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NAL ACCELERATOR CONTROL SYSTEM DESIGN PHILOSOPHY

Alan D. Albert

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Design Goals

(1) The Control System should be capable of pre-programmed automatic operation with, at most, (2) one operator required to be on duty. (3) Each major component of the accelerator system (e.g., linac, booster, main synchrotron, etc.) should be capable of independent automatic operation. This is essential, both for reliability and for maintenance. If the central controller is down, the system must still be able to run. Independent levels of both routine and emergency maintenance need to exist for any reasonable reliability of the system. A single integrated system for a machine complex of this size would be so complex as to be totally unmanageable. (4) Manual operation should be possible in emergency modes only.

(5) Control System software should be written in as high order a language as is possible (e.g., extended Fortran IV), to minimize programming time, costs, errors, and to permit the accelerator designers to directly interact with the system without having to go through a machine-language programmer.

(6) Both the hardware and software systems should be modular, easy

to change, and, as much as possible, use standard off-the-shelf modules.

Basic Design Philosophy

To achieve the first two design goals, the routine controlling of any major accelerator component must be accomplished by a stored program control device; most probably one of the small digital control computers. Further, these small control computers require a higher level integration and control from the central control point, indicating a system using a master computer with several or so satellite computers (3).

To simplify the hardware development effort and to enhance the system operation, functional items to be remotely controlled should be designed for direct digital actuation and feedback. Manual analog controlling (4) will be accomplished by an A/D "kludge" box during checkout and maintenance. The "kludge" box then becomes a maintenance tool instead of a permanent part of the system. The latter occurs when manually-operated systems are later automated.

To achieve the software goals (5), computer purchases must be very carefully made. Available software, especially Extended Fortran IV, Real Time Monitors and Input/Output systems, must be carefully evaluated. The satellite computer structure also has some special advantages for utilization of the above sorts of advanced software.

In order to be able to store and compile with these sorts of languages, a large core memory and a reasonable random access bulk storage are necessary and expensive. With a satellite system, compilation and debugging can be accomplished at the central computer or on an off-line satellite at the central location. The object code developed can then be transferred directly to the operating computer. All of this can be accomplished under the control of the real-time monitor while the system is controlling the accelerator(s). The satellite system enables this advanced software utilization without requiring the expensive memories at each location.

In general, hardware prices are becoming quite cheap. A small 16-bit central processor with a medium size core memory often costs less than a magnetic tape unit with controller and is about the cost of one-half of a man year of programming labor. Such a computer would have very limited usefulness if it existed alone, but in a satellite mode can be made to perform as a system several times as costly.

The last goals (6) are readily met today. Most control computers have an extensive family of options, interface equipment and compatible "front end" and sensor equipment. Modular software depends on a good real-time monitor, other advanced software, and care in the design of the entire system. The latter task is the most difficult and will depend to a great degree on how our prototype development program is accomplished.

Prototype Systems

The prototype systems currently being designed can either be independent systems, with the attendant duplication of equipment and added costs, or can be a small set of satellite systems. The latter choice not only will save money now and provide a greater hardware and software capability initially, but the detailed design ideas can be tested in a real (instead of simulated) environment.

By developing two or three small satellite networks, invaluable experience can be gained with different makes of computers and with their accompanying software. Hardware/software "efficiency" for a specific task is impossible to evaluate without actually using the systems.

The Linac section has already purchased an SDS Sigma 2 computer with 12K words of core. The first step in the building of a small satellite network can be made with this facility. The linac facility was intended to be expanded by the addition of a high-speed printer, a random access disc, a CRT/keyboard system and a card reader. With the further addition of computer-to-computer interface units, an additional 4K of core, and a magnetic tape unit, the linac facility will be able to act as a true central computer in a satellite network. It is planned for the Booster and RF sections to purchase limited capability Sigma 2 CPU's (8K core) with computer-to-computer interfaces to complete this first network. We will then share the expensive peripherals (magnetic tape, card reader, random access disc, high-speed printer, high-speed paper tape reader, etc.) between three groups. Utility programs and similar control/display programs can be developed jointly, thus saving considerable redundancy in programming. As a step towards the design goals for the entire control system, the intricacies and special problems connected with satellite operation will be confronted and solved before the final system is designed.

The main ring, beam transfer and experimental facilities prototype systems should probably use different hardware and will, perhaps, make up two more small satellite networks. It is hoped that these systems can be specified and purchased initially as complete networks.