EPICS BASED CONTROL SYSTEM FOR THE KOMAC RF SYSTEM

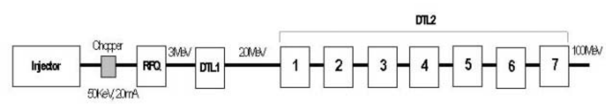
J. C. Yoon, J. W. Lee, K. M. Ha, J. H. Kim, J. M. Kim and J. Choi,
Pohang Accelerator Laboratory, POSTECH, Pohang 790-784,Korea

Abstract

This paper presents the RF control system for KOMAC (Korea Multi-purpose Accelerator Complex). KAERI (Korea Atomic Energy Research Institute) has been performing the project named KOMAC. As the 3rd phase of the project, 20MeV proton accelerating structure is under development. The new design is based on the use of VME based Multi-function modules connected to the specific low level RF Controllers (LLRF) via distributed I/O modules and Serial communication modules. The control system was based on EPICS (Experimental Physics and Industrial Control System) from the end of 2003. Installation and commissioning of the RF module is scheduled on 2004. Control system to integrated the RF System to the KOMAC control system is implemented. Hardware, software and various applications are developed to support the operation of RF Control system. This paper EPICS based control system for KOMAC RF.

INTRODUCTION

The final objective of KOMAC project is to build a 20-MW (1 GeV, 20 mA, cw) high power proton linear accelerator to study basic researches, industrial applications, and nuclear transmutation. It is planed that 20MeV, 100MeV, 250MeV and 1GeV proton beam will be supplied for the applications. Since 1997, KAERI has been developing high power proton linac from injector to 3MeV RFQ with 1MW RF system in the KTF (KOMAC Test Facility). For the second stage of the KOMAC project extended to 100MeV, Korean government had accepted a feasibility study and a proposal, and the project is starting. The second stage accelerator will deliver 20MeV and 100MeV proton beam for users. The simultaneous beam sharing to many users is planed, and with the scheme, many proton beam line can be installed in the user facility. Many spin-offs of the accelerator technologies for industrial applications will be included in the KOMAC project in nano-technology, biotechnology, etc. It is hoped that this accelerator will be useful for the nuclear data production with 100MeV proton beam. Figure 1 shows the accelerator structure and parameters of KOMAC. The LLRF consists of a 350MHz signal generator, a 160W solid state amplifier, amplitude/phase control loops, and RF interlocks. The designed field stability in the RFQ cavity is within ± 1% amplitude and ±1.4° phase using feedback control loops in the LLRF. For frequency control, another tuner controller module was used. The RF interlock signals comes from excessive reflected RF power, circulator arcs and window arcs. The LLRF control requirements are cavity field control, cavity resonance control, RF & clock generation and distribution, and Master Oscillator generation and distribution. The control system now shows very stable and reliable characteristics enough to meet our control requirement. However, the control system is continuously being upgraded to accommodate additional control requirements such as the low level RF electronics. Part of the low level electronics were up-graded and replaced for enhanced performances of the phase feedback and automatic gain control loop, but the automatic phase-lock loop sowed some instability due to poor phase circuits, phase noises, and poor interface with control circuits. We use the EPICS tool kit as a foundation of the control system. We developed RF control system for use VMEbus based TCP Modbus Multi-function board. During the maintenance period, RF control system was upgraded. And control software was modified to support these changes. Application software for LLRF device and operator interface software are being developed. The overall development of the EPICS based RF control system, field installation, and integration test will be completed by the end of July 2004.



Ion	*Proton*
H- Energy	*100MeV*
Max. Peak Current	*20mA*
Pulse Width	*0.1 to 2mSec*
Max. Rep. Rate	*120Hz*
Max. Beam Duty	*24%*
Max. Average Current	*4.8mA*
Klystrons	
350MHz, 1MW	*2*
700MHz, 1MW	*7*

Figure 1: Accelerator structure and parameters of KOMAC

SYSTEM CONFIGURATIONS

The control system for PEFP (Proton Engineering Frontier Project) RF System is VMEbus based system. A PowerPC single board computer host module that is running the vxWorks real-time operating system. Control interfaces of the system consist of analog input/output, digital input/output, and TCP Modbus LAN connections. All essentially monitored, controlled signals of PEFP RF and cryogenic subsystems are well incorporated and engineered into the new VMEbus system to fulfill requirements of the commission stage. For future modification or expansion of the existed system, we have already reserved enough rooms for control interfaces revamping. The whole control environment is shown in

Figure 2.

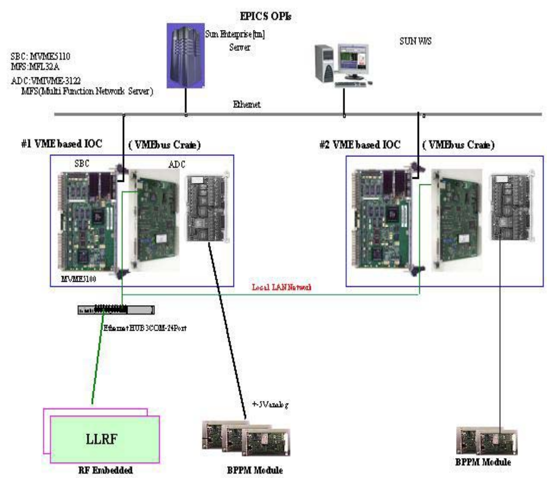


Figure 2: Structure of PEFP RF Control System

Figure 3: A picture of *Multifunction VME Board*

Multifunction VME Board (MFL32) Specification

We developed Multifunction network-based VMEbus board for TCP Modbus. As shown in Fig. 3, also We developed EPICS drivers (EPICS device supports).
* 16bits A/D converter, with range of 0 - ±10 V : 8 Ch, * Analog Differential Linearity Error : 1 LSB max @ 16 bits ADC, *16bits D/A converter, with range of 0 - ±10 V @ 5 mA: 2 Ch., * Analog Differential Linearity Error : 1 LSB max @ 16 bits DAC, * Digital In/Output : 32Ch., * Dual operation Local processor: used 32 bits, Micro processor, 1 Ch. 10/100Base T Ethernet port, * VMEbus Interface: A16/D16 Slave Read/Write Data Transfer, * Serial Communication (UART) : max. 9.6kbps , Full Duplex RS232 port (Console Port), * Electrical Isolation :analog input photo coupler isolation, DC/DC Converter Galvanic isolation

RF EPICS IOC

Our main focus was to integrate TCP Modbus with EPICS and we have therefore implemented several functions in the DLL to support EPICS. Special attention was given to maintain time correlation of data through the use of time stamps and time stamped events. The IOC uses the Channel Access protocol for communication with other nodes and provides the infrastructure to manage the creation and processing of data structures known as records. Records are the data types of EPICS and support both scalar data and arrays bundled with attributes such as the process variable's name, processing rate, units, and alarm limits. The DLL supports these attributes. Two device support routines, one for initialization and one for processing are required for each record type that is supported by the IOC. These routines are modified to make calls to the DLL.

Initialisation

An EPICS IOC starts by loading the binary software image and then a "dbd" file containing a description of all the data records and enumerated types used in the in-memory database. The instances of variables are defined in "db" files. During processing of a "db" file, record and device specific routines are called to initialize the record. The DLL is called during each record instantiation to create the shared memory variable and link the record data field to the shared memory variable. In the diagnostics applications at PEFP RF the IOC is responsible for completely initializing the DLL using data in the "db" file. The Modbus client program or any other program could initialize the shared memory if desired.

Processing

The connection between the MFL32 (*Multifunction VME Board)* and the embedded LLRF Controller is established using the MODBUS TCP/IP socket mechanism. The MFL32 is a client and the LLRF Controllers are servers. The LLRF Controller has only a simple connection mechanism i.e. the "socket mechanism" rather than Remote Procedure Call (RPC) that supports rich client-server mechanism. Thus, communication between the LLRF Controller (servers) and the MFL32 (client) is established using the socket. Fig.6 Structure of RF control software. The MFL32 can automatically control LLRF Controller by sending a set of commands through the TCP/IP network. Sending modbus address commands does the cavity field value; for example, the execution command specifies the duration of the current form. The MFL32 listens to the TCP/IP port to receive a message or command from the MFL32 through the network. Upon receiving a command from the MFL32 running under dual port memory through the network.

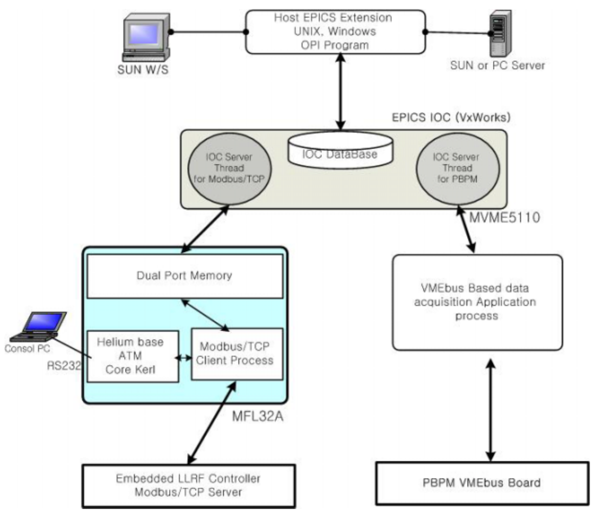


Figure 6: Structure of RF control software

User Interface

We use SUN W/S host computer in the PEPF RF control system. The host computer also serves a development environment for VxWorks, which is the operating system of IOCs. X-terminals are used as an operator interface in the RF control system. We currently use the version R3.14 of EPICS on this host machine. A test of the latest release of EPICS software, R.3.14 .4, is under way. The user interface of the PEFP RF control system two friendly graphic pages on the display screen of the control console. One is for the PEFP RF low-level system routine operation that includes system status and control parameters of the low-level system as shown in figure 7. The operator and machine engineer can fine tune and control the low level electronics of the PEFP RFQ & DTL system through this page. The other pages, display all the important parameters of Modbus network statutes, VMEbus analog & digital In/output values etc. The purpose of this pages display is focusing on global system status and debugging value RF IOC system.

CONCUSION

Final design review of the RF Control Systems for PEFP. Owing to the upgrade project of LLRF embedded controller, we have the chance to carefully examine and rebuild our intelligent Modbus client for LLRF subsystem. We have developed EPICS device support for multifunction network-based TCP Modbus Client board (MFL32). The data-acquisition times 100ms for all scanning data time. The RF control system was initially installed EPICS IOC based and system control tested in test laboratory in March 2004.

Figure 7: EPICS Extensions of RF control system

REFERENCES

[1] J. C. Yoon, J. W. Lee, J. Choi and S.H. Nam, *"EPICS based Vacuum Control system Using Ethernet Multi Serial Device Servers for PAL Storage Ring," ICALEPS2003, Gyeongju, Korea, October 2003*

[2] M. Takagi, S. Yoshida, *"Network-based Waveform monitor for the J-PARC accelerator complex", ICALEPS2003, Gyeongju, Korea, October 2003*

[3] http://www.aps.anl.gov/epics/

[4] http://www.wrs.com

[5] http://www.kaeri.re.kr/npet/proton

[6] K. T. Seol, H. J. Kwon, and Y. S. Cho, *"The feedback control functions of the LLRF System for PEFP RFQ," APAC2004, Gyeongju, Korea, March 2004*