THE SATELLITE MINICOMPUTER -- A PRACTICAL SOLUTION TO ACCELERATOR CONTROL*

by

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Introduction

Computer control of any large industrial or research facility generally requires the presence of a rather extensive collection of distributed interface devices. These devices serve to couple the control computer to the process, in order that pertinent digital and analog data may be acquired by the computer, and to provide a means for the computer to output set-point information to the process.

In the past several years, implementation and control of the required distributed interface devices have generally been carried out through hardwired digital-logic under the direction of a central control computer (i.e., operations performed by every remote interface device effectively originate from a single, centrally-located computer).[1] Recently, it has become evident that a standard minicomputer or even a micro-processor may serve as the interface-device controlling element at these remote locations.[2,3] Satellite minicomputers, located at each remote data collection and control point throughout a facility, may communicate with a central control computer but are responsible for all actions at the local area.

Decentralization of the interface system, by allowing distributed interface computers to share the overall control problem, means not only that the central computer task is reduced but that installation, checkout, and maintenance at the local area are more easily accomplished.

An Operational Satellite

The injector complex of the 800-MeV Proton Linear Accelerator at the Clinton P. Anderson Meson Physics Facility (LAMPF) is an excellent example of a remote area controlled by a large central control computer. Owing to the overall complexity of the area, control and diagnostics of the H^+ and H^- ion sources and the low energy beam transport lines are accomplished locally (Injector Control Room, ICR) or through the control computer (Central Control Room, CCR) located one half mile away.

Initial operation of the H^+ ion source was accomplished through a digital-logic interface unit under control of the central computer. It soon became evident that the desired flexibility in operation and maintenance could not be effected by this "hardwired" device. A satellite minicomputer (Nova) was installed two years ago with hardware and algorithms to ultimately service three ion-sources, three console display and local control stations, communications to and from central control (via data-link), and finally several low energy emittance diagnostic stations. Recently, algorithms have been added to give central control the capability of gathering low energy emittance data in addition to an existing ICR presentation of beam emittance. During normal operation, the satellite computer provides a continuous update of pertinent ion-source data to both CCR and ICR. Figure 1 shows the ICR installation with the Nova satellite minicomputer and ICR console controls.

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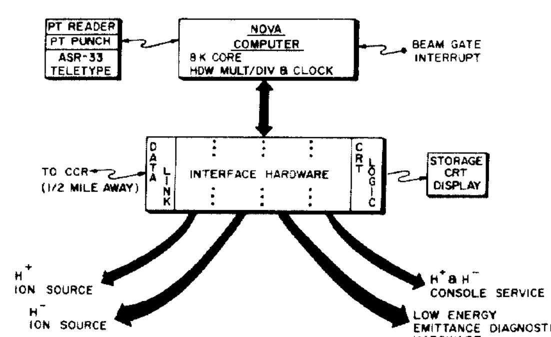
Fig. 1. LAMPF Injector Control Room Console with Satellite Minicomputer (left rack), Peripheral Devices, and Console Control/Display Panels.

Organization of the Satellite System

The block diagram of the satellite minicomputer system installed in the LAMPF injector area is shown in Figure 2. Again, owing to the complexity of control and diagnostics at the injector complex, the satellite minicomputer has been provided with more peripheral I/O devices than would be required in other remote areas of LAMPF. A storage CRT display provides local graphics readout while a high-speed paper tape punch/reader and teletype generally aid in operation of the system. Software changes or additions are carried on paper tape, generated on a large batch computer, and entered through the high-speed reader.



PRESENT HARDWARE CONFIGURATION OF THE SATELLITE MINICOMPUTER - LAMPF INJECTOR CONTROL AREA

Figure 2.

The minicomputer I/O bus was extended to an assortment of interface logic (located within the console racks) for the purpose of providing communications to and from CCR (via computer-computer data-link), the ion-sources, the console display and command devices, and to the low energy emittance diagnostic hardware.

An input from the LAMPF Master Timing System serves to slave the system to the accelerator in order that beam-correlated data may be acquired.

The satellite minicomputer may be thought of, most generally, as a data-concentrator with several sources of data together with the necessary control algorithms to provide a coherent operating discipline. The entire satellite system, however, is only one of sixty remote data acquisition and control terminals throughout the LAMPF accelerator and experimental area.

Software Organization

The operating algorithms of the Nova minicomputer are core resident, resulting in faster response and easy access to a desired code. The 8192-word core memory has provided ample space for the software package needed to run the system.

An ion-source data-scan and console update/service code is executed automatically, on a periodic basis, via interrupt from a real-time clock located within the Nova main frame. Ion-source data are placed in a data-bank in memory, and console display devices (meters, lights, BCD numeric readout, etc.) are updated from the data-bank. If ICR is in control of the injectors, the algorithm searches for any binary or analog command requests from the console and services the requests found.

Data requests from CCR, via the data-link, have a top interrupt priority and are serviced from the in-core data-bank mentioned above. Command requests (binary or analog) are channeled to the appropriate ion-source or emittance diagnostic hardware provided ICR is not in control.

Parity information is carried with all data transmissions to and from the satellite system. Software checks are made to determine the validity of the data prior to use within the satellite algorithms.

Background Algorithms

The several mainstay operating-algorithms (CCR Data-Link, data-scan, and console update/service), as previously mentioned, are interrupt driven either periodically or asynchronously as required. A core resident emittance reduction and display algorithm, used in low energy beam diagnostics, runs in a non-interrupt "background" mode when requested by the ICR operator. Beam emittance displays are generated on the storage CRT while the teletype is used to control the program.

Other debugging, system diagnostics, tape read/punch, and core dump codes are also executed in the "background" mode while the main operating algorithms continue to run in interrupt mode.

Other Satellite Systems at LAMPF

The control and data acquisition of twenty multiple-wire beam diagnostics devices, located in the LAMPF experimental area beam lines, will soon be coupled to two satellite minicomputer systems. Information gathered and pre-processed by these interface computers will be sent to CCR for final use via data-link. The high data collection rates and the total number of data points required would tax the existing hardwired interface devices. The satellite minicomputers provided an excellent solution to this interface problem.

Conclusions

The value of using more "intelligent" interface devices in large facilities controlled by a central computer control system has been indicated. In addition, an operational satellite-minicomputer system at the LAMPF injector complex has been described. The overall flexibility gained in the use of an interface device based upon satellite minicomputers has proved to be an important step forward in the engineering of computer control systems. Operational experience over the last two years at LAMPF with the injector interface system has provided a sound basis for these conclusions.

References

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