The IHEP Accelerator Utilities Control System

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Abstract

This paper presents the IHEP Accelerator Utility System (AUS) architecture and the hardware and software organization of the Utility Control System (UCS). The size and complexity of UNK requires a multi-level multi-processor control architecture. Low level control for utility subsystems is performed by distributed equipment controllers. The next high level of control is carried out by front end computers (FEC) spread around the main accelerator ring and Beam transfer line (BTL) and is interconnected with higher level computers and operator consoles by a control network. A review of the general features is given.

Introduction

The IHEP Accelerator Utility System (AUS) includes safety equipment for personnel and machinery in the premises of the accelerator complex. The Utility Control System (UCS) is composed of the following sub-systems : electricity distribution network, gas analysis and compressed air, ventilation, fire-fighting and drainage. It is made up of hardware and software designed to automate the control and so increase the effectiveness of the accelerator operations staff and the utility control staff.

The UCS must transmit the necessary information to the dispatchers and to the operators of the respective services, as well as allow them to set, change or monitor utility systems parameters. It is also necessary to ensure the correct order of the actions of systems and operators to guarantee the security of personnel as well as the protection of the accelerator equipment. It is requisite to keep a record of AUS state changes and UCS operators actions.

To perform these functions, UCS must provide for AUS data acquisition, AUS data processing and archiving, the generation of control messages and transmission of these messages to the equipment of the respective control systems, the creation and update of the respective information databases, the presentation of the AUS state information to the operators, the generation of parameter-out-of limits warnings and provide the possibility for manual remote control of the equipment and equipment diagnostics.

Organization of UCS Hardware.

A peculiarity of utility systems is the unusual diversity in the low-level data acquisition devices (pick-ups) and in the control devices in different sub-systems. Since the AUS sub-systems will be installed in all operational buildings of the accelerator, a hierarchical structure is the obvious one for the UCS hardware (fig. 1).

The data acquisition and control hardware is built in Euromechanics (EM) crates with the MULTIBUS1 (MB1) backplane bus and in an industrial-designed servo-amplifier equipment crate (EC). This configuration (one EM and one EC) provides support for 256 transducer inputs, 32 electrically operated valves and 8 actuator drivers for AC electric motors. All the motors for the compressors, pumps and valves used throughout the utility equipment are interfaced by Digital Servo Amplifier cards (DSA). A PC-16 module with an i8086 microprocessor is used as a crate controller in this configuration.

An analysis of input/output signal requirements for the various AUS subsections shows that they, as well as the TPS connection, the generation of remote starting signals for the control devices in a given building and the control message transmission may be effected using the following basic set of electronic modules :

- a multi-channel digital-input module with 96 input lines with opto-coupler isolation: input signals: 24 V 10 mA.
- a multi-channel digital-output module with 16 output lines with opto-coupler isolation; output signals: 5V, 400 mA;
- a multi-channel analog-input module with 16 input lines with galvanic isolation: input signals: +10 V with 5 mV precision;
- a multi-channel analog-input module with 16 input lines with galvanic isolation; input signals: 0-20 mA (this may be combined with the previous module);
- a 2 to 4 channel IRPS interface module; this will enable the data to be exchanged with the higher level controllers.

The EM data acquisition and control crates in one building are connected to a Utility Control Computer (UCC) using the MIL-1553 bus. The latter will provide the inter-linking of all sub-systems within a building and the transmission of the control messages to the sub-system controllers installed in the EM crates. The UCC provides the communications through the network with the accelerator control computer, as well as with the central accelerator control console and local consoles in the operations buildings or utility consoles in the services buildings. The above requirements are satisfied within the conventional architecture of accelerator control systems by a front-end computer (FEC) and one based on a Motorola 680xx microprocessor is used as the UCC .

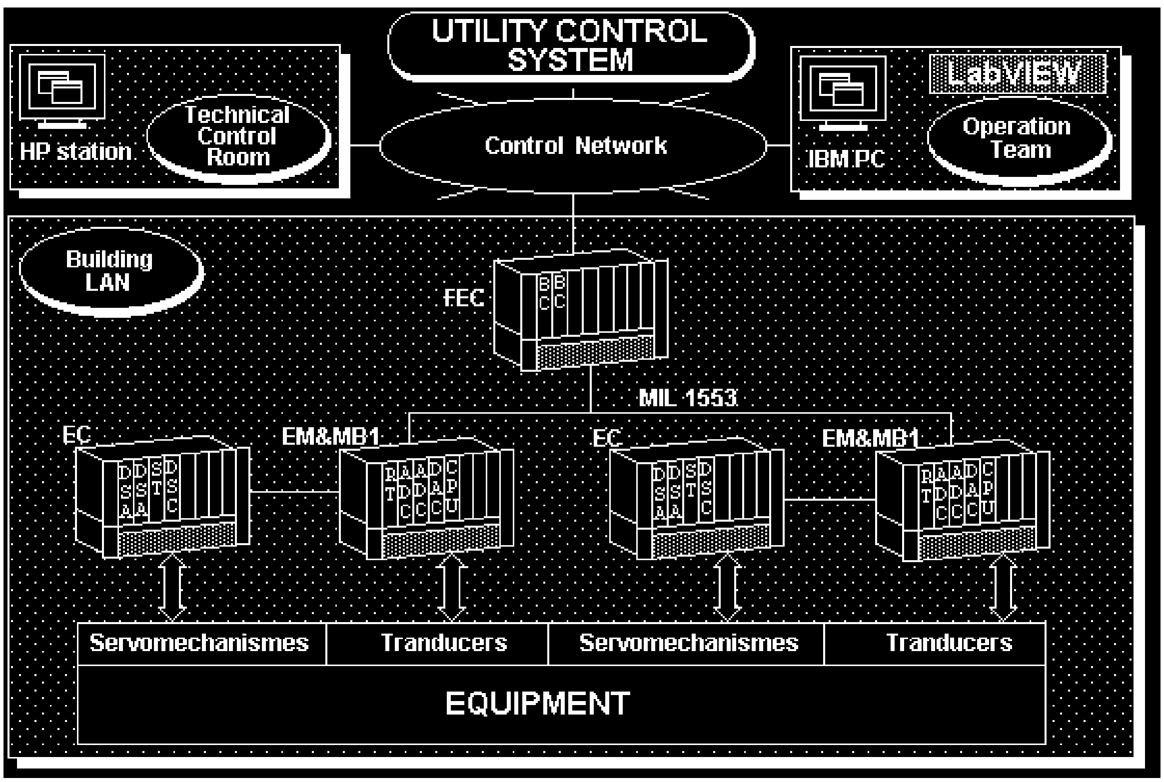

Fig. 1. Utility Control System.

A local console based on an IBM-PC computer is connected to the building LAN for start-up, tuning, repair and equipment diagnostics purposes and may also be used as a local operator console for all sub-systems in the building. In like manner, additional IBM-PC-based consoles, located in different buildings of the accelerator complex, may be connected, provided they have a Control Network connection.

Obviously this architecture for the UCS presupposes that reliable independent sub-systems will be employed for the low level equipment control of each sub-system of the AUS. These independent control sub-systems must ensure the reliable operations of the AUS sub-systems even in case of malfunctions of the equipment at higher levels of the UCS (EM & MB1 and UCC) and the data links (MIL-1553 and computer network). Hence, these independent sub-systems for low-level control must comply with the current standards and must be attested accordingly.

In addition to the central accelerator control console, it is necessary to provide consoles for the UCS services in the premises of the respective services. Utility consoles provide information, displaying the state of the systems, while local consoles are mostly employed for test runs, diagnostics and repair.

The UCS software

The MTOS may be used as the operating system for the EM & MB crate controller (PC 16 module), The remote terminal (RT) MIL-1553 bus driver, as well as a RS-232 serial port driver for possible later use, are to be built into the MTOS kernel. Furthermore, utility and application-level protocols are to be developed to download tasks from the higher-level computer (UCC), to the PC-16, to initiate or to suspend the execution of the given tasks, to remove the tasks from the controller memory through the MIL-1553 bus and/or through a RS-232 serial port, as well as to ensure the interaction in the command-reply mode.. The FEC operates under LynxOS and uses the standard means of UCS equipment access, adopted for all the accelerator control system, DEC workstations and ULTRIX are used for the accelerator control computers and consoles The appropriate choice of operating environment for the local console is MS Windows, as this setting provides a uniform user interface for all applications. Since the development of applications under MS Windows is quite laborious work, the use of commercial software development kits and libraries seems to be the obvious solution to simplify the programming of applications and user interface. To interact with the higher-level computer through the network, the PC/TCP Development Kit of the Windows Sockets library is to be used.

LabVIEW for Windows, capable of creating an almost complete set of applications based on an IBM PC/AT, may be used for applications development. A set of VIs and servers which realize a protocol for remote access from upper level computers and consoles to the ECs has been developed. This software provides convenient tools for representation and access from LabVIEW applications to different accelerator equipment. The icon-based graphical programming system LabVIEW provides a powerful environment for control system design and gives significant gains in productivity with no sacrifice in performance and flexibility.

Such tools have already been used in the Beam Transfer Line (BLT) electricity control system and for creating a prototype for the BTL utility systems.

Conclusion

The use of a hierarchical, networked architecture is suitable for this system. The distributed sub-systems can be incrementally upgraded - or even replaced - with a minimum of impact to the rest of the system. During the last accelerator run the BTL UCS was tested. The number of available menus on the local control console have been increased progressively to cover all the required functionality and their performance has been improved using feedback from the operators. Most problems occur when the different pieces of equipment are first connected to the network; mainly due to cabling faults. The main advantage expected from using the UCS is the fact that is an OPEN SYSTEM available for many services and the design is based on the key elements: integration, distribution, easy of use, expandibility and reliability.

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