RECONFIGURABLE EMBEDDED INTERFACE SYSTEM FOR HIGH ENERGY ACCELERATORS

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Abstract

A reconfigurable embedded interface system has been developed using micro-controllers for high energy accelerators. The system has up to 28 digital I/Os and 8-channel AD converters (10 bits), interrupt functions allowing control systems to access any accelerator components over the network. The components involve beam-position monitors, current monitors for bending magnets, ion pumps, vacuum valves, insertion devices, RF components, ion-gauges, and beam-lines. The interface is programmed to carry out specific tasks in accordance with requirements for experiments and research purpose. The interface employs PIC micro-controllers,and it can be connected to the network. The interface is easily reconfigured using its bootloader by uploading a new program from the remote distributed control system through the network. The test of the system has been successfully carried out for a monitoring system for AC power consumption at the control room of B-Factory, KEK. The design and implementation of the reconfigurable interface embedded system for high energy accelerators are described in this paper. It can, thus, reduce cost of reconfiguring procedures that would have otherwise caused costly implementation.

INTRODUCTION

High energy accelerators comprise a large number of components and sensors such as digital and analogue I/Os. The components involve a number of actuators, beam-position monitors, current monitors for bending magnets, ion pumps, vacuum valves, insertion devices, RF components, ion-gauges, and beam-lines. These components are controlled by a control system, composed of client/server computers connected to the network[1].

An intelligent embedded interface is necessary to interconnect between the server and accelerator components. Each server has at least two network interface controllers(NIC). One is connected to clients and other servers for the entire network, and another to its "private" network below the server. With this configuration, the server is capable of accessing to any components of the accelerator through the private network. Furthermore, the interface has to be reconfigurable so that it can be upgraded its control software in accordance with requirements of physics experiments. This is also true when the accelerator components has to be improved to achieve better performance of the accelerator. In this paper, a reconfigurable embedded interface system for high energy accelerators described. implementation.

CONFIGURATION

The hardware configuration of the interface system is kept as simple as possible to reduce cost. It has been designed and implemented using embedded micro-controller, PIC 16F87* series and additional circuitry such as analogue buffers, level-shifters and digital interfaces. A commercially available network interface, X-Port, is employed to interconnect between the network and the serial ports of the micro-controller[2].

The software of the interface is composed of two pieces of program including the bootloader and the control program for interfacing/controlling the accelerator components. The bootloader program resides at the bottom of the EPROM area[3]. The bootloader allows for the interface system to overwrite the control program by loading an upgraded program from a host computer through the network. Here we focus on the reconfiguration of the interface.

The procedures for boot-loading are done as follows:The control program is written in assembler, C or any higher level language, and it is in general compiled in the Intel Hex TEXT format. The Intel Hex format is a simple format containing text lines starting from preamble character ':' followed by data length, address, data identifier (or record type), data, and checksum. Uploading program, or 'Uploder' which can transfer the program in the Intel format from the host to the interface system has been developed in Java. Using the Uploder, the control program in the embedded interface system can be upgraded by uploading a revised program from a host computer, or the server of the control system, connected to the network. A client can also be a host to upgrade it using the Uploader.

Upon reset, the embedded interface system waits for a simple command from the Uploader running at a host computer until timeout occurs typically three seconds. The command is just one of following characters :'R'un,'B'oot as well as a reply-character 'S'uccess, 'F'ail, '.' (send-new-line) for the host. The REIS passes control to the existing program when the timeout occurs and there is no command sent from the host.

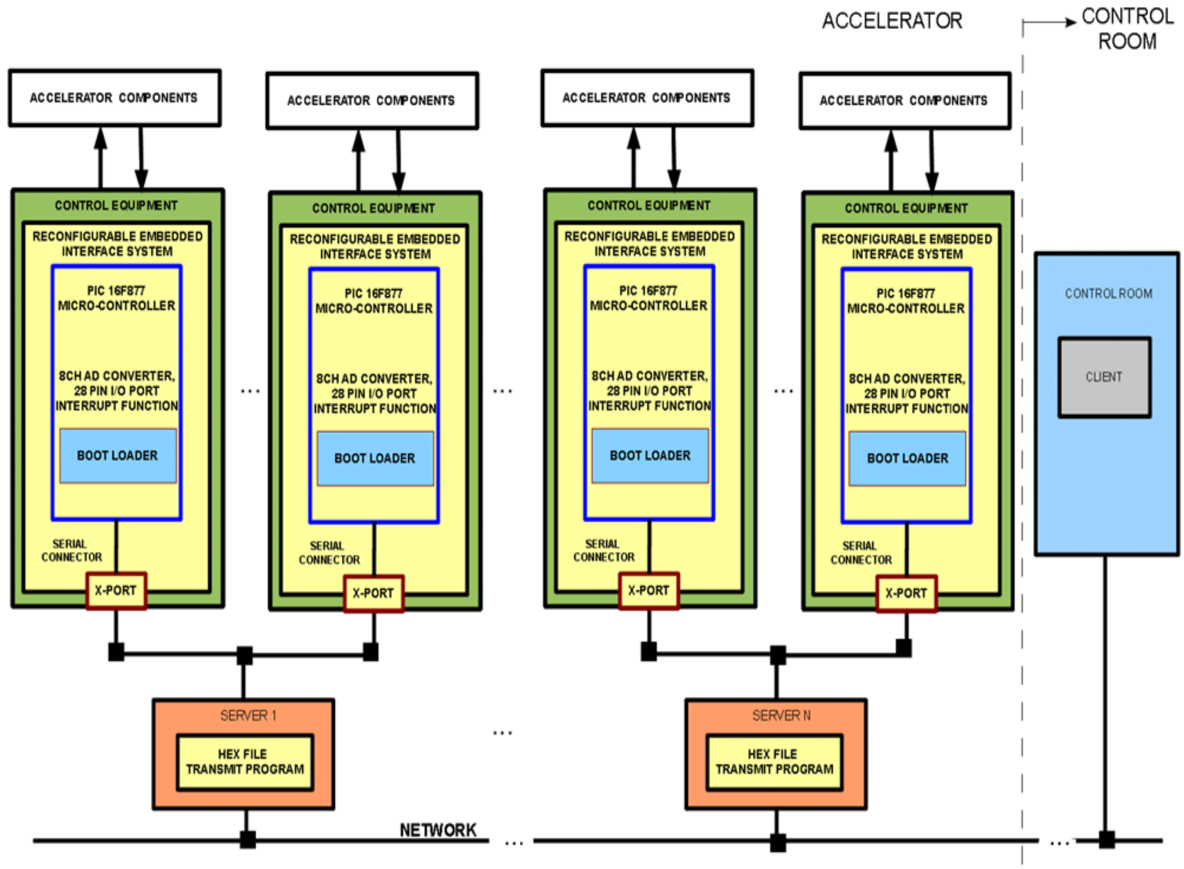

Figure 1 : Block diagram of the reconfigurable embedded interface system.

To upgrade the control program in the Intel format, it is very simple. The Uploader of the host computer sends 'B' character followed by the new program line by line. Upon receiving the character 'B' followed by ':' in consecutive text lines, the interface system verifies the contents whether there is an error in it by comparing the checksum and syntax of the format This is carried out line by line. Finally, it overwrites the existing control program in the EPROM area if there is no error in each line. In response to each success line, the interface systgem sends '.' character to ask for the next line in the control program. On completion of the transfer, it replies 'S' character implying that the transfer is success otherwise 'F' to let the host know the failure status during the upgrading process. The failure status 'F' is also sent if there is any communication error between the host and the embedded interface system. The Uploader suspends the transmitting procedure when it receives 'F' and then resumes from the beginning. Using a network stream capture tool (NSCT) which allows to capture/analyze the incoming and outgoing packet-stream between the embedded interface system and server computer is used for debugging the communication procedures[4].

APPLICATION

Figure 2 shows the block diagram of the monitoring system using the reconfigurable embedded interface system. The reconfigurable embedded interface system has been applied to a prototype for the monitoring system of power consumption rate at the B-Factory control system at KEK[5].The monitoring system consists of clients/servers that fetches AC current data from embedded interface systems connected to a number of sensors, i.e., the current transformers(CT), through the network. The CTs are clumped across the AC power lines. Each interface system has eight CTs with different I-V characteristics in terms of sensitivity, offset, and magnetic saturation characteristics caused by ferrite-cores. The system had to be implemented at minimum cost providing network connectivity as well as analogue data acquisition functionality. Thus, for the interface system, they have to be remotely configured to adopt itself with the different output characteristics of the CTs.

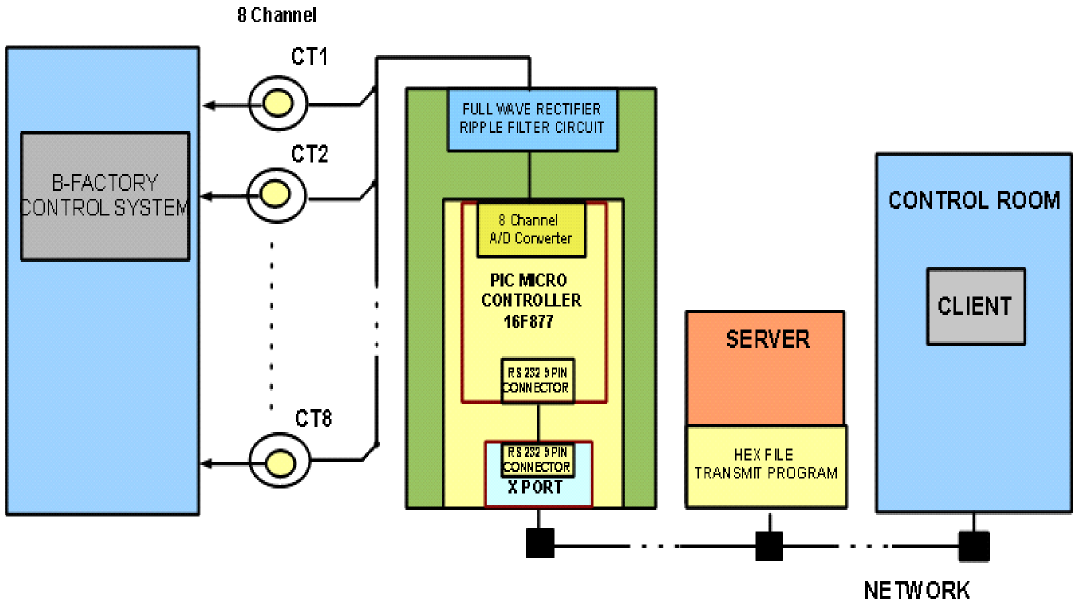

Figure 2: The monitoring system using the reconfigurable embedded interface system.

The characteristic transfer function of the CT have been measured, and expressed with polynomial functions in terms of AC current passing through the CT and it output voltages. Then, the coefficients of the polynomial functions of the CT have been calibrated to achieve better accuracy. This is done by comparing the measured current values with the known-current value, and then by upgrading the control program in the interface through the network. As a result, the clients/servers can acquire AC current data by inquiring through the network. The interface system is measuring the output voltages of the eight CTs at an interval of 50ms. The control program in the interface system has a digital low pass filter to achieve better noise reduction. On receiving an inquiry from a server, the interface system converts the latest output voltages of the CT, and then calculates/converts them into actual AC currents corresponding to the power consumption rate. Finally it replies the power consumption rate to the server. After receiving the power consumption data, the clients depict the present status of the power consumption rate onto the graphic displays.

CONCLUSION

The reconfigurable embedded interface system has been designed and implemented for high energy accelerators. The system has successfully tested at KEK's B-Photon Factory. Experimental results at the B-Factory, KEK, show that the embedded interface system allows client/server computers to access accelerator components over the network. Furthermore, it is capable of being upgraded through the network, providing rich flexibility at a low cost.

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