at three points including the klystron window, the circulator and the RF window. The interlock system also monitors a vacuum condition in DTL tank. When the fault signal is detected, the RF drive should be switch off within a few macro-seconds.

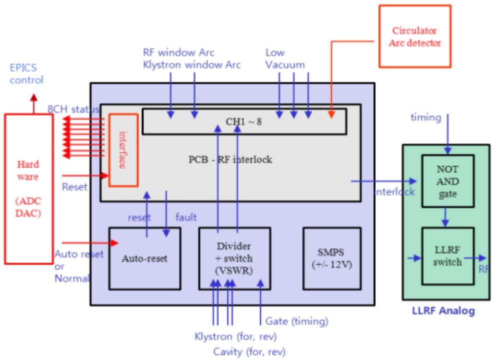

Fig. 2. Block diagram of the RF interlock unit.

Figure 2 shows the block diagram for the local interlock device for the RF faults including the RF arc and the abnormal VSWR. The interlock device includes a fast analog interlock module with comparators and latches, an auto-reset module, a VSWR module for the RF interlock device, and power supply [2]. The interlock device has eight channel inputs and is connected to the EPICS control system for monitoring the interlock status.

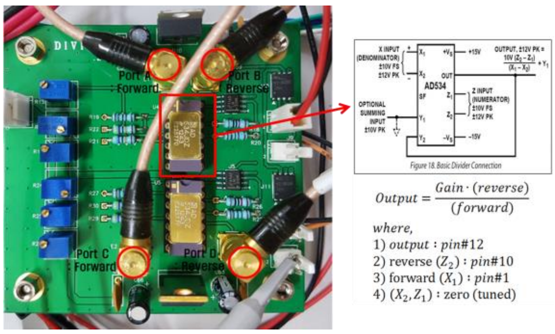

Fig. 3. VSWR detection module

Figure 3 shows VSWR interlock board which generates interlock signal when the ratio of forward and reverse signals is more than a certain value.

5. interlock test

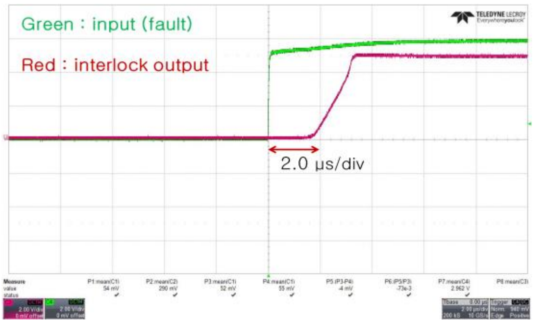

Fig. 4. Response time measurement of the RF interlock unit.

The response time of the interlock device was within 3us as shown in figure 4. A total of 9 RF interlock boards have been tested, and their average response time is within 3us.

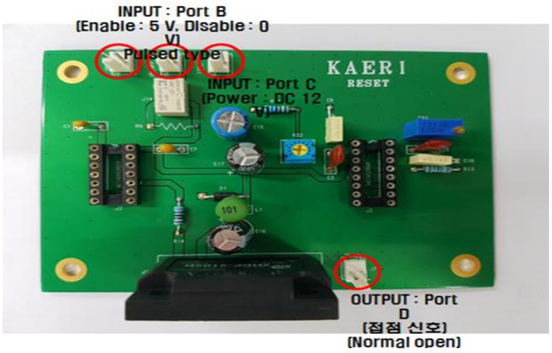

Fig. 5. Auto-reset board in RF interlock unit.

Figure 5 shows an auto reset board for special cases such as RF Conditioning. If a fualt such as RF arcing occurs, it turns off the RF drive and resets the RF interlock before the next RF pulse interval. Figure 6 shows that the interlock signal is released after a certain period of time.

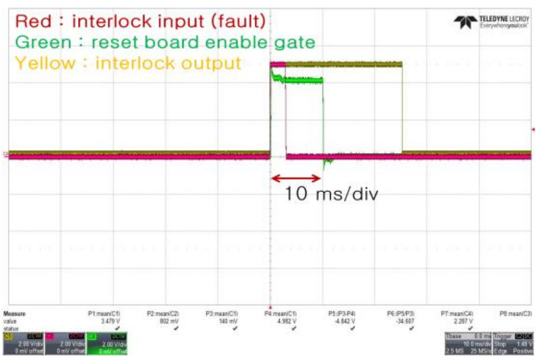

Fig. 6. Auto-reset board test

6. Conclusions

The high power RF system needs the interlock system to protect critical high power components from a variety of the faults including the RF arc and the abnormal VSWR. The RF interlock system must identify a range of faults across a total of 9 RF subsystem, and must be able to switch off the RF drive within a few macro-seconds before damage is caused. The RF interlock system consists of an RF interlock module, an auto-reset module, and a divider module for the VSWR detection. The test results mean that the RF drive can be shut off within 4µs in the case of a fault event during the linac operation, and the HPRF system can be protected from the faults.

REFERENCES

[1] Y.S. Cho et al., "The KOMAC Accelerator Facility", Proceedings of IPAC'13, Shanghai, China (2013).

[2] K.T. Seol et al., "Design of Machine Protection System for the PEFP 100 MeV LINAC", Proceedings of IPAC'12, New Orleans, USA (2012).