Integration of the HVCM PLC into the PEFP Control System

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1. Introduction

The High Voltage Converter Modulators (HVCM) for the 100-MeV accelerator was installed to drive the 20-MeV linac. There are two klystrons in the 20-MeV linac and one modulator was used to drive two klystrons simultaneously. The HVCM for the 20-MeV linac area in Korea Atomic Energy Research Institute (KAERI) is shown in Fig. 1. We were faced with the necessity of integrating Programmable Logic Controllers (PLCs) for the HVCM into the Proton Engineering Frontier Project (PEFP) control system.

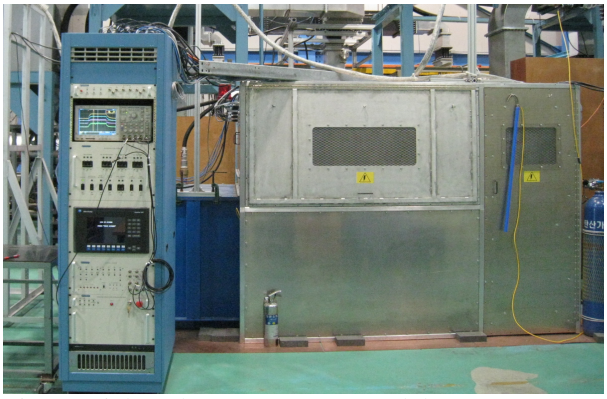

Fig. 1. High Voltage Convertor Modulator (HVCM) to drive two klystrons of PEFP 20-MeV Linac

At the PEFP, Experimental Physics and Industrial Control System (EPICS) has become the most widely used solution for building control systems for 100MeV proton accelerator [1]. The EPICS as a standard development tool is a distributed architecture that provides several solutions such as independent programming tools for operating system, operator interface tools, and archiving tools.

Although EPICS is used directly in our control system, HVCMs were delivered with the Allen-Bradley ControlLogix as a PLC. The industrial PLC has been verified for safety systems. We need to connect an interface from our EPICS control system to AB-PLC using Ethernet/IP (ControlNet over Ethernet) protocol over Ethernet. In this paper, we will present the communication protocol and EPICS IOC installation for the EPICS based PLC control system.

2. Design of System Integration

The PEFP control system is based on networked and distributed infrastructure. The PLC systems use ControlNet protocol to integrate their lower systems. The PLCs should be connected with an accelerator control system to integrate operation data from all subsystems. We need to integrate the PLC with the EPICS based control system over Ethernet. One of the advantages by using EPICS is to be able to share diverse EPICS supports. We can use the EPICS device and driver support for Input Output Controller (IOC) of the HVCM PLC from EPICS site [2,3]. To install EPICS IOC, there are some development environment requirements such as base version and extra modules. Some hardware and software configuration are installed as follows:

- PLC 1756-ENET: Ethernet Interface
- EPICS base-3.14.11
- Linux Soft-IOC

The PLC IOC produces Process Variables (PVs) of the EPICS Channel Access (CA) through tag information in Windows-based Rslogix5000 ladder software.

2.1 ControlNet over Ethernet

To integrate these into the EPICS-based accelerator control system, the EPICS IOC needs read and write access to the PLC data. The PLC offers several interfaces: Ethernet, ControlNet, DeviceNet, RS-232 and others. The ControlLogix Ethernet interface module 1756-ENET uses EtherNet/IP, the ControlNet protocol, encapsulated in Ethernet packages, with specific service codes. The encapsulation structure of Control and Information protocol (CIP) to connect Ethernet/IP based communication with PLC is shown in Fig 2.

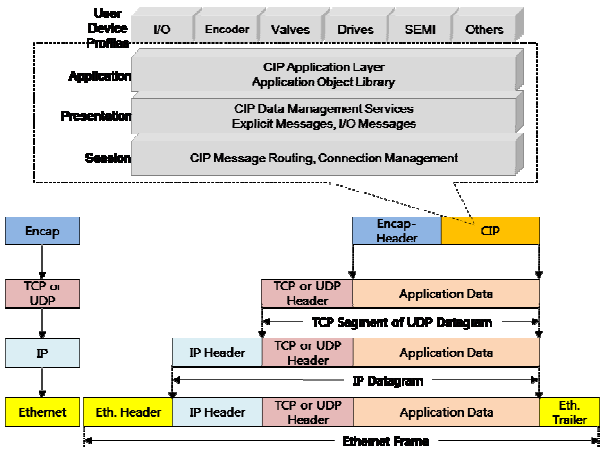

Fig. 2. TCP/IP encapsulation for CIP application

Since the PLC is already equipped with an Ethernet interface, it is desirable to use the same technology for transferring the PLC data. Existing support and knowledge for cabling, network hardware,

configuration and maintenance can thus be utilized.

2.2 Software Configuration

The PEFP application development environment was set up to minimize the amount of EPICS system administration work. The directory structure is consistent with conventions used by the scripts, rules, and makefiles provided with the official EPICS software distribution. EPICS database with PV names constructed according to the different syntax rules used for the PLC tag names and the corresponding EPICS database records.

The I/O point names can be read by scripts to generate tag name lists used in the PLCs and PV names for EPICS databases which are loaded into IOCs. Tag names are grouped by EPICS record type and packed into data transfer arrays which are used by a communications driver to move data for the operator displays between the PLCs and IOCs. The ControlNet protocol is a deterministic serial communication system, its specification extends from the physical to the application layer of the seven layer ISO OSI model.

2.3 EPICS Based Input Output Controller

The certified development tools, distributed control infrastructure, and efficient maintenance are requirements of the PEFP software development tool. The EPICS tool provides the CA communication protocol to make TCP/IP connections and transfer process variables among EPICS IOCs. We purchased three computers for the PLC programming and EPICS operator interface (OPI) and IOC. The laptop computer was used for programming the PLCs (Windows XP systems). The workstation was used for developing the EPICS screens and databases (Linux system). The HVCM control system was installed on IBM server shown in Fig. 3.

Fig. 3. HVCM control system for interfacing IOC to PLC Ethernet/IP

The IBM server computer (Linux system) was purchased. Identical EPICS application development environments were set up on them. That both an IOC and PLCs are how to connect, send, and receive PVs matched with PLC Tags using CA protocol is presented in Fig. 4.

For each PLC, the EPICS driver code arranges the tags in scan lists depending on the requested update rate. One thread per PLC handles all read/write requests. EPICS device support allows analog, binary and multi-bit records to use the driver for input and output. Tags have to refer to a scalar value, a single array element or a structure element, not whole arrays or structures.

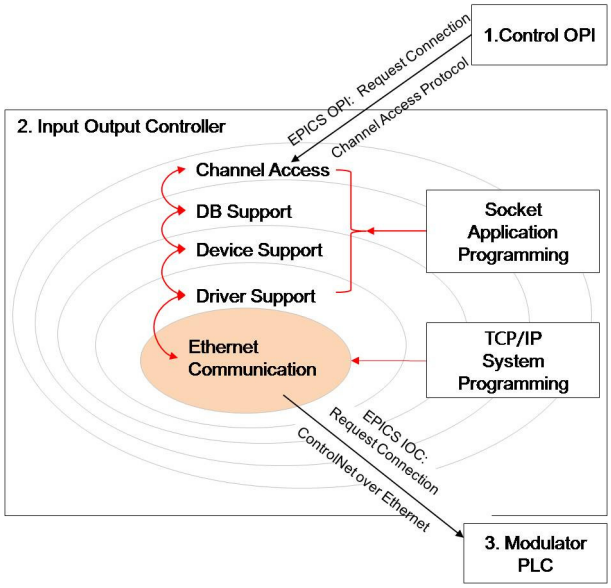

Fig. 4. EPICS Input Output Controller (IOC) structure for control communication between IOC and PLC

3. Conclusion

We have installed EPICS device/driver supports for the PEFP HVCM PLC. It is possible to use the published EtherNet/IP specification together with the openly available Allen- Bradley extensions to read and write tags on a ControlLogix system. The EPICS support is convenient to use. This EPICS IOC software will be tested on Linux Soft-IOC of the IBM server. After conformed as an IOC, all of modulator PLCs is connected by an EPICS IOC.

4. Acknowledgements

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