

CONTROL SYSTEM FOR BEPCII LINAC POWER SUB-SYSTEM

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Abstract

Power subsystem has been upgraded for energy improvement of the BEPCII Linac. As a result, new control system was in need. This paper proposes the designing and implementation about the power-supply control system. There are 156 sets of power supply in the system, which is divided into 6 parts, according to the type of magnet. The control system is intended to make operations more convenient and efficient in beam regulation, which provides functions to meet such situations, like single regulation, recover the beam configures from data files, one-button to switch the machine's working mode. What's more, the software provides a method of slow-change to protect the power supplies, when the values change steeply. Compare to the old system, this new software is more maintainable and extensible. This software is based on Qt, the GUI toolkit for C++, and connects to the control box through the EPICS (Experimental Physics and Industrial Control System). The whole 156 sets of power supplies are controlled by control boxes, which is ARM+FPGA/CPLD-Structure front-end IO. This control system has commissioned with beam on BEPCII LINAC in September 2013, which plays an important part in the yearly machine restart and beam recovery.

INTRODUCTION

BEPCII is the upgrade of the BEPC (Beijing Electron Positron Collider), which will provide two rings in the existing tunnel serving high energy physics (HEP) (1.5GeV) and synchrotron radiation (SR) (2.5GeV) research[1]. It uses a full energy linac for injection, which is an electron-positron linac. The injection energy is 1.55 to 1.89 GeV. The control and monitoring of the power supplies must meet the physical requirement in two modes and provide reliable and efficient tools for the beam regulation. Except for the fundamental functions, like value set, data read back, status monitor, all the power supplies should be adjusted to switch the machine mode from colliding mode to the synchrotron radiation mode.

ARCHITECTURE OF THE CONTROL SYSTEM

Control system of BEPCII LINAC power supplies follows a standard model [2] of distributed architecture known as the "three-layer", which are OPI layer (operator interface), the front-end layer, and the device control layer. Two sets of PC/Linux are used for EPICS IOC development and Client Apps, and two sets of PC/Windows are used as operator station, where VNC is

applied to show the running program on PC/Linux. Fig. 1 describes the architecture of the system.

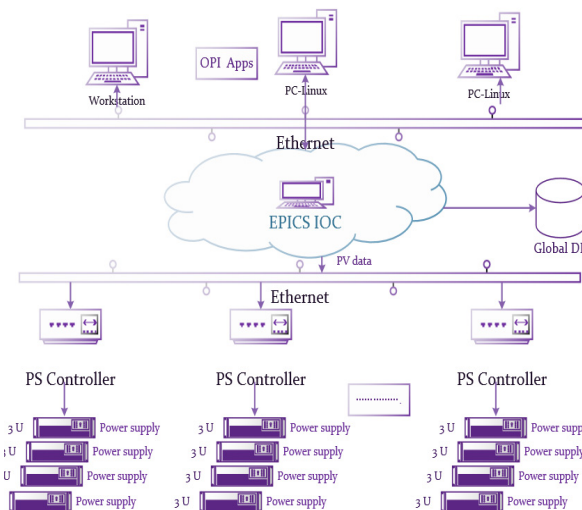


Figure 1: Architecture of the system.

The platform of the control system is based on EPICS system, which is widely applied in BEPCII. EPICS provides a structure of three parts: IOC (Input and Output Controller) running on server-end, CA (Channel Access), OPI (Operator Interface) running on client-end[3]. In this power supplies control system, EPICS acts as the middle layer between the devices and client applications.

PV data collected by controller will be stored in EPICS real-time database. Client apps like power supplies control program could fetch the PV data from EPICS real-time database by creating channel accesses and calling related functions.

The front-end controller of power-supply is the application based on characteristic ARM+FPGA/CPLD structure front-end IO. Fig.2 shows the architecture of the power supply controller.

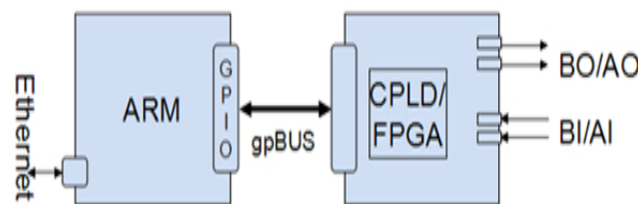


Figure 2: Arm-Linux+FPGA /CPLD architecture.

The code following is part of .db file. It shows how the EPICS IOC Records are created:

```
record(waveform,"$(user):wf")
{
    field(DTYP,"Modbus Channel")
```

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```

field(INP,"$(ipa),1,4,0,64") #read modbus multi-
register parse parameter
field(SCAN,".5 second")
field(NELM,64)
field(FTVL,4)
}
record(longin,"$(user):reg0")
{
field(DTYP,"Modbus Channel")
field(INP,"$(ipa),1,4,0,1") #direct parse from
$(user):wf memory
field(SCAN,".5 second")
}
    
```

OPERATOR INTERFACE AND CLIENT APPLICATION

Power-supply control program is an upgrade program totally different from the original one, which is developed in a kind of un-popular programming language called EDM. EDM is one example of the EPICS display manager providing a collection of widgets to fulfill windows-based GUI system, which is hard to maintain or extended to new functions. While the new operation program is developed based on Qt, a C++ GUI cross platform framework, which provides good extensibility and maintainability. It is one of the main reasons for this upgrade. Qt is a cross-platform application and UI framework for developers using C++ or QML, a CSS & JavaScript like language. Besides of the efficient code, abundant function library and graphic widgets support is another advantage to be concerned.



Figure 3: Qt-based Control system GUI.

Fig. 3 shows the operation interface of the running control system. In the middle of the GUI, parameters include the current, setting value, reference value, and the status if power is work, from 156 sets of power supply are

monitored. 156 sets of power supply are organized into five groups according to the type of magnet, and each group is embedded in a tab page. Below the monitoring area, are the error alarm bar, the value-adjust scroll bar and information notification area. On the right are function-call buttons.

As mentioned in the beginning, besides the basic functions provided, the program has developed chartered methods to simplify the beam regulation procedure, such as stored value reloading and one-button switch for the HEP/SR mode.

The flow-process diagram of the system is shown in Fig. 4. At initialization, the program bounds widgets in windows to widget array to make widgets named and to be called easily. And the channel access is created, as well. Once the initialization is done, a timer for background epics access is installed, which realize the real-time data monitoring. At the same time, the function buttons are listened to call certain features.

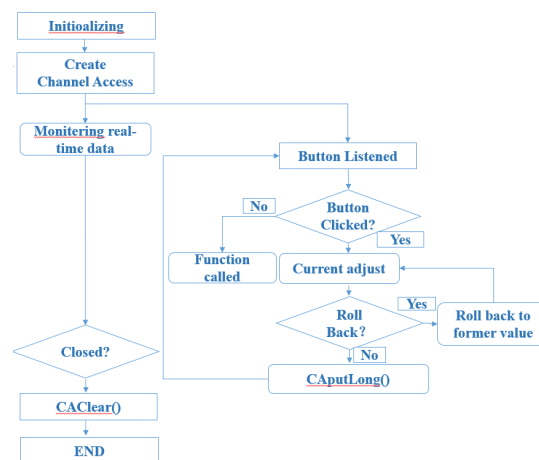


Figure 4: System flow-process diagram.

To realize the communication between function-button and the function, the signals and slots is applied. The signals and slots mechanism is a central feature of Qt and probably the part that differs most from the features provided by other frameworks. A signal is emitted when a particular event occurs. Qt's widgets have many predefined signals, but we can always subclass widgets to add our own signals to them. A slot is a function that is called in response to a particular signal. Qt's widgets have many pre-defined slots, but it is common practice to subclass widgets and add our own slots so that we can handle the signals that we are interested in. Together, signals and slots make up a powerful component programming mechanism [4].

Single power supply adjustment is the first step to beam regulation. Once a good status is settled, the present configuration of all the power supply will be stored in file. The stored files can be invoked by pressing the file-load button to recover the former status. In fact, the file-load method is used more often in particle application, for the machine could quickly regain the state when the configuration is stored.

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One-button switch is another feature designed for convenient beam regulation. The program record the latest file operation automatically and write the file path into configure file. When the switch function-button is clicked, the program would recover the machine status from the recorded data file, the shell command will be called to inform other sub system to synchronize. The flow-process diagram is shown in Fig. 5.

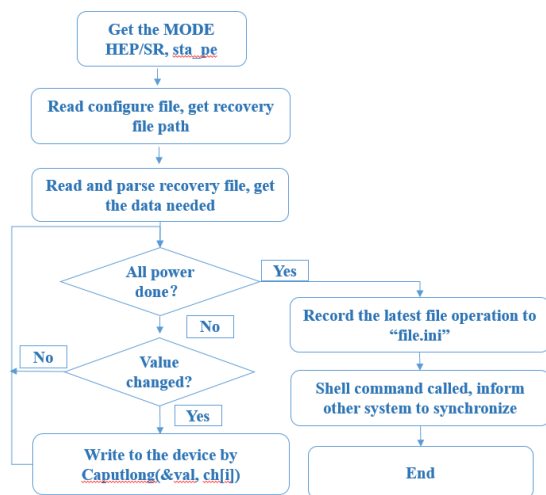


Figure 5: Flow-process diagram of one-button switch.

Apart from the basic operation introduced above, the Qt based power supply control program also provides some extensions according to operation need. For example, the step-change function to protect the power supplies when values change too steeply. Threshold limit is designed to protect power supply from excessive current. The roll-back function could efficiently fix false operations.

CSS is a collection of tools: Alarm handler, archive engine, as well as several operator interface and control system diagnostic tools. Most of them deal with Process Variables (PV), i.e. named control system data points that have a value, time stamp, alarm state, maybe units and display ranges, but they do this in different ways. One tool displays the value of a PV, one displays details of the PV configuration, while another concentrates on the alarm state of a PV. Each individual tool deserves some attention, and the Experimental Physics and Industrial Control System toolkit, EPICS, indeed offers each functionality as a separate tool. A key point of CSS is the integration of such functionalities [5].

Fig. 6 shows the CSS based PSI controller, which is mainly responsible for the switch power supply. In detail-configure interface, the program provides power parameters calibration.

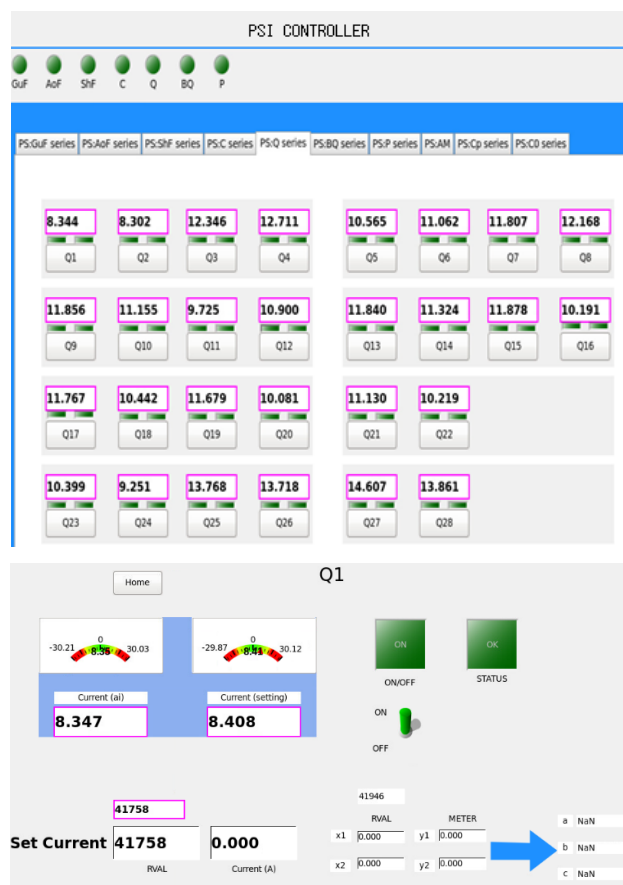


Figure 6: CSS-based PSI controller.

CONCLSIONS

Since September of 2013, the BEPC II LINAC control system has gone through commissioning with beam. During the first two months, the system has extended some features according to the user requirements and actual needs, which proves the good expansibility and portability. Up to June of 2014, the system is on stable operating. A new feature has been added to the program, which will automatically synchronize machine's mode from the storage ring system. Together, the upgraded power supply control system is reliable and extensible.

REFERENCES

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