

FRAMEWORK UPGRADE OF THE DETECTOR CONTROL SYSTEM FOR JUNO*

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Abstract

The Jiangmen Underground Neutrino Observatory (JUNO) is the second phase of the reactor neutrino experiment. The detector of the experiment was designed as a 20k ton LS with a Inner diameter of 34.5 meters casting material acrylic ball shape. Due to the gigantic shape of the detector there are approximate 10k monitoring point of temperature and humidity. There are about 20k channels of high voltage of array PMT, electric crates as well as the power monitoring points. Since most of the first phase software of the DCS was developed on the framework based on windows, which is limited by operation system upgrade and commercial software, the framework migration and upgrade are necessary for DCS of JUNO. The paper will introduce the upgrade framework of the DCS based on EPICS (Experimental Physics and Industrial Control System) running Linux OS. The implementation of the IOCs of the high-voltage crate and modules, stream device drivers, and the embedded temperature firmware will be presented. The software realization and the remote control method will be presented as well as the development of the GUIs by CSS (Control System Studio). The upgrade framework can be widely used in the project with the similar hardware and software interfaces.

INTRODUCTION

The Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose neutrino experiment. It was proposed in 2008 for neutrino mass hierarchy (MH) determination by detecting reactor antineutrinos from nuclear power plants (NPPs). The site location is optimized to have the best sensitivity for mass hierarchy determination, which is at 53 km from both the Yangjiang and Taishan NPPs. The experiment is located in Jinji town, Kaiping city, Jiangmen city, Guangdong province, CHINA. The neutrino detector is a liquid scintillator (LS) detector with a 20 kton fiducial mass, deployed in a laboratory 700 meters underground. JUNO consists of a central detector, a water Cherenkov detector and a muon tracker. The central detector is a LS detector of 20 kton fiducial mass. The central detector is submerged in a water pool to be shielded from natural radioactivities from the

surrounding rock and air. The water pool is equipped with PMTs to detect the Cherenkov light from muons. On top of the water pool, there is another muon detector to accurately measure the muon track [1]. See Figure 1 schematic view.

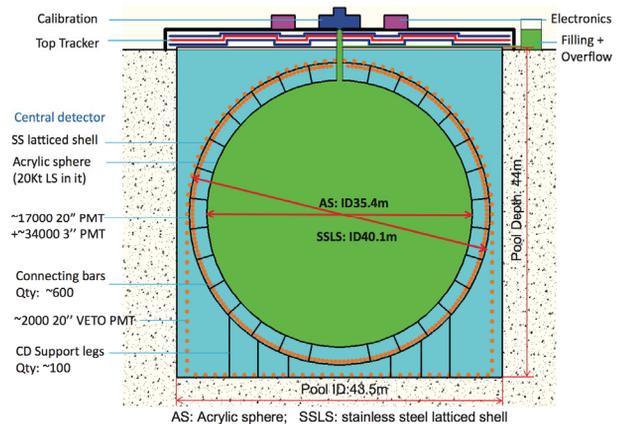


Fig. 1: A schematic view of the JUNO detector.

The main task of the detector control system (DCS) is to probe the parameters affecting the performance of the detector for long-term monitoring and control. Since JUNO is the second phase of the reactor neutrino experiment. Before that the DCS of DayaBay Reactor Neutrino Experiment was developed to support the running neutrino-oscillation experiment. The experiment has been taking data for almost 3 years and making steady progress. And the first results have already been released. And most of the first phase framework of the DCS was developed based on windows, which is limited by operation system upgrade and commercial platform upgrade. The framework of DCS migration and upgrade are necessary. The DCS of JUNO will implement by open source framework based on Linux.

REQUIREMENTS AND FRAMEWORK DESIGN

The detector of the experiment was designed as 20k ton LS with an Inner diameter of 34.5 meters casting material acrylic ball shape. Due to the gigantic shape of the detector there are approximate 1k monitoring point of temperature and humidity, 20k channels of high voltage of

*Manuscript received May 30, 2016. This work was supported in part by the Jiangmen Underground Neutrino Observatory (JUNO) experiment. It was proposed in 2008 for neutrino mass hierarchy (MH) determination by detecting reactor antineutrinos from the nuclear power plant (NPP).

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array PMT, and thousands of electric points to monitor and control. The goal of the system design is to setup a framework for easy integration of subsystems as a module. The main task is to probe the parameters including pressure, temperature, humidity, liquid level of the scintillation, electronics, gas pressure and the pressure in the lobby and all the electrical and mechanical environment working status of the devices. Control some devices, such as calibration systems, gas systems, water systems, CCD and power. Operating state of the system devices are monitored and recorded in real time. When an exception occurs the system can issue timely warnings at the same time through a secure interlock. Meanwhile the devices can be protected by the safety interlock automatically to prevent equipment damage and personal protection.

According to the actual hardware and software requirements of the experiment the system will use a hierarchical framework. The system will be divided into three layers: the global control layer, the local layer and the data acquisition layer. See the Figure 2 below.

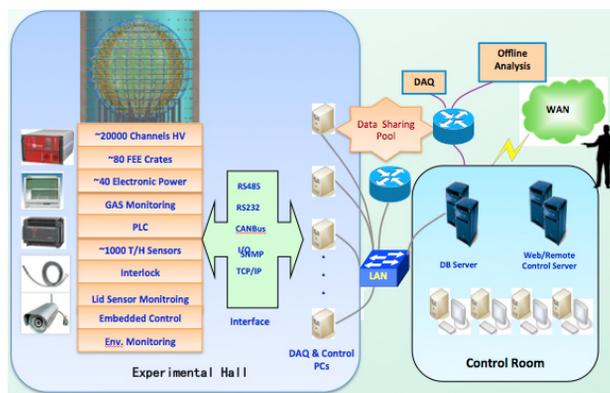


Fig. 2: Framework of Detector Control System

The global control layer will realize the overall experimental equipment information collection, safety interlock, remote control, data storage, network information release and privilege management. Local control layer will realize the local control of the local equipment in the experiment hall. And support the local device monitoring, data recording, data upload and alarm. The data acquisition layer is response for the various hardware interfaces. It can support for embedded systems such as ARM, FPGA and standard industry interface hardware such as PLC, USB and serial RS232 interface and acquisition, which based on the network devices such as the TCP/IP data acquisition interface.

The system will be built on a distributed system development method. According to the experimental equipment distribution characteristics the distributed data exchange platform will be used for the development. Global control systems share the data and the interactively control commands by information sharing pool. Configuration files will use the text format specification,

which can realize the remote configuration, distributed sharing and management.

The system uses a module-based approach of development. This method can achieve rapid integration of complex systems. From a functional view the system will be divided into data acquisition, control module, alarm module, memory module, data sharing and processing, system configuration, privilege management and user interface. Each subsystem can choose module assembly interface based on the actual system requirements. The modules can be divided by sub- system as following:

- High voltage monitoring system, including the central detector PMT high voltage system, RPC high voltage etc.
- Detector electronics chassis monitoring system, including the central detector electronics, RPC detector electronics, both inside and outside the pool detector electronics, monitoring content includes electronic temperature, power supply, fan, over current protection, low-voltage power supply.
- Temperature and humidity monitoring system, including liquid temperature detector, temperature monitoring room.
- Gas monitoring system, including the gas support system and center detector cover gas system.
- Center detector overflow tank monitoring, oil monitoring, liquid level clarity, camera monitoring and the calibration system of monitoring center.
- Experimental hall of environmental temperature, humidity, pressure monitoring system, the radon monitoring system, video monitoring.
- Control room monitoring system, database system and Webpage remote monitoring system.
- Water system

KEY TECHNOLOGY

The key technology of detector control system is the integration framework development of the software. The system will develop a set of integrated management module according to the detector hardware requirements. The system functions will be realized by the conceptual design and the detailed modular design. For the hardware system using commercial framework or special design system the data acquisition module will be designed for the integration. The commercial software will interface with the DCS framework by the integration. The software design is completed after repeated assembly test and performance test before put into use. The user feedback will be fully considered during the software design and the commissioning period. The software will enter the formal running when the stage of training finished.

Top development platform is open source platforms called EPICS (a widely used software platform for the large-scale control system physical device). The device driver can be developed by hardware I/O controller (IOC)

server. Subsystems in the pre-design stage will build a prototype for the development of hardware drivers to test the hardware and software functions. Figure 3 shows the picture of hardware prototype [2].



Fig. 3: Prototype of the Detector

Each detector subsystem model will be tested in test-bed platform, as well as data acquisition interface. For the hardware which has no prototype device simulation models will be made with the software development team and a common definition of the interface specification, including data format, the transmission frequency, control flow, the interface distribution, database table and so on.

The development of data acquisition and storage software are based on Eclipse RCP. The PyEpice function library is a bridge of Python language and EPICS Channel Access. It can collect and save data from EPICS IOC to data acquisition and storage software. JDBC is used for storage and collecting data to MySQL database. Fig. 4. Shows the schema of data acquisition and storage.

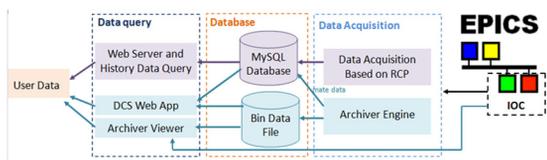


Fig. 4. Data Acquisition and Storage

With the use of LAMP (Linux + Apache + PHP + MySQL) web server can be build to display the data from MySQL database in web page. It can be used to realize the remote monitoring of the real-time operation information and historical operating status of each subsystem in experiment. Figure 5 shows the database schema of the DCS [3].

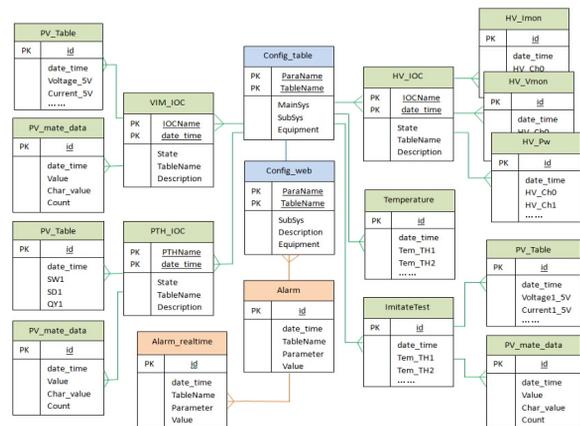


Fig.5: Database Schema of the DCS.

REALIZATION

The realization of the software is to remotely monitor and control the high-voltage crate and the high-voltage board. The driver uses a device communication driver software module “StreamDevice” based on data stream with the TCP/IP protocol. “StreamDevice” achieves remote control of the stream devices by sending and receiving string data. The development of the remote monitoring and control GUI is developed by CSS (Control System Studio). The software can remotely monitor and control voltage, current, fan speed and temperature of the embedded devices. When an exception occurs the systems will display the alarm in time. The IOC communication module of SNMP equipment and Modbus equipment is developed by C language [4]. Figure 6 shows the high voltage GUI.

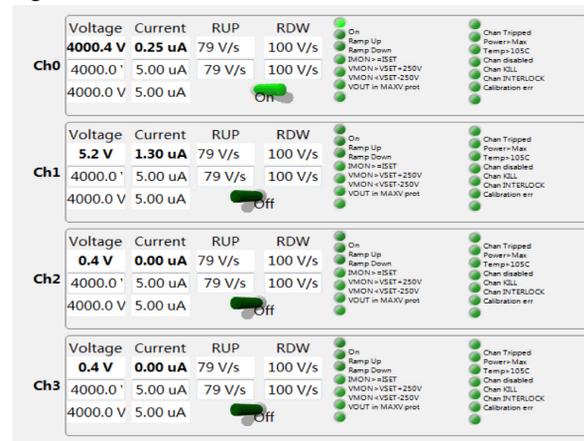


Fig. 6: High Voltage Software GUI.

REFERENCES

- [1] JUNO CDR, arXiv:submit/1361070 [physics.ins-d]
- [2] Zimin Wang, Status of JUNO prototype, JUNO Document 1229-v3, 2015.
- [3] Cui Wang, "Research and Implementation of Data Acquisition and Storage for JUNO Detector Prototype Control System," unpublished, 2016.
- [4] Ziguo Han, "Research and Implementation of Equipment Monitoring and Control System Based on EPICS in JUNO," unpublished, 2016.