PROTOTYPE DESIGN FOR UPGRADING CENTRAL SAFETY AND INTERLOCK SYSTEM

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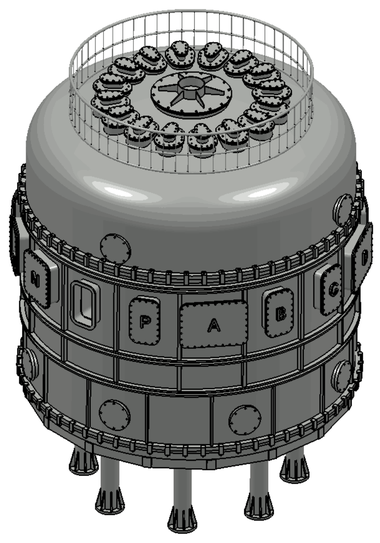
Abstract The national project of experimental advanced superconducting tokamak (EAST) is an important part of the fusion development stratagem of China. The safety and interlock system (SIS) is in charge of implementing the investment protection of human and tokamak from potential accidents. With the development of physical experiment, the CSIS had come close to reaching its limits for expandability. For instance, the former central safety and interlock system based on PLC just offers digital I/O channels with 1ms scan time. What more, the primitive GREEN and RED circles dashboard, and intermittent event record display problem make the central control team determines to update the CSIS. In this paper, we'll present EAST machine and human protection mechanism and the architecture of the upgrading central safety and interlock system.

Background

Experimental Advanced Superconducting Tokamak (EAST)

Magnetically Confined Fusion Engineering

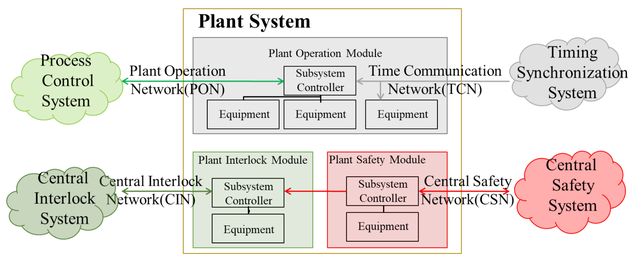


Main parameters of fusion project	
Toroidal field, B_0	3.5 T
Plasma current, I_P	1 MA
Major radius, R_0	1.7 m
Minor radius, a	0.4 m
Aspect ratio, R/a	4.25
Elongation, K_x	1.6-2
Triangularity, δ_x	0.6-0.8
Neutral Beam Injection	4 MW/ line
2.45GHz Lower Hybrid Current Drive	4 MW
4.6 GHz Lower Hybrid Current Drive	6 MW
Electron Cyclotron Resonance Heating	1 MW
Core Temperature	~ 100 million
Pulse Length	~1000s

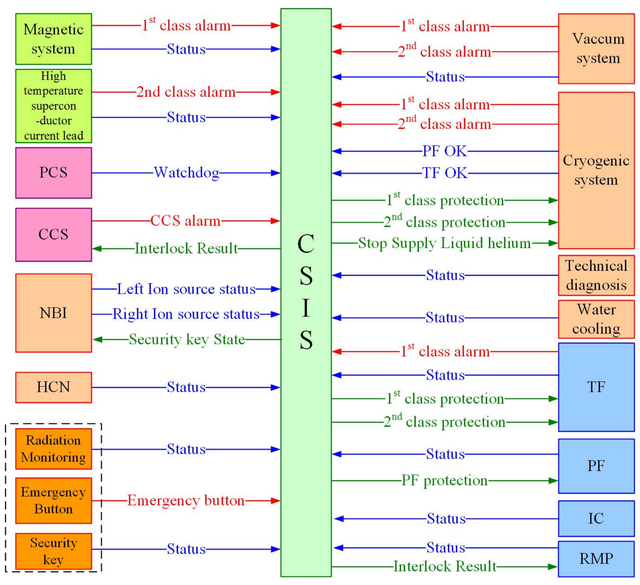
Motivation

- Two architectures should be designed according to timing requirements
  - Slow architecture based on PLC ~ Response time 1ms (compatible)
  - Fast architecture based on cRIO ~ Response time 50μs (new integrated)
- Multifarious security facilities should be integrated into SIS
- More stable, more friendly HMI

Logical Functions



Interface between CSIS and plant systems

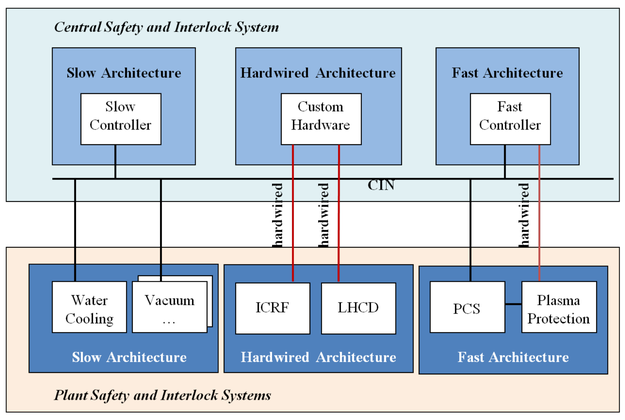


Main Subsystems	
Vacuum	SLOW
Cryogenic System	SLOW
Power Supply System	FAST
Water Cooling System	SLOW
Technical Diagnosis System	SLOW
Hi-Temp Superconductor Current Lead	FAST
Central Control System	FAST
Plasma Diagnostics	SLOW
Data Acquisition & Central Control	FAST
Plasma Control System	FAST
Ion Cyclotron Range of Frequency	FAST
Lower Hybrid Current Drive	FAST
Electron Cyclotron Resonance Heating	FAST
Neutral Beam Injection	FAST
Remote Handling System	SLOW

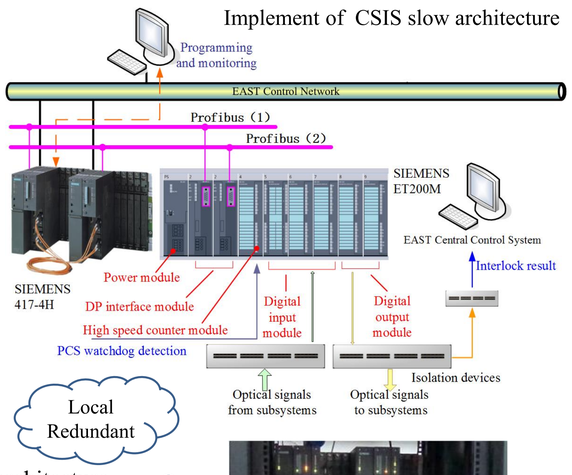
Classification of the prototype SIS signals

Signal	Value	Response
Status	High	OK
	Low	alarm
1st class alarm	High	1st class protection
	Low	OK
2nd class alarm	High	2nd class protection
	Low	OK
Protection	High	actuator
	Low	null

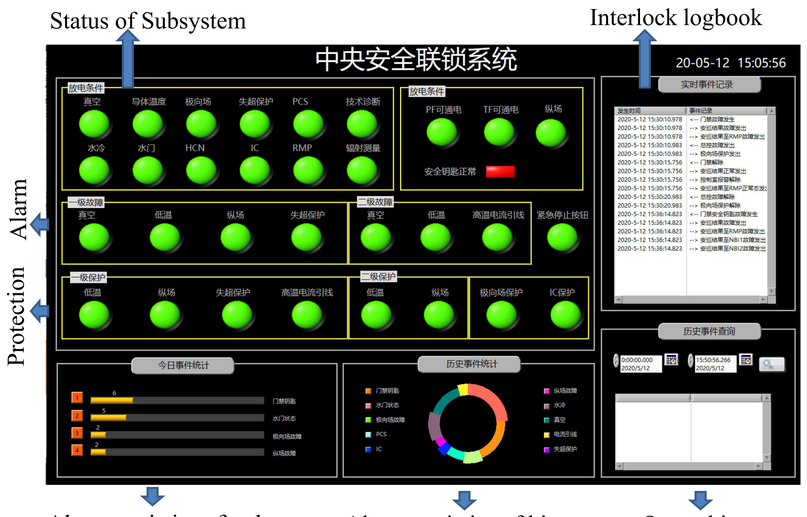
System Components

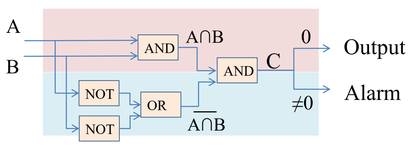


Structure of the prototype SIS



OPC UA Variable from slow and fast architecture are collected through OPC UA



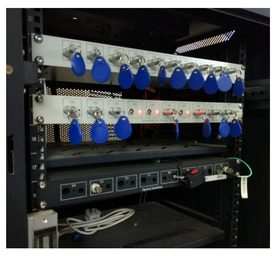


Safety calculation mechanism in FPGA

C=0 Output=A∩B

C≠0 Alarm

Security Facilities in CSIS



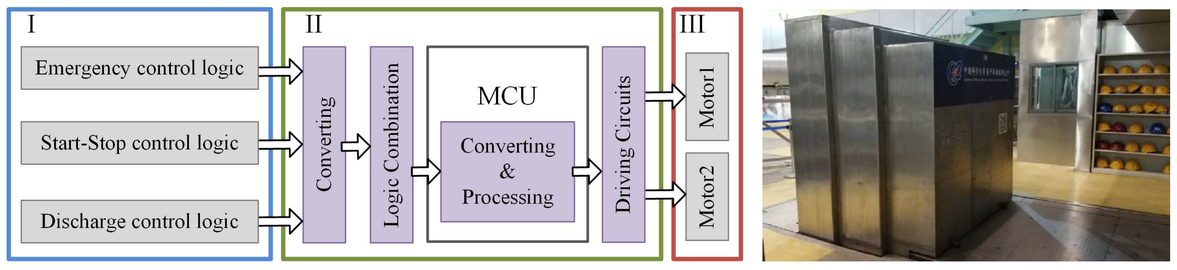
Security key

Face recognition switch

Emergency button

Neutron (n) and Gamma ray (c) detector

All the statuses are integrated in the central safety and interlock system



Logic in Part I decides the states of motors' rotation and water door's proper position

Summary

EAST central safety and interlock system has been redesigned. SIEMENS PLC and National Instruments cRIO are integrated into a single system taking care of slow and fast interlock functions. The fast safety and interlock system is able to react within 50μs. Work supported by the National Key R&D Program of China No.2017YFE0300504 and No.2018YFE0302104.