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Reliable Local Controller for ITER Coil Power Supply

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Abstract

The AC/DC converter supplies direct current of up to 68 kA continuously to ITER superconducting coil for a few weeks or months. It requires a reliable controller because the energy up to gigajoule units is stored in the superconducting coil.

In this paper, the design methods and characteristics of ITER local control system are explained to meet the requirements and for the high reliability.

Introduction

ITER I&C system is divided into central I&C system and plant system I&C as shown in Figure 1. Plant System I&C shall monitor all the parameters of the system and shall have features included for local operation and machine protection.

The proposed local controller for AC/DC converter is required high reliability for below reason:

- The converter supplies direct current to superconducting coils and they store a large amount of energy in units of gigajoules.
- The local controller controls up to 6 series AC/DC converter (4-Quadrant).

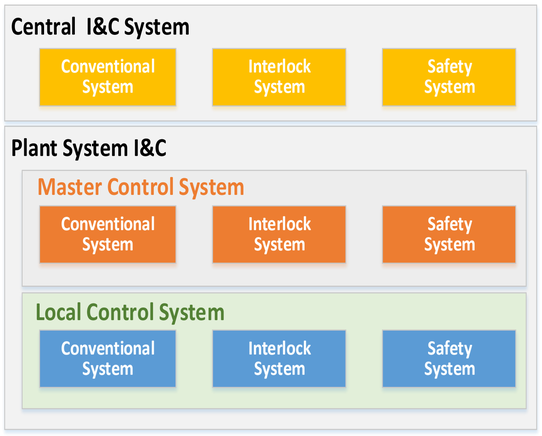

Fig1. ITER I&C System

Reliable Local Controller for Korea AC/DC Converter

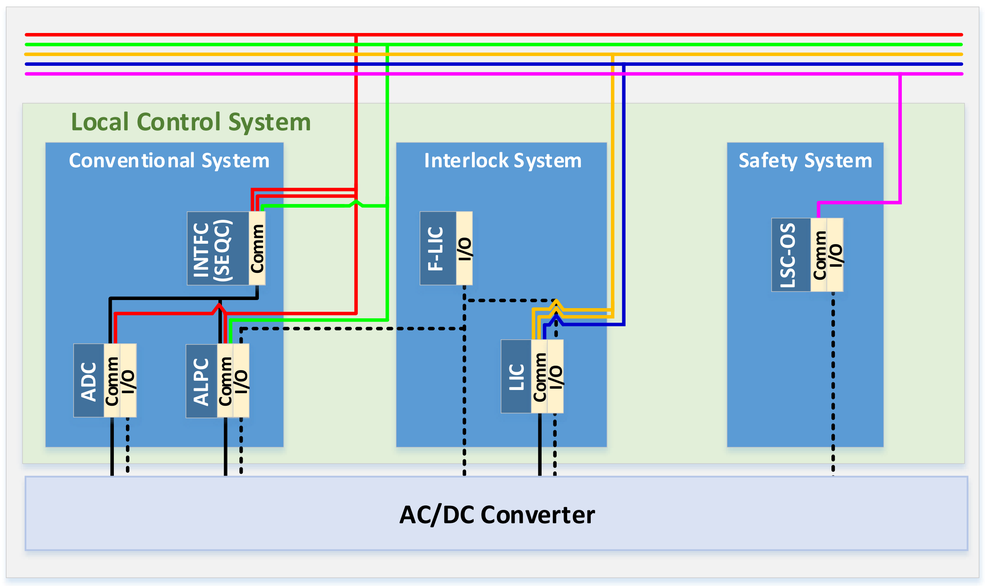

Fig2. Network Architecture of Local Controller

The local controller for AC/DC converter, which supplies power to ITER superconducting coil, consists of Conventional system, Interlock system and Safety system.

- **Conventional system** provides control, local data acquisition, monitoring, alarm handling, logging, event handling and data communication functions.
- **Interlock system** provides local device protection functions for AC/DC converter.
- **Safety system** provides occupational safety functions for AC/DC converter.

Table1. Role of Components

INTFC (SEQC)	Provides interface with host system to receive control commands and operation parameters for ALPC. INTFC is for only one converter. SEQC is for up to 6 series converter
ALPC	Controls converter with commands and operation parameter from INTFC(SEQC) with 2.5kHz frequency.
ADC	Acquires data from converter
F-LIC	Provides local investment protection functions and monitors critical converter status and interlock status of parent system.
LIC	Monitors data related local investment protection and determines if the converter is in normal operation.
LSC-OS	Transmits occupational safety related data to parent system.

In order to provide reliable control converter, we propose to apply 3 features to the local controller as follows:

- [1)]Multi transient data recorder and dual channel communication
- [2)]F-LIC for local investment protection at the top level
- [3)]Configuration using reliability certified controllers

[1)] Multi Transient Data Recorder and Dual Channel Communication

The conventional system is designed with multi transient data recorder and backup data for reliable control.

Multi Transient Data Recorder

When operating AC/DC converter, INTFC (SEQC) and ALPC collect logging data into the circular buffer. If some fault occurs, they save logging data from the circular buffer.

- Logging period is 200 ms (pre-trigger 100 ms, post-trigger 100 ms)
- IEEE 1588 Precision Time Protocol (error < 50 ns) is applied

Dual Channel Communication

For normal operation, communication with the parent system is dual channel communication

- 1kHz UDP communication for real-time data
- 10Hz TCP communication for slow data

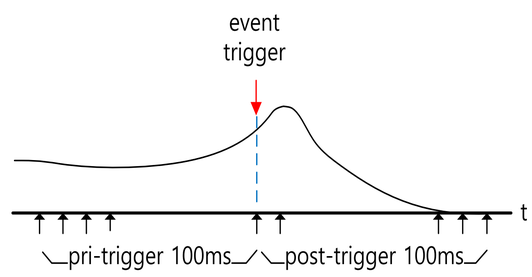

Fig3. Transient Data Sampling

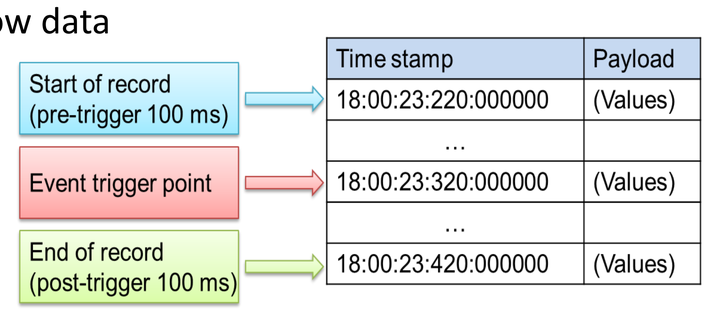

Fig4. Example of Transient Data

[2)] F-LIC for Local Investment Protection at the Top Level

The F-LIC requires high reliability because it should perform the protection of local investment as the top level equipment under any circumstances.

- Designed/developed **as analog circuit board**
- **"IEC 61508 Compliance Assessment"** is performed

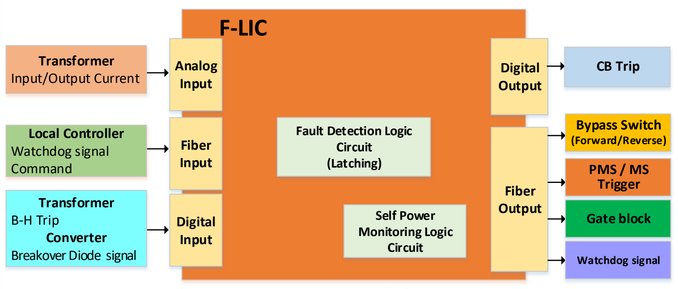

Fig4. F-LIC Architecture

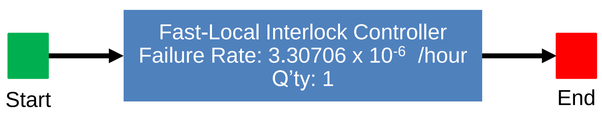

Fig5. F-LIC Hardware Reliability Block Diagram

Table2. Assessment Result of F-LIC

Item		ITER Requirement	Assessment Result
FMEDA	PFD	$< 10^{-2}$	**2.0044×10^{-3}**
	PFH	$< 10^{-6}$	**3.0621×10^{-7}**
FMECA	RPN	-	**4 ~ 9**

FMEDA : Failure Mode, Effect and Diagnostic Analysis
FMECA : Failure Mode, Effect and Criticality Analysis
PFD : Probability of Failure per Demand
PFH : Probability of Failure per Hour
RPN : Risk Priority Number

[3)] Configuration using Reliability Certified Controllers

Reliable local controller requires high reliable component. Zynq SoC with built-in ARM standard Intellectual Property (IP) core is used for conventional system. The local interlock system and safety system are required SIL-2 level, but we applied over qualified SIL-3 PLC. And CPU power module and its communication are redundant in order to ensure reliability.

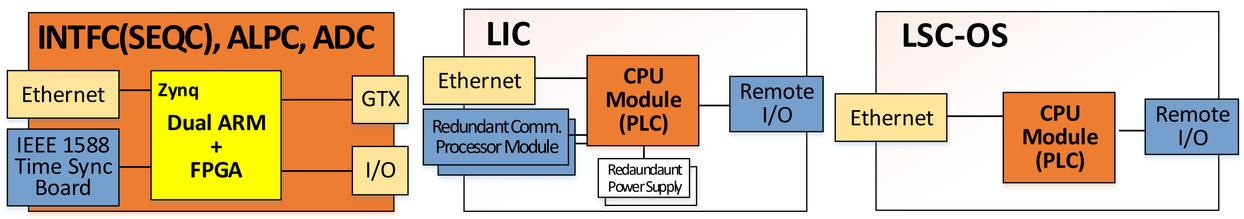

Fig6. INTFC (SEQC), ALPC, LIC, LSC-OS Architecture

Conclusion

ITER AC/DC converter requires reliable control. In this paper, we proposed to enhance the reliable local controller for ITER AC/DC converter with;

- Multi transient data recorder and dual channel communication
- F-LIC for local investment protection at the top level
- Configuration using reliability certified controllers

Figure 7 shows cubicles that implement each system. The cubicles will be delivered to the ITER site soon.

Fig7. Conventional/Interlock /Safety cubicle

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