

# CONTROL SYSTEM FOR PEPF INSTRUMENTS WITH MODBUS PROTOCOL\*

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## Abstract

20MeV proton linear accelerator of the PEPF (Proton Engineering Frontier Project) has above 10 magnet power supplies and getter pumps to interface with Modbus protocol. VME IOC (Input Output Controller) has been designed and constructed for the control system by using VME serial I/O. The driver support module of the VME IOC has been developed to initialize the IO board and communicate with the instruments through EPICS. Operating console and storage module for operators in the control room has been programmed on PC and SUN of the operator interface.

## INTRODUCTION

Power supply control system for quadrupole magnets has become more important in remote control system as a rapid transformation in a system monitoring and control is taking place due to an evolution of various states. Above 150 drift tube magnets have been installed and commissioned to guide the beam from LEBT to DTL for a 20MeV proton accelerator system of the Proton Engineering Frontier Project (PEFP) [1]. All these magnets need to be powered by a highly stabilized current to sustain a focused beam. Specifications of the installed magnets power supplies and parameters of control and display are presented in Table 1.

Table 1: Specification of magnets and magnet power supplies

Output voltage, current, power	DC30V, 330A, 10kW
Regulation topology	full bridge SMPS
Control	full digital
Ripple	<+/- 0.1% of Vout at 20kHz
Communication	RS485 Modbus-RTU

The control system needs to control 10 power supplies to supply currents with DTL quadrupoles magnets. The main issue in developing the control system is to maintain simple and uniform procedures for the power supplies remote management. Even though all the power supplies have a serial interface (RS422/485) and an internal processing controller, they follow different protocols. We use Modbus as a communication protocol to control the magnet power supplies.[2] Almost the control communities in electron and proton accelerators used the Experimental Physics and Industrial Control System

(EPICS) [3]. We decided to partly apply the EPICS toolkit to the control systems including a magnet power supply.

## POWER SUPPLIES CONTROL SYSTEM

### Control hardware

Power supply system has 485 serial ports with Modbus/RTU protocol [3] for remote interface in processing controller as shown in Fig 1.

Even though the ports have a merit to reduce the number of cables between the magnet power supplies and the control system due to a multi-drop communication we connect serial cables separately to prevent interferences between power supplies simultaneously. This control hardware developed based on EPICS is classified in three groups; OPI (Operator Interface) layer of the Sun Workstation, Linux PC which an operator in the control room can access, IOC (Input/Output Controller) layer of the VME system in which the EPICS core is performed, Device layer connected between a power supply and an IOC. Fig 2 shows the control system architecture and the interface layer.

We installed vxWorks as a real time operating system with tornado at single board computer of motorola power PC of VME system. The system can be supported functions of a hardware interlock such as various faults and provided a software interlock such as a current limitation. Multi channel VME IO board is used to interface between a CPU in the VME system and the control board in the power supplies.

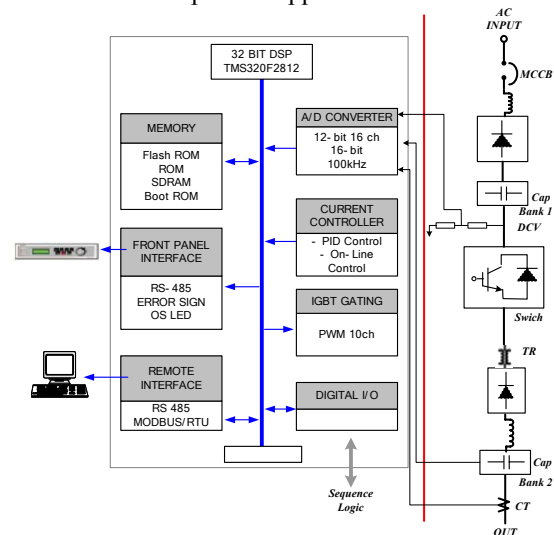


Figure 1: Schematic diagram of the local controller in the power supplies.

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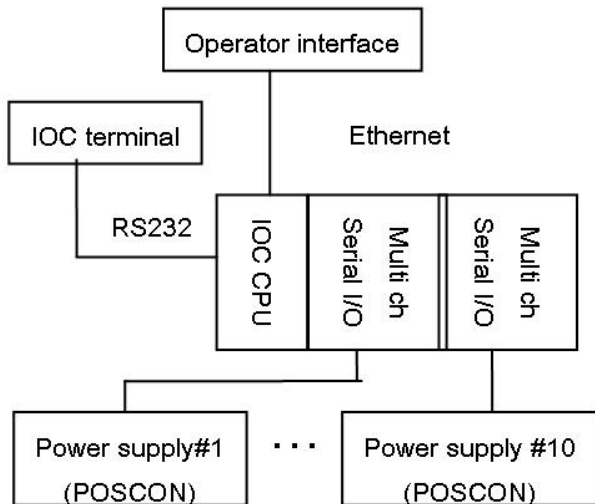


Figure 2: Schematic diagram of input output controller of the magnet power supplies

*EPICS implementation on the control system*

We have implemented software of EPICS for the VME IOC and OPI to control remotely the power supply. IOC's software which has a channel access, a record support module, a device support module, a hardware driver, actually controls the power supplies. Channel access has been programmed to interface between the IOC and OPIs. Support modules of the record and the device have been coded to process data from the power, especially which can analyze modbus bus protocol. The hardware driver of IOC has been developed to initialize the IO board and communicate with power supplies through EPICS. Operating console and storage code for operators in the control room has been configured on PC and SUN of OPI.

*Input output controller's programming*

The IOC starts by loading the EPICS image file which has a ".dbd" file containing a description of all the data records and enumerated types used in the in memory database at record support module. The instances of the variables are defined in ".db" files. During processing ".db" file, record and device specific routines are called to initialize the record. When VME IOC boots, it links a host computer (SUN) which compiles EPICS image file needed to IOC. Start scripter in a boot parameter of IOC has been coded to link the file of "iocshell" which downloads the image file through Ethernet.

Data processing performs by modules of the record and the device when the IOC communicates the power supplies. The sent and received data packed with Modbus is decoded to a hexadecimal value at in IOC and in the power supplies after checked with error of cyclic redundancy checking (CRC). Hardware driver has been coded to initiate boards and ports of the IO board and handle registers of control and data. Monitoring analog data periodically scans and receives with a polling method. Commands send to the power supplies with an event driven method only when operators are necessary.

Hardware driver was designed to resume automatically when recovery from instant faults of communication between the power supplies and the IOC.

*- Operator Interface in the control room*

The control system of PEFP monitoring windows of an OPI layer control an operation safely and tracks the historical data though utilizing an archived data when it is required to check an archived data set. PEFP control system has a storage module to store the data of a control in a real time and to read archived data. We used the channel archiver for data retrieved storage. The channel archiver is an archiving toolset for the EPICS.

The status and severity of the alarm are set and checked whenever a record to control power supplies is processed. When a change is detected, a routine is called which sends a message to each process the monitoring record. This process is supported by the Alarm Handler which is an interactive graphical application to display and monitor PEFP control system database alarm states. It serves as an interface between an operator and the PEFP control system database and it communicates with the database by using channel access function calls. The Alarm Handler is installed with Redhat Linux9.0.

*Communication test*

*- Communication test of a local controller built in the magnet power supply*

In order to check on the local communication module in the power supplies a simple human machine interface (HMI) for windows was built. The program was made of Visual C++. We have checked and tested the communication module by using a laptop computer and a RS 485 to a RS 232 converter. Communication between the Laptop and the power supplies operates stably.

*- Communication test between a magnet power supply and a host in EPICS environments*

In order to test a communication in EPICS environment, we have assembled the VME system including VME CPU and I/O boards and constructed a control panel in the SUN host as shown in Fig 3 and 4.



Figure 3: Picture of the VME IOC for the power supplies

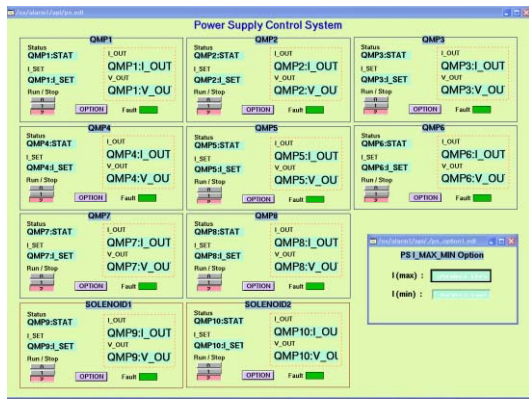


Figure 4: Operating console implemented by EDM

When an operator sends the commands the power supplies respond spontaneously. We can see that the power supply controlled well by the host console. We need to check on long term system reliability.

## CONCLUSION

An interface system to control the magnet power supplies of a 20MeV DTL has been developed. The control system has been focused on a remote reliable control between power supplies and operators during early communication testing. Alarming function has been added to detect faults and a system warning status. These functions are compatible to the VME with vxWorks as well as Linux PC. A modular test with real power supplies and a code debugging has been performed.

## REREFENCES

- [1] Y. H. Kim, Proceeding of 2006 Particle Accelerator Conference (2006)
- [2] D. Bishop, Preceding of 1997 the International Conference on Accelerator and Large Experimental Physics Control Systems
- [3] <http://www.modbus.org>
- [4] <http://www.aps.anl.gov/epics/>