The Implementation of KTX Central Control System

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Abstract

Keda Torus eXperiment (KTX) is a new medium-sized reversed field pinch (RFP), designed and implemented jointly by the University of Science and Technology of China (USTC) and the Institute of Plasma Physics at the Chinese Academy of Science (IPPCAS). All the components fabrication and assembly completed in August 2015, and the central control system (CCS) has operated stably since the first discharge shot. The CCS for KTX is used to integrate, harmonize and supervise all of the control subsystems, it consists of graphical user interface (GUI), process control system, timing system, safety & interlock system, gas injection system and shot information server. Almost all the systems are implemented by using PXIe devices, and the software environment is LabVIEW Real-Time. The details about the central control system architecture and components will be described in this article.

Background

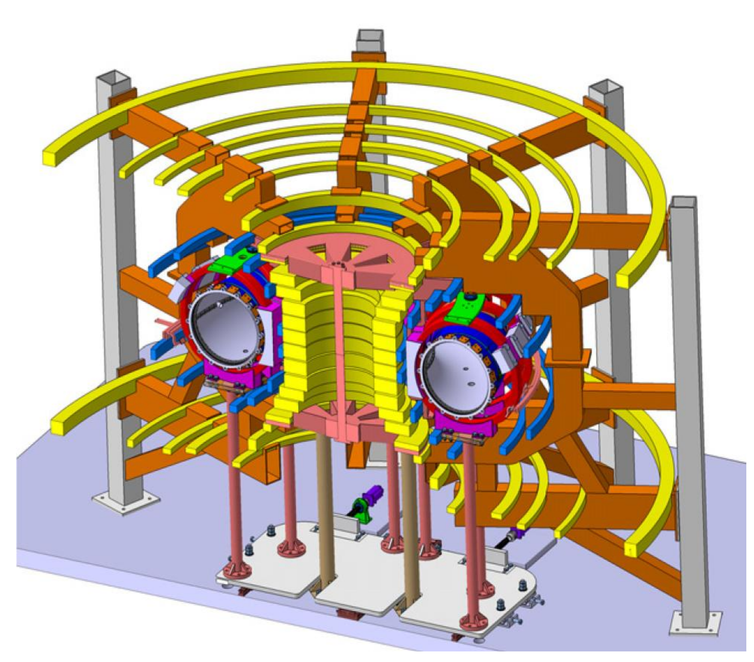
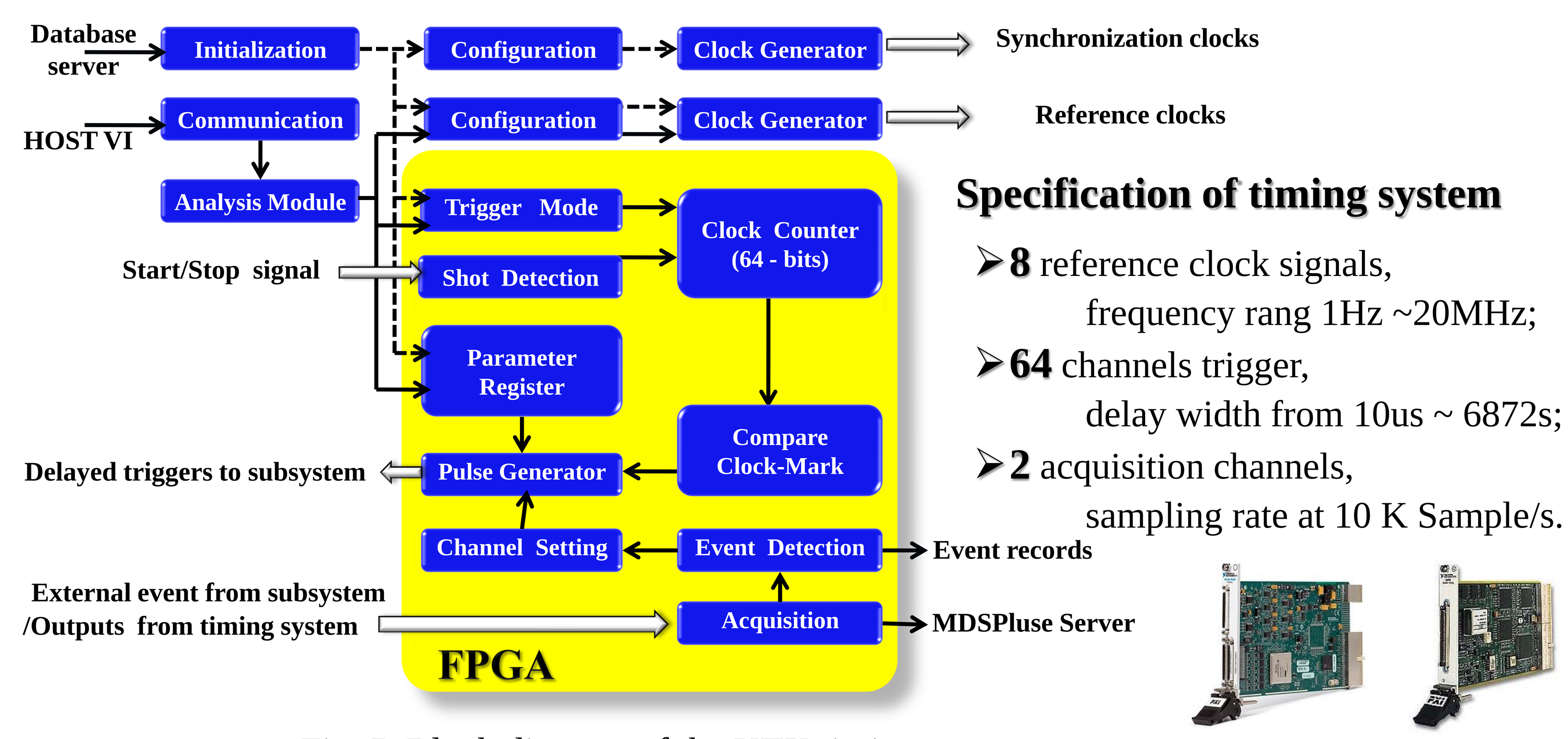


Fig. 1. A cutaway view of the KTX machine

Main parameters of KTX machine	
Major radius	1.4 m
Minor radius	0.4 m
Thickness of vacuum vessel	6.0 mm
Thickness of conducting shell	1.5 mm
Plasma current	1.0 MA
Pulse of discharge	100 ms
Loop voltage	10 ~50 V
Plasma inductance	2.9 μH
Total magnetic flux	5 WB
Electron temperature	800 eV
Plasma density	~ 10^{19} m^{-3}
Maximum TF (averaged)	0.7 T



Specification of timing system

- **8** reference clock signals, frequency rang 1Hz ~20MHz;
- **64** channels trigger, delay width from 10us ~ 6872s;
- **2** acquisition channels, sampling rate at 10 K Sample/s.

Fig. 5. Block diagram of the KTX timing system

Architecture and Functions

Main functions of CCS :

- Kindly GUI for operators;
- Process control and supervision;
- Synchronization and timing;
- Interlock and safety protection;
- Vacuum valves control;
- Provides shot information;
- Network maintenance.

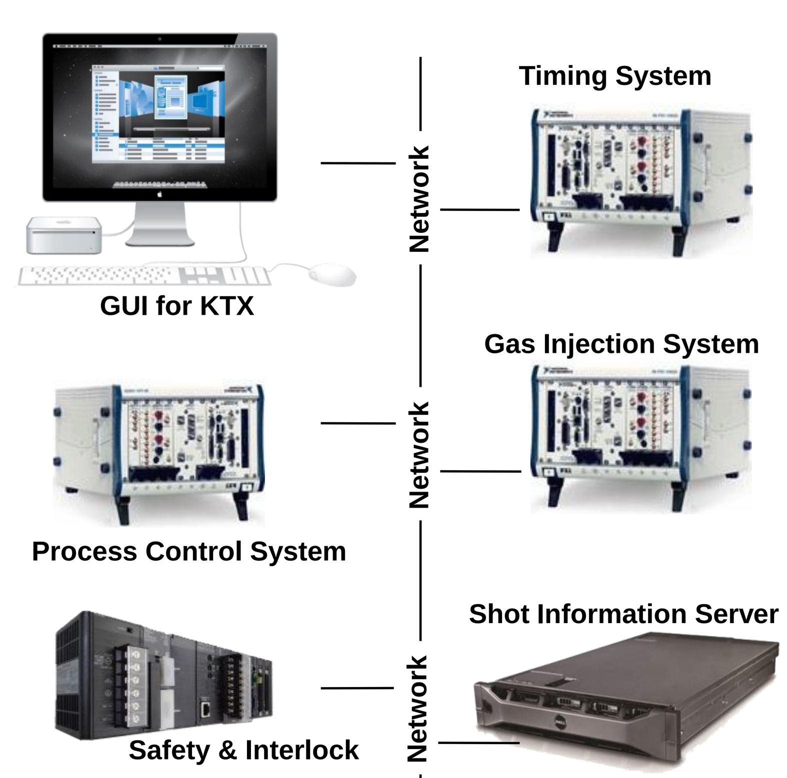
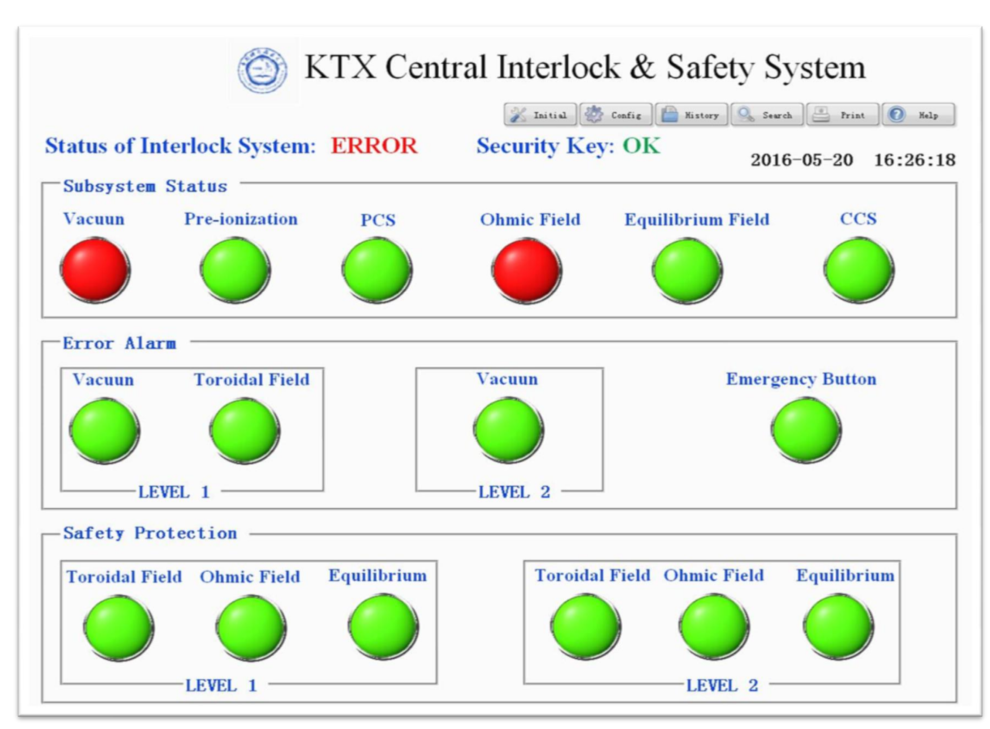


Fig. 2. Structure of KTX central control system



- Scanning time 1 ms Filter: 3-cycle detection

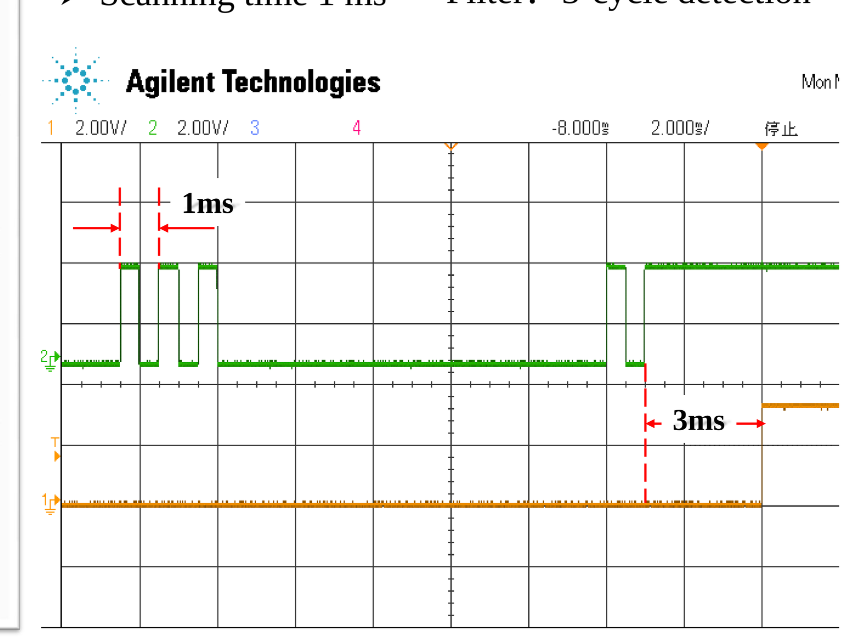


Fig. 6. Touch panel of Interlock & Safety system

Fig. 7. Test result of the I&S response delay

Networks

- Interlock & safety network: multi-model fibers, remove ground loops ;
- Timing network: all fiber lengths are same, triggers to different places within the same delay;
- RFM network: share real-time data among systems regardless of bus structure and operating system;
- Gigabit Ethernet network: machine control and data transmission, isolated from the Internet.

Control System Components

Folder of CCS Graphical User Interface

- Discharge Configuration
- Subsystem Parameter Setting
- Timing & Synchronization Setting
- Vacuum valve waveform Setting
- Signal Test Setting
- Parameter Archiving
- Recall History

Fig. 3. Interface of KTX central console

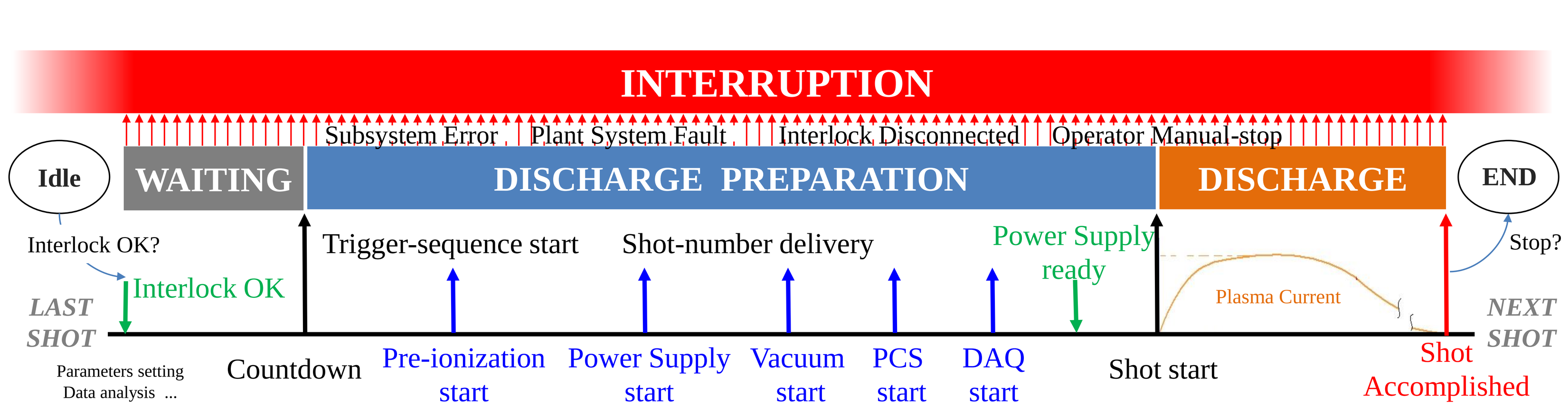


Fig. 4. Discharge operation flow in KTX

Summary

The new central control system has already been applied to KTX experiment since August, 2015. The whole system has correct control schedule during the discharge process, provides accurate operation sequence to plant systems, and monitored the status of subsystems without interruptions. The application shows that the new system runs stably and accurately, fulfills the design requirements of KTX central control system.

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