RF TEST STAND CONTROL SYSTEM FOR XFEL/SPRING-8

T. Fukui[1], T. Hasegawa[1], N. Hosoda[1], H. Maesaka[1], T. Masuda[2], T. Morinaga[2], T. Ohata[2], T. Ohshima[1], Y. Otake[1] , K. Shirasawa[1], S. Takahashi[2], M. Yamaga[2], and A.Yamashita[2]
[1]RIKEN Spring-8 Joint-Project for XFEL, Hyogo 679-5148, Japan
[2]JASRI/SPring-8, Hyogo 679-5198, Japan

Abstract

The X-ray free electron laser (XFEL) facility is under construction at SPring-8. An rf test stand was built for the XFEL to ensure the performance of the delivered rf components under a high-power condition and to establish a conditioning procedure for stable operation with the designed rf power. In addition, the test stand is used to determine the performance characteristics of a low-level rf system, a precise water temperature control system, a vacuum system, an rf high-power system, and a low-noise power supply. In this paper, we describe a software framework for controlling these systems and the test results of a newly developed software component that includes device drivers with Solaris 10 for x86.

INTRODUCTION

The X-ray FEL (XFEL) project at SPring-8 aims to build an 8GeV XFEL facility on the SPring-8 site. The XFEL consists of an electron gun [1], a beam deflector, a prebuncher cavity, a booster cavity, an L-band correction cavity, an L-band buncher, a C-band correction linac, a S-band linacs, and main C-band linacs [2]. In addition, a number of in-vacuum undulators of 4.5m length will be aligned after the accelerator. An rf test stand was built for the XFEL to ensure the performance of the delivered rf components under a high-power condition and to establish a conditioning procedure for stable operation with the designed rf power. In addition, the test stand is used to determine the performance characteristics of a low-level rf system [3], a precise water temperature control system, a vacuum system and an rf high-power system [4]. The control system of the test stand controls and logs these systems and a safety interlock system. Most of the software components will be used for the XFEL, and GUIs will be used for the commissioning and maintenance of the XFEL.

OVERVIEW OF THE SYSTEM

We designed the control system using the MADOCA (Message And Database Oriented Control Architecture) framework [5]. We use PCs with SUSE Linux Enterprise as operator consoles. These operator consoles are equipped with dedicated graphics boards to support dual displays. The device control layer consists of various parts, such as the VMEbus system and a programmable logic controller (PLC). The RPC-based communication layer connects the operator consoles and VME systems over the Ethernet. For the local control of a precise water temperature control system, a vacuum system, an rf high-power system, the safety interlock system, and the low-noise power supply, we adopt a slow control system deploying PLCs.

Figure 1: From left to right – rf low-level control units in water-cooled 19-inch rack. The precise water temperature, vacuum, rf high-power systems are located in the two 19-inch racks on the right.

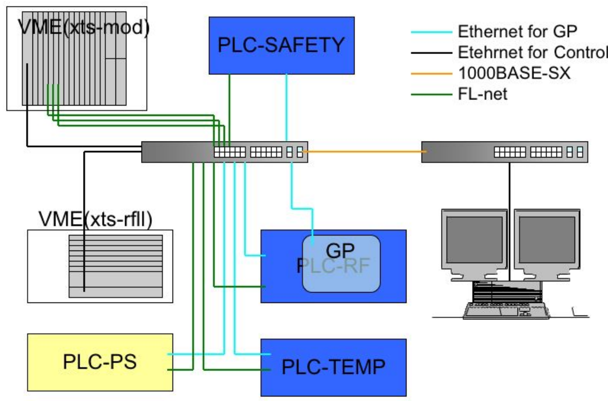

Figure 2: Schematic of network system.

PLCs are linked with VME systems through the FL-net, which is an Ethernet-based factory floor network [6]. We adopt a VME CPU board based on the IA architecture with CompactFlash, a mass-storage device, and run Solaris 10 on it. High-speed A/D and D/A VME boards [7] operating with a 238MHz clock are adopted to detect phase/amplitude signals generated by the klystron and to generate signals of Q and I components for the klystron input. The trigger delay unit (TDU) [8] is a 5712MHz synchronous delay VME module with 24bit counters and prescalars. The rf low-level system is installed in water-cooled 19-inch racks to maintain a constant temperature (typically 26±0.2˚C), as shown in figure 1. In addition, the flow of cooling air must be designed to not vabrate the rf cables to ensure stable operation [9]. Operation programs have been developed using X-Mate, a GUI builder based on X-Window. For the main database of the system, the existing Sybase-based DB server for SPring-8 is used [10].

NETWORK SYSTEM

We adopt a simple network configuration to realize both high performance and simple network management, as shown in figure 2. A Gigabit Ethernet with optical fibers is installed as a backbone network to avoid electromagnetic interference and to separate a signal ground line between the high power rf and the operator console. To separate the functions of the network, a virtual LAN (VLAN) is used. The VLAN allows the sharing of the backbone between the control network and the FL-net network. Three FL-net segments are used to control the PLCs. Another segment is used to communicate with a graphical touch panel (GP) and PLCs. All PLCs except the safety interlock system share one GP and operators can manage the PLCs from a single panel.

VIRTUALIZATION

We apply a virtualization technology, called Solaris Containers, to the VME systems that control multiple equipment groups. This technology enables us to separate such VME systems into various virtual hosts. Each virtual host manages an independent equipment group [11]. At the rf test stand, we apply this technology for FL-net control. We consider three FL-net segments, one for the safety interlock system, one for the precise water temperature control system, and one for the vacuum, rf high power, and low-noise power supply system. Each segment connects the separated VME FL-net board and can be accessed from a single VME CPU, which is equipped with a 1.8GHz PentiumM CPU and 1GB memory. We have installed three virtual hosts on the VME CPU, and RPC server processes are run on each host concurrently, as shown in figure 3.

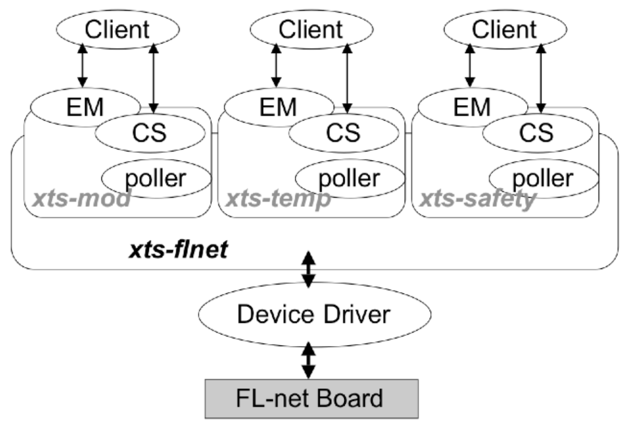

Figure 3: Schematic of FL-net control VME with three virtual hosts.

DEVICE DRIVERS

We adopt the VME CPU board equipped with a 1.8GHz PentiumM CPU and 1GB memory with Solaris 10 for x86. We have developed a nexus driver for PCI to VME bus bridge. For the leaf drivers for each VME board, we have only compiled the source code on Solaris 10 because the register map of the high-speed A/D, D/A, and TDU VME boards is almost the same as that used in the SCSS prototype accelerator facility. The existing leaf driver currently works well on Solaris 10. The circuits of the A/D and D/A boards have been redesigned and new functions have been added. We have developed new leaf drivers to support new functions and their testing is underway.

GUIS FOR THE OPRATOR CONSOLE

Operation programs for the rf high-power control, vacuum, and timing systems have been developed using X-Mate, and some programs such as the waveform display for the A/D board, were copied from the SCSS prototype accelerator facility. Figure 4 shows the GUIs used for the test stand operation. The alarm surveillance program is used the same as the SPring-8 control system. An alarm display is developed using wxPython with Festival, which is a general multilingual speech synthesis system [12].

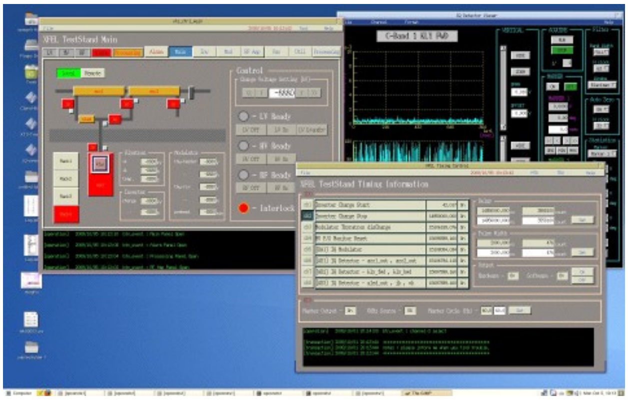

Figure 4: GUIs used at operator console at test stand.

SUMMARY AND FUTURE PLANS

We have designed and developed a control system for an rf test stand based on the MADOCA framework. We use PCs with SUSE Linux Enterprise as operator consoles. The device control layer consists of the VMEbus system and PLCs. The PLCs are linked with VME systems through the FL-net and apply virtualization technology. Several GUIs for operations have been developed using X-Mate and an alarm display have been developed using wxPython.

Because the rf test stand is used to determine the performance of the system, the control system has the same configuration as the XFEL accelerator. We plan to use the control software for hardware commissioning. The first test of the main C-band linac unit will be conducted in November 2009. The control software is also expected to be used at maintenance.

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