CURRENT STATUS AND PERSPECTIVES OF THE CRYOGENIC CONTROL SYSTEM OF EAST

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Abstract

EAST (Experimental Advanced Superconducting Tokamak) is the first full superconducting experimental Tokamak fusion device in the world which has been carried out ten campaigns since its implementation at the end of 2005. The cryogenic control system for EAST was designed based on DeltaV DCS of Emerson Corporation which has been in operation for the same time period and has been proved to be safe and stable. However, Manny control components have been running beyond the expected lifetime gradually. Many problems from control system have affected the cryogenic system reliability. This paper presents the current status and upgrade solutions of the cryogenic control system of EAST.

INTRODUCTION

EAST (Experimental Advanced Superconducting Tokamak) is the first full superconducting experimental Tokamak fusion device in the world which has been carried out ten campaigns since its implementation at the end of 2005[1]. The cryogenic system is one important subsystem which is to cool down the superconducting magnets and relating components [2]. The total cold mass of EAST is about 250 tons. As shown in Figure.1, the cryogenic system is composed of a helium refrigerator and a helium distribution system. The helium refrigerator is composed of gas management system, compressors station, cold box and 10000 liter Dewar. All heat exchangers, absorbers and four turbine expanders are installed in cold box. The basic design capacity of the refrigerator is 1050 W/3.5K +200W/4.5K +13g/s LHe +12~30kW/80K [3]. To maintain the cryogenic state of the EAST cold components, the helium refrigeration system (HRS) supplies three helium coolants, SHe, liquid helium, and gaseous helium for the SC coils and their feeder lines, current leads, and thermal shield, respectively. The cryogenic distribution system (CDS) has sufficient mass flow to operate each of the SC coils.

Pulsed heat load is the main different factor between the cryogenic system of full superconducting Tokamak system and other large cryogenic systems. The cryogenic system operates in a pulsed heat loads mode requiring the helium refrigerator to remove periodically large heat loads in time. This operation mode must be taken into account for the design of the control system. The EAST cryogenic control system (ECCS) was designed based on DeltaV DCS of Emerson Corporation and has been proved to be safe and stable [4].

However, Manny control components have been running beyond the expected lifetime gradually. Many problems from control system have affected the cryogenic system reliability. This paper presents the current status and upgrade solutions of the cryogenic control system of EAST.

CONTROL SYSTEM OVERVIEW

As shown in figure2, the network of the cryogenic control system is composed of three parts: cryogenic redundant control local area network (LAN), data exchange LAN and main control data server LAN. There is a firewall between the intranet and extranet to ensure the security of the intranet. The cryogenic redundant control LAN employs a three-layer control structure including of the process layer, control layer and supervisory layer. The process layer includes all the field instruments, actuators, sensors and transducers. All the process variables and status information is converted to supervisory by control layer.

The control layer includes two local control cabinets for cold boxes and cryogenic distribution system and a remote control cabinet for compressor station. Local control cabinet includes redundant MD controller, power module and I/O cards. The remote control cabinet includes R5 remote I/O cards and serial card. The remote control system connects to local control by serial cards in terms of MODBUS protocol. New compressors are controlled by PLC and also connect to local control by MODBUS protocol. New PBS turbine is controlled by HEXTR provided by PBS Company and connects to DCS by local bus. New ATEKO turbine is controlled by PLC and as a profibus slave of DCS based on Profibus DP.

The supervisory layer is the interface between the operator and control system, including a professional plus station, four operator stations and an application station as OPC server. In this layer, engineers can configure the program software and manipulate for the cryogenic system.

The data exchange LAN is the auxiliary system of the cryogenic control system. The system includes database server, data acquisition and processing system, web server and FTP server.

The cryogenic data are stored in database server in data exchange LAN connecting to the cryogenic control LAN by application station using OPC protocol. Some important data is sent to the database of the EAST main control system. Some temperature of the magnet coils is acquired by technical diagnosis system. The temperature data are shown in the cryogenic monitor interface. So the process data will be transmitted to the database and

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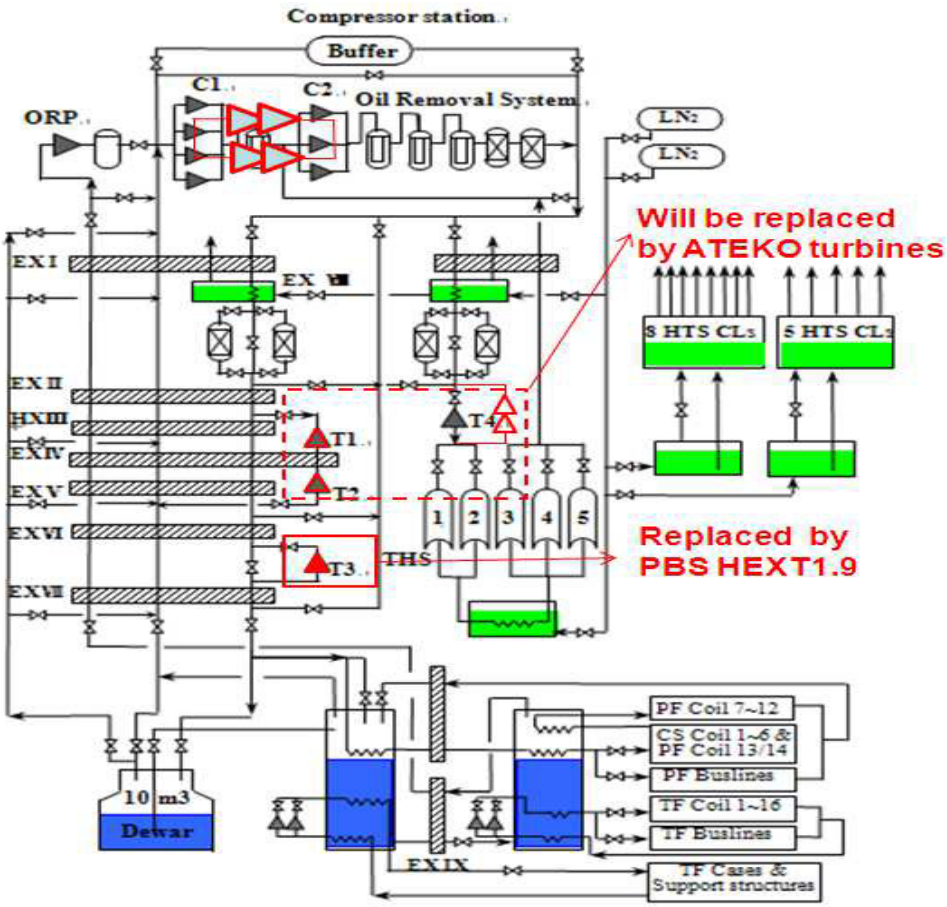

Figure 1 PFD of EAST cryogenic system

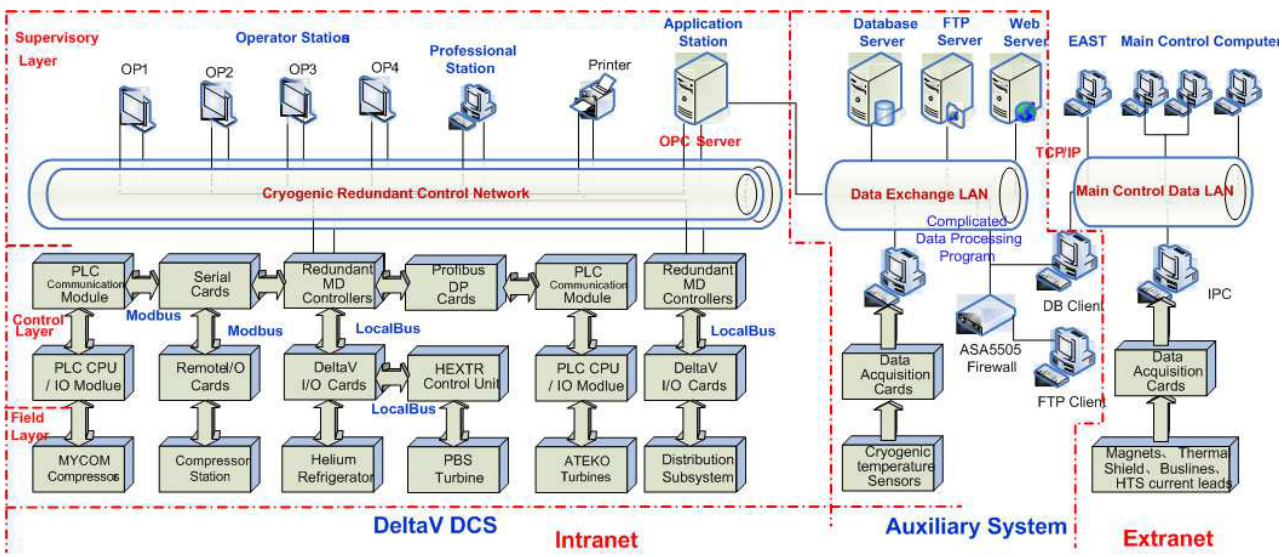

Figure 2 EAST cryogenic control system based on DelatV DCS

exchange system, then send to the DelaV system by OPC protocol.

The data acquisition and processing system has been developed for the temperature and mass flow rate. In order to remotely learn the operation status of the EAST

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cryogenic system by internet, the remote control supervisory system has been developed based on the TCP/IP architecture.

CURRENT STATUS AND UPGRADE

The ECCS has been in proved to be safe, stable and expand in operation for many years. However, ECCS is still operating on Windows NT operating system. New hardware may not be introduced because of missing driver support. The manufacture will no longer provide supports for the old DletaV version. It's very difficult to backup and recover the control system. Once the engineering station or application station fails, the entire cryogenic control system is in danger of paralysis. Many problems caused by the control system have affected the cryogenic systems reliability. At same time, the performance of control system gradually decreases. The memory of MD redundant controller of DCS is only 32M. The load of MD controller is approach to 90% which affects the running speed of the cryogenic control system. Historical data query is slow, resulting in the operation management efficiency decreased. The alarm system function is limited with many nuisance alarm and records query slowly. In addition to, there are some risks in the communication system because the old type 3COM switch has been off production with no supports. The communication efficiency deceased with error rising, occasional packet losing and network clogging. Some new instrumentation and new solutions can not integrate in DCS system. Therefore, it is necessary to maintenance and upgrade EAST cryogenic control system in order to keep the EAST device safe, reliable and stable in operation.

EAST have two campaigns every year and each campaign will last for 3~5 months. So, the upgrade solution can't affect the EAST campaigns. The two solutions have been considered. Upgrade of the DeltaV system is the near term plan to maintain the EAST operation reliability. The DeltaV version will upgrade from V6.3 to V12.3 which operate in Windows 7. PCs and switch will be replaced [5]. System upgrades will improve the performance of the existing device, eliminate hidden faults and enhance the stability of the DCS system which operates into a new life cycle. New Profibus DP will be installed in the DeltaV system for communication with PLC system.

PERSPECTIVE CONTROL DEVELOPMENTS

The upgrades of the commercial control system are very limited because of the fund shortage. The deltaV system upgrades only include the software and PCs not the device of the control layer. There are still potential risks from the hardware of the control layer. The other solution is to upgrade the ECCS based on the EPICS. The central I/O system will be converted to the Profibus field bus. Control System Studio (CSS) will be as the framework software for the new system. This solution is successful used for the large scale cryogenic control system at DESY [6]. We started the design of new system in this year. The architecture of ECCS based on EPICS is shown in figure 3. Subsequently, we will decide on the specifications for the prototype. The test of the prototype and determination of the specification for the new system will be followed in next year. At last, we intend to introduce the new system based EPICS into operation in parallel with the current system.

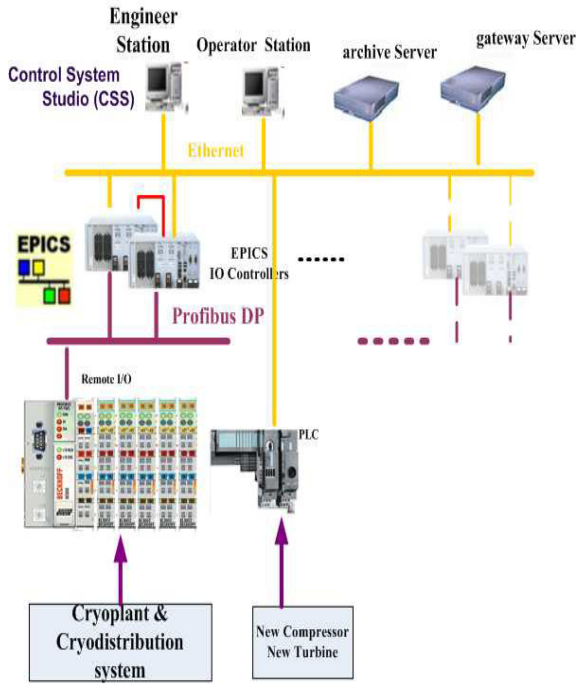

Figure 3: ECCS based on EPICS

CONCLUSION

The upgrades of EAST cryogenic control system have been discussed in this paper. There are one near term and future plan for the upgrades. The DeltaV system upgrades have been implemented on September 2015 and will be tested in the new EAST campaign. In the future, the new EAST cryogenic control system based on EPCIS will be designed and implemented.

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