Development of the EPICS-based Monitoring and Control System for EAST Fast Control Power System

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***Abstract*–For the 2015 EAST experimental campaign, the Fast Control Power System (FCPS) has been newly developed. FCPS is composed of the main circuit and the control and protect section. The main circuit of FCPS includes the high-voltage circuit breakers, the multi phase rectifier transformers, the AC/DC rectifier, and the DC/AC inverters. Because of the complexity of FCPS and the poor working environment, the remote monitoring and control system is considered as a very important part of FCPS. The developed monitoring and control system is based on EPICS framework, and includes the data acquisition module, FCPS status monitoring and control module. The above modules are developed as EPICS device support modules. The monitoring and control system communicates with the control and protect section through the serial RS-485 protocol and with the main circuit through modbus protocol based TCP/IP. In addition, this system also includes a module that is developed with C. It is considered as the front end executable module of Plasma Control System, and communicates with PCS through the reflective memory (RFM) cards. All the status and the acquired data from FCPS are demonstrated on the OPI developed by Control System Studio, and are archived by the MDSPlus database. The new monitoring and control system has been test and showed the stable and robust performance.**

I. Introduction

The newly development FCPS [1] in EAST is a kind of large capacity single phase inverter, which excites feedback coils to produce magnetic field to restrain plasma's fast vertical displacement. The method of multiple inverters paralleled with current sharing reactor is presented to meet the need of large current and fast control. The main circuit of FCPS includes the high-voltage circuit breakers, the multi phase rectifier transformers, the AC/DC rectifier, and the DC/AC inverters. The new Fast Control Power System has 6 parallel branches and every branch has 3 series inverters.

The status monitoring for old FCPS is only designed at the front panel of control cubicle. Experimenter must monitor the system status and setup the relative parameters by manual on site. Because of the complexity of FCPS and the poor working environment, the remote monitoring and control system is also considered as a very important part of FCPS.

The controller of new FCPS is redesigned with Data Signal Processing (DSP) technology to meet real-time control. The host computer can output the voltage to the controller by the data acquisition card, and the controller acquires the voltage to control the voltage / current output of FCPS. At the same time, this controller receives the parameters of power supply and sends the status of controller to the monitoring host by the RS485 bus. The control interface provides the base for the remote monitoring and control system.

Experimental Physics and Industrial Control System (EPICS) [2] is a software tool as a main framework to deploy distributed control systems in large scientific environments especially ITER [3]. It has so many benefits, so the developed monitoring and control system for FCPS is also based on EPICS framework.

The key requirements of the remote monitoring and control system are listed as follows:

1. Measure the status of power supply system, including total voltage or current, branch voltage or current, temperature, the status of cooling water, and show them in the OPI.
2. Show alarm information in the operator interface when power supply appears the exceptions.
3. Control the output mode (voltage or current) of FCPS, and monitor the status of main controller.
4. Archive all of data in the MDSplus [4] database in order to analysis system status offline.
5. Receive the command from Plasma Control System (PCS) to control the FCPS by the RFM cards [5].

II. System Structure

According to the above requirements, the monitoring and control system includes the following modules:

- Data acquisition module
- Status monitoring module
- Feedback Control with PCS

The system's architecture is as shown in Fig. 1. It will communicate with data acquisition console, data servers, FCPS, PCS. Data acquisition console is used to forward the commands from the central control system to this system, for example shot number and pulse time. During the pulse,

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PCS sends the command to this system by RFM card in real-time. All of status data and acquired data are stored in MDSplus in the data servers [6].

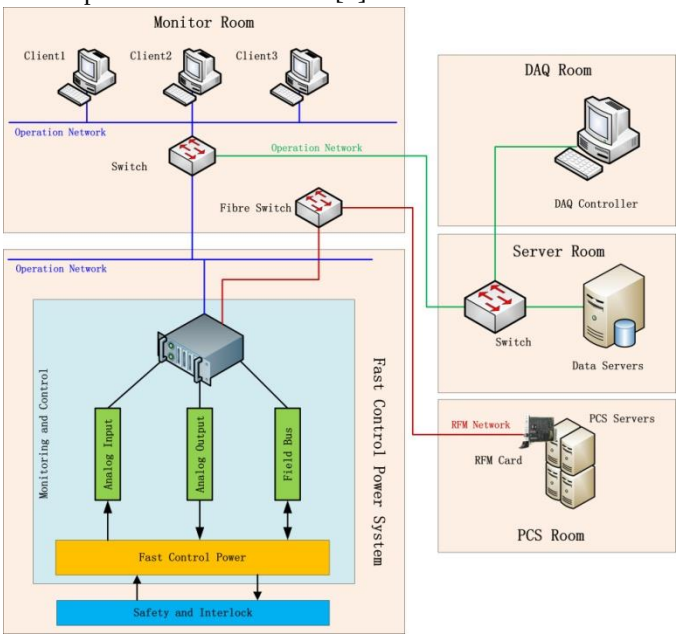

Fig. 1. System structure of FPCS.

A. Data acquisition module

This module receives the shot number and data acquisition time from data acquisition console, and waits the trigger signal from the central control system to acquire the total output voltage / current and branch output voltage / current of FCPS. Then the acquired data will be stored into MDSplus in real-time.

B. Status monitoring module

This module includes two parts. One part is responsible for monitoring the status of controller of FCPS and send parameters to the controller through the serial RS-485 protocol. The other part is responsible for monitoring the status of main circuit through the modbus protocol [7] based on TCP/IP.

C. Feedback Control with PCS

This module is considered as the front end executable module of PCS and communicates with PCS through the reflective memory Network. It receives the command from PCS, and outputs voltage through data acquisition card according to the command.

III. System Implementation

A. Hardware Structure

Fig. 2 shows the main hardware structure of the monitoring and control system.

1. cPCI-5565PIORC is connected to RFM network and used to communicate with PCS.
2. PXI-6259 has 32 channel and 1MHz multichannel sampling rate. It is used to acquire the output voltage and current signal from power supply, and output analogue voltage according to the command from PCS.
3. WAGO [8] is used to acquire the status signal of main circuit, including 6 DI, 1 DO and 1 AI module, and provide the modbus interface.

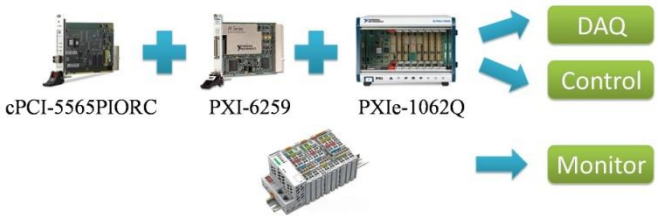

Fig. 2. Hardware structure of FPCS.

B. Software Structure

The software is mainly based on the EPICS, and its environments are listed as follows:

1. Redhat 6.3 64bit
2. EPICS 3.14.12

The software system includes four levels (the operator interface, data processing, EPICS device support and Linux driver). Fig. 3 shows the software framework of the monitoring and control system.

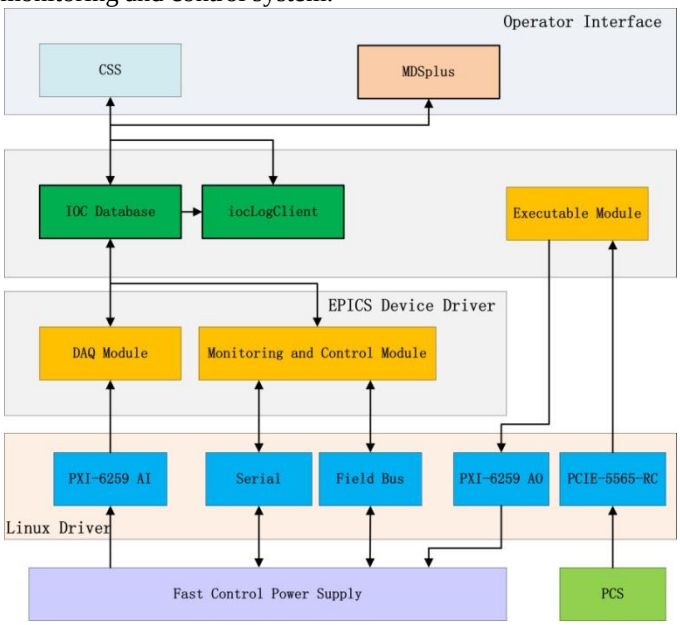

Fig. 3 Software structure of FPCS.

The EPICS device support modules are developed for PXI-6259, RS-485 and modbus interface.

1. The device support module for PXI-6259 is mainly used to setup the relative parameters (sample rate, channel enable, input range, trigger, clock and so on), read the acquired data and write the data to analogue output channels.
2. The device support module for RS-485 is responsible for communicating with the controller of FCPS. It can be used to setup the parameters of RS-485 communication, read the the status of controller and write parameters of controller.
3. The device support module for modbus interface is used to communicate with WAGO devices. The modbus protocol is based on the TCP/IP, so every WAGO devices has a specific IP address.

RFM card is just only used to receive the command from PCS during the pulse discharge. So the relative software module also receives the shot number and pulse time from data acquisition console. Fig. 4 shows the work flow of RFM card.

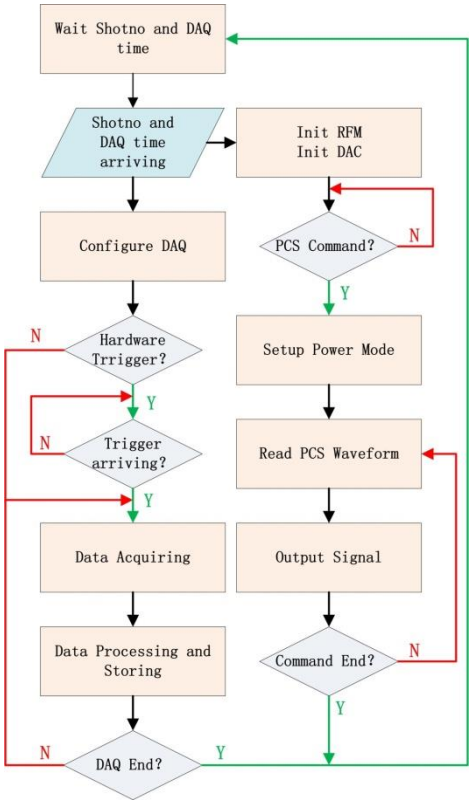

Fig. 4 Work flow of RFM card.

Operator interface is developed with Control System Studio (CSS) which is an integration environment for OPI, alarm, data plot and so on. It can show the status of FCPS and alarm information.

IV. Operation Results

The new monitoring and control system has been tested and used during 2015 EAST experimental campaign. This system has run continuously and stably about 5 months with over 6000 shots in the 2015 EAST campaign. It showed the stable and robust performance.

Fig. 5 shows operator interface for controller of FCPS. User can monitoring the controller status, start or stop the controller, and set up run mode.

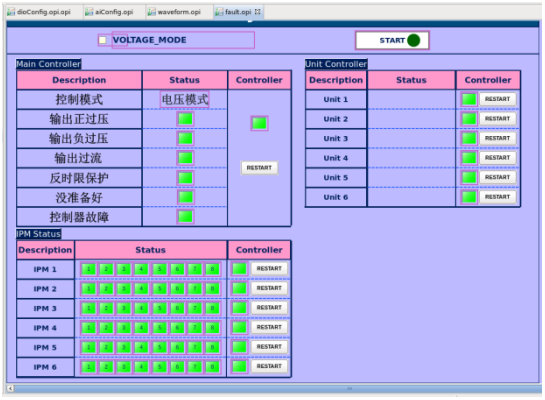

Fig. 5 Operator interface of controller.

Fig. 6 shows every branch status of FCPS and fault status.

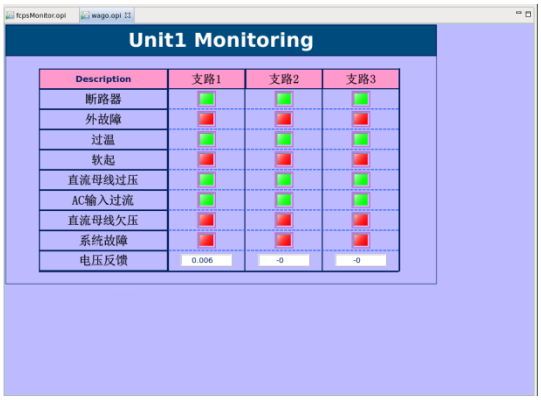

Fig. 6 Operator interface of branch of FCPS.

User can access the pulse data for output voltage / current of FCPS by webscope which is an online tool for displaying EAST data. Fig. 7 shows output voltage from FCPS.

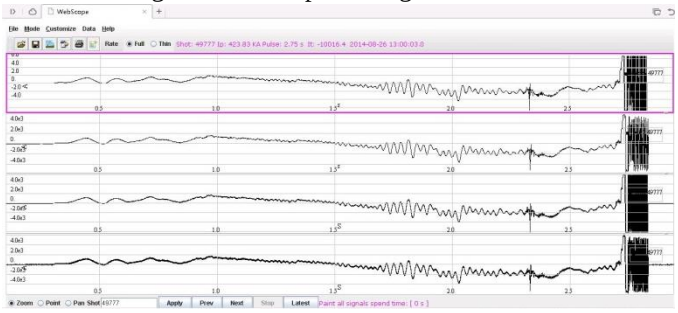

Fig. 7 Data access from MDSplus.

V. Summary and Future Work

This system based on EPICS was modularly designed to meet the monitoring and control requirements of FCPS. This involves publishing its signals in an EPICS network and storing the data in a MDSPlus database, together with a redundant local control for testing purposes. During the 2015 EAST campaign, this system is tested and verified to meet the key requirements of this system.

The further work line moves toward applying the EPICS framework to other subsystems.

Acknowledgment

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