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Development and operation of fast protection for KSTAR

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HIGHLIGHTS

- The evolution of KSTAR machine interlock system.
- The evolution of KSTAR fast interlock.
- The fast interlock interface.
- The operation results of the fast interlock.

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ABSTRACT

Protection for the Korea superconducting tokamak advanced research (KSTAR) is somewhat more complicated than for the previous tokomak generation. External reasons for this increased complexity are the initial and maintenance costs, and internal reasons relate to various characteristics of the tokamak and long pulse operation. KSTAR has two protection mechanisms: the device protection system protects damage to superconducting coils etc. from events within the other systems, and the fast protection system protects the internal vacuum vessel components against damage from heating and the long pulse plasma.

The fast protection system initially contained the plasma control system (PCS), central control system (CCS), and the heating devices. In 2012, a fast interlock interface was implemented for PCS fail-safe. This detected the absence of plasma current using the diagnostic signals and discharge operation gate windows of the timing synchronized system (TSS), and activates the operation gates and heating stop from the CCS. Additional fast interlock logic was implemented to reduce damage to the plasma facing components (PFC) and other materials by overheating and improper operational state of heating systems after starting the discharge sequence. However, the fast interlock interface system has failed to protect the heating during PCS malfunctions since 2013.

This paper introduces the KSTAR protection system, and describes the fast protection interface, with testing and operational results, then discusses future plans for a more effective and safer protection system.

1. Introduction

The fast interlock is part of the machine interlock system for the Korea superconducting tokamak advanced research (KSTAR) [1–4]. The machine interlock system has been upgraded every year with additional or modified supplementary systems since 2008. Major alterations to interlock functions depend on changes to heating devices and power supply systems. The fast interlock concept was adopted in 2009 to protect from heating beam injection into the tokamak while plasma density was low, and the function logic was updated to protect against the neutral beam (NB) injection at low plasma density, to increase KSTAR heating capacity.

In 2012, the fast interlock system needed new logic and devices to prevent damage from increased heating capability in the event of plasma control system (PCS) malfunction after commencing a shot. The first fast interlock interface device was designed and manufactured, but testing showed device required updated protection logic. In 2013, the updated system was tested with real signals and events, and was integrated into the machine interlock system in 2014.

The fast interlock system comprises PCS, central control system (CCS) [5], fast interlock interface system, diagnostic system and time synchronization system (TSS). This paper briefly describes the machine interlock system and the architecture of the fast interlock

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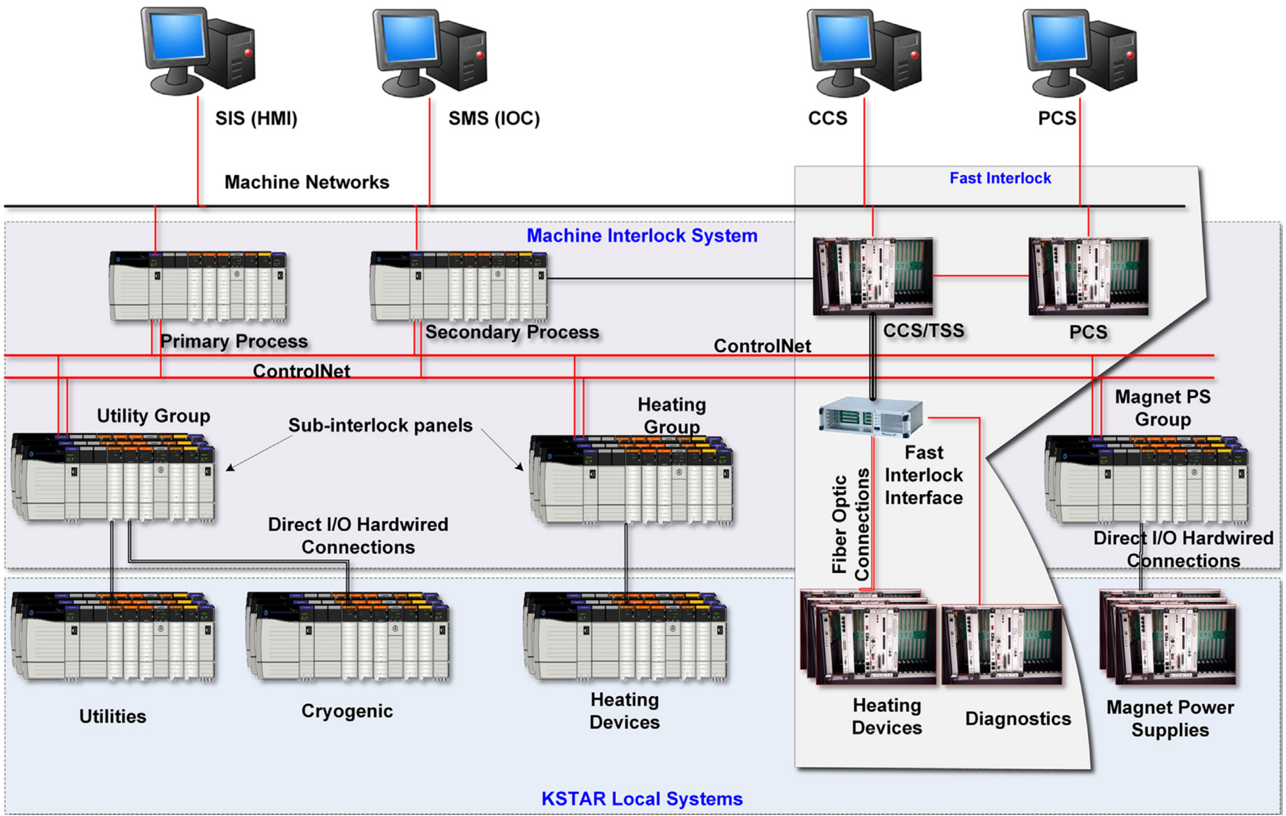

Fig. 1. Architecture of KSTAR machine interlock and fast interlock systems.

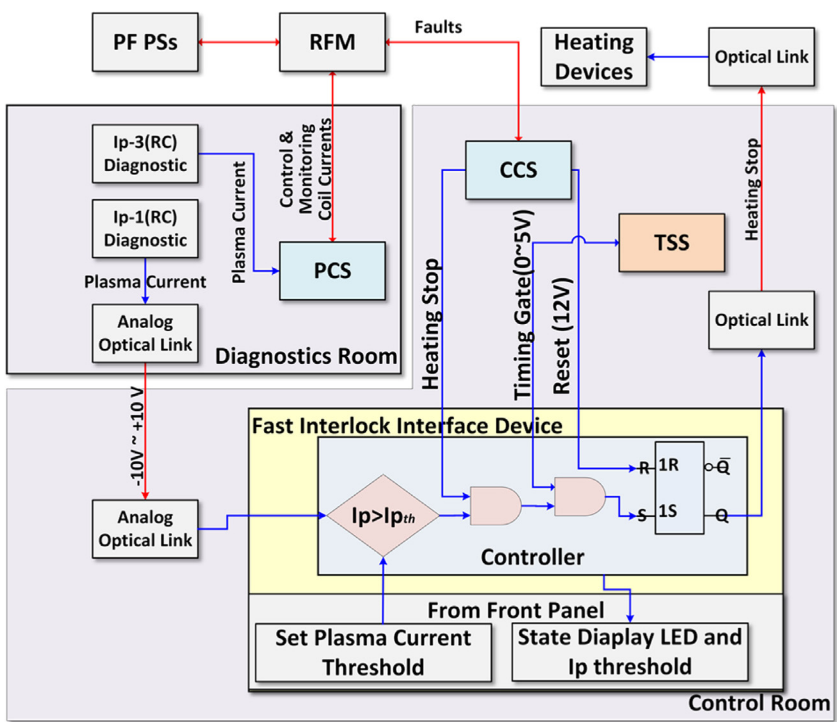

Fig. 2. Fast interlock signal flow, version 3.