APPENDIX XIII. CONTROLS FOR THE ENERGY DOUBLER

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A. Introduction

The philosophy followed in the present Fermilab Computer Control and Monitoring System will be continued in the Energy Doubler Controls and Instrumentation. The present system has developed in an historical manner; many things that were done in the early phases of the accelerator are no longer necessary or have been replaced by new installations. Thus, there is considerable redundancy in the existing control system---enough so that the present system is capable of including the initial Doubler control with only minor extensions. Of course, there are modifications and extensions that make for convenience and improvement. These will be incorporated as operating experience is gained. Since the addition of the Doubler primarily impacts the Main Ring and Switchyard control system, a brief description of these segments of the entire system is presented first. Next a discussion of necessary modifications to the existing system is presented, followed by a discussion of new installations.

B. Present Control System

The present system and its components have been described previously.[1] In summary, the system is schematically shown in Figure XIII-1. The total Main-Ring control system is shown in Figure XIII-2.

The control console consists of interactive multicolored text-display terminals, CRT graphic-display unit, and necessary knobs, buttons and keyboard for operator control. The Xerox computer is equipped with 64K of core memory. a 48-Megabyte dual-spindle disc pack, and 12 interrupts. The Xerox RBM (Real-Time Batch Monitor) operating system, which is a relatively powerful system providing foreground/background capabilities, is used. The Xerox computer core assignment and timing cycle are shown in Figure XIII-3. The resident foreground includes the data pool, remote-and-local-console servicing programs, library routines, name tables, continuous plotting routines, etc.

The non-resident foreground is divided into three areas reserved for the application programs associated with three control consoles. The background is

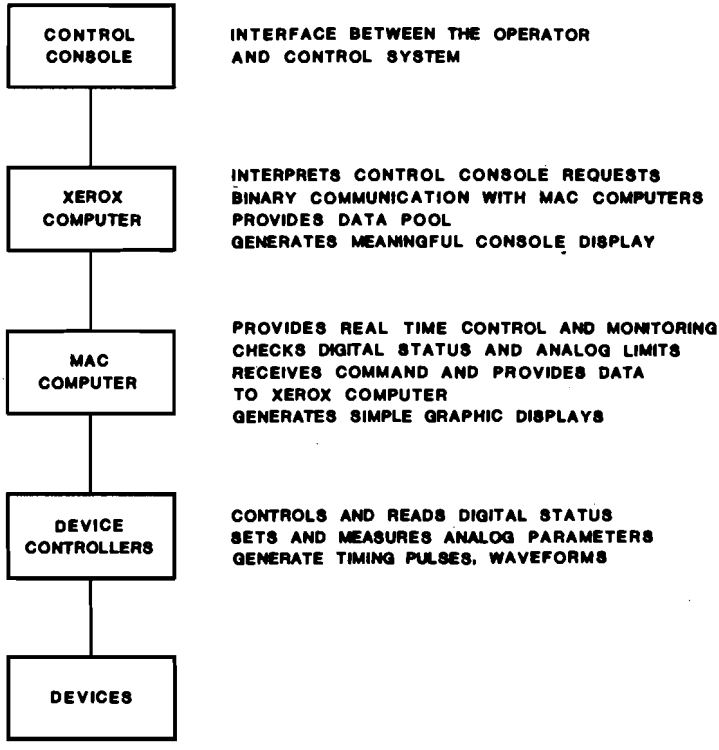

Fig. XIII-1. Control flow diagram.

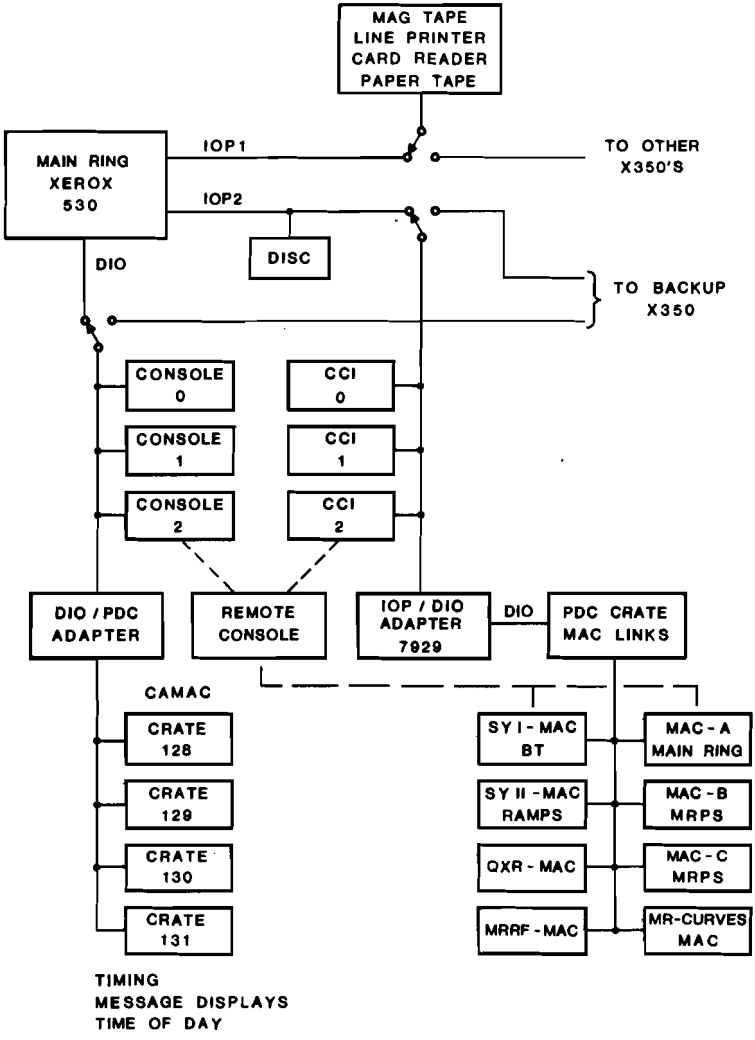

Fig. XIII-2. Main Ring and Switchyard control system.

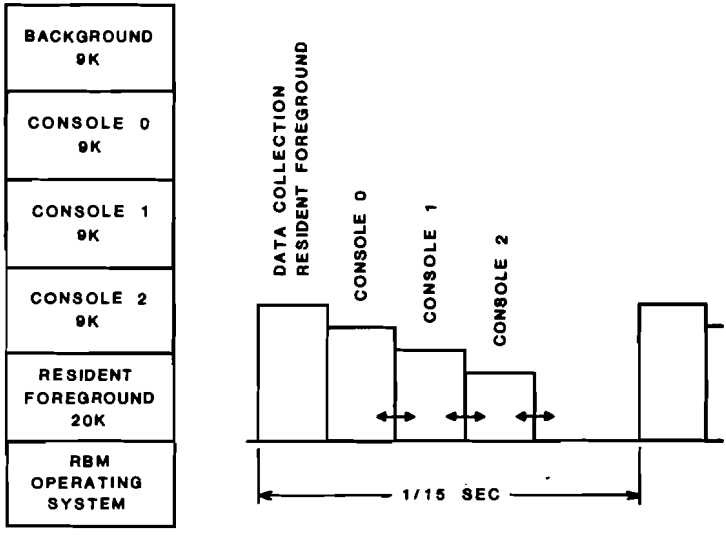

Fig. XIII-3. Main Ring Xerox computer core assignment and timing cycle.

used for program development. A relocating loader is used that brings in a core image program from the disc and relocates it before execution. Overlaid programs are relocated into another disc file before execution, so that no overhead is required for overlay loading during execution.

The Xerox computer operates at a 15-Hz rate in serving consoles and communicating with the MAC computers. The 15-Hz rate was chosen because it is the injector pulse rate and provides a good response time to the consoles.

The Main-Ring Xerox computer communicates with eight MAC computers. The MAC computers are responsible for providing real-time control and monitoring, scanning devices for correct status and analog settings, sending alarms to the Xerox computers, generating simple graphic displays, and interpreting the commands and sending data to the Xerox computer. They are also used as software function generators, for making measurements at selected clock times, and for temporary storage of data needed by the Xerox computer.

The MAC computers are assigned particular areas of the accelerator and communicate with a number of device controllers to which the devices are connected. The MAC computers presently on the Main-Ring Xerox computer and the characteristics of their device controllers are shown in Figure XIII-4. Although different hardware schemes exist in the various areas, standard communication exists between the Xerox and all the MAC computers. All device controllers can revert to local control for testing and troubleshooting and are equipped for controlling a 64-channel A/D converter.

Various clocks are used to time the different accelerator areas. All are derived from a Master Clock having a nominal 1-MHz frequency that is synchronized to the 6-Hz line frequency. A selectable 5/10-kHz clock is distributed in the Main Ring and 1 MHz is distributed in Switchyard. These two clocks have a gap of four pulses at the start of the Main-Ring cycle. The Main-Ring rf system uses a 1-MHz booster clock which has various gaps at the booster 15-Hz rate. Device-controller timing modules are used to generate pulses at selected times in the accelerator cycle.

C. Modifications Necessary for Energy Doubler

Independent of the Energy Doubler, but also important to it, operating experience and increased demands on the Main-Ring control system have made it desirable to modify the existing system, which has changed little from the

COMPUTER	PRESENT CORE	MAX CORE	CONTROLLER LINK	BITS PER LINK WORD	WORD RATE	TOTAL LENGTH	NO. CONTROLLERS	COMMENTS
			CONTROLLER LINK					
MAC-A	16K	24K	SERIAL	32	10K	23000'	55	SPECIAL CONTROLLER PLUS S.Y. CRATE
MAC-B	8K	* 8K	SERIAL	18	35K	500'	1	SPECIAL MADC CONTROLLER
MAC-C	16K	24K	SERIAL	34	18K	23000'	30	SPECIAL CONTROLLER FOR P.S. CONTROL IN S.Y. CRATE
MR CURVES	8K	* 8K	SERIAL	34	25K	2000'	2	CAMAC TYPE HARDWARE
SY I	32Kc	64Kc	SERIAL	34	20K	10000'	30	CAMAC TYPE HARDWARE
SY II	6K	* 8K						
QXR	32Kc	64Kc	SPECIAL USE FOR SPILL CONTROL					
MR RF	24K	24K	PARALLEL	38	100K	1200'	38	SPECIAL CONTROLLER

* CAN BE EXPANDED TO 64K WITH ADDITION OF CAMBRIDGE MEMORY CHASSIS

Fig. XIII-4. MAC computer characteristics.

initial installation. In the past, for example, lightning storms and magnet failures have caused the dc-coupled link repeaters in several of the Main Ring service buildings to fail. These are being replaced with transformer-coupled links. In addition, to improve the utilization of cables around the ring, a block-transfer channel and a separate link for the utility crate are being installed without adding additional cables.

The bit rate on the data link will be increased to 1 MHz, decreasing the overall link transmission time by 10%. There are devices in the Main Ring requiring better timing resolution than provided by the present 10-kHz clock frequency, and installation of the 1-MHz clock used in the experimental areas will accomplish this. All these improvements to the Main-Ring system will occur with the replacement for the repeater system that is now being installed.

More directly related to providing a control system for the Energy Doubler is the present spare capacity in the installed Main-Ring control system. Each device slot in the utility crate typically handles one device, such as a power supply, timing modules, etc. Each DI and DO channel on the HLU provides 16 bits of data in or out. The 64-channel multiplexed A/D converter in each of the buildings has approximately 16 channels open. Thus, there is spare capacity available in each service building for use by the Energy Doubler and, if further channels are needed, it would be relatively easy to increase the capacity by the addition of more utility crates.

All 12 channels on both the North and South Main-Ring television systems are used. In fact, the Main-Ring South system, two additional channels, A and B, have been squeezed into the system. When additional channels are needed on the TV systems, new trunk-line amplifiers can be installed, which will provide 27 new channels.

D. New Installations for the Energy Doubler

The necessity of maintaining operation of the Main Ring during Doubler development will place a heavy burden of the existing Main-Ring/Switchyard computer/console system. Recently, work has begun on a network of PDP-11's for control of the external-beam lines. This was initiated to give more local control to each experimental area. In addition, this effort will allow the X530 computer currently used for the external-beam lines to be utilized in the Main Ring, Doubler and Switchyard. The configuration of the system would then

be as shown in Figure XIII-5. This configuration would allow three consoles to be shared by the Doubler and Main Ring plus up to three for the Switchyard. Actually, two Switchyard consoles probably are all that are needed. The additional Switchyard console is needed because of the two additional extraction points, Main Ring to Doubler and Doubler to external-beam lines. In an attempt to prevent endless proliferation of control consoles, a study is currently underway to give a console more than one graphic display unit. At present, if an operator wishes to study more than one aspect of the accelerator, another console is needed. This modification will certainly allow the present consoles to handle the addition of the Doubler. The remote-console concept, which presently allows a console to operate from any utility crate in the Main Ring or Switchyard, will also be used with this system.

The Energy-Doubler power supplies can be programmed in a manner similar to the system for the Main-Ring power supplies. The link for this system will plug into the Main-Ring utility crate, and the hardware will be identical to that for the Main-Ring Power supplies.

The Doubler rf system can be attached as part of the regular Doubler/Main-Ring control system by adding a few utility crates. Additional utility crates will be necessary for the control of the extraction system for the Doubler.

This system will handle the initial operation of the Doubler. As operational experience is gained, the system can be expected to expand in much the same manner as the current control system. The system discussed above should accommodate such expansion without drastic revisions.

Reference

[1]R. Daniels et al., The NAL Computer Control System, IEEE Trans. Nucl. Sci., NS 20, June 1973.

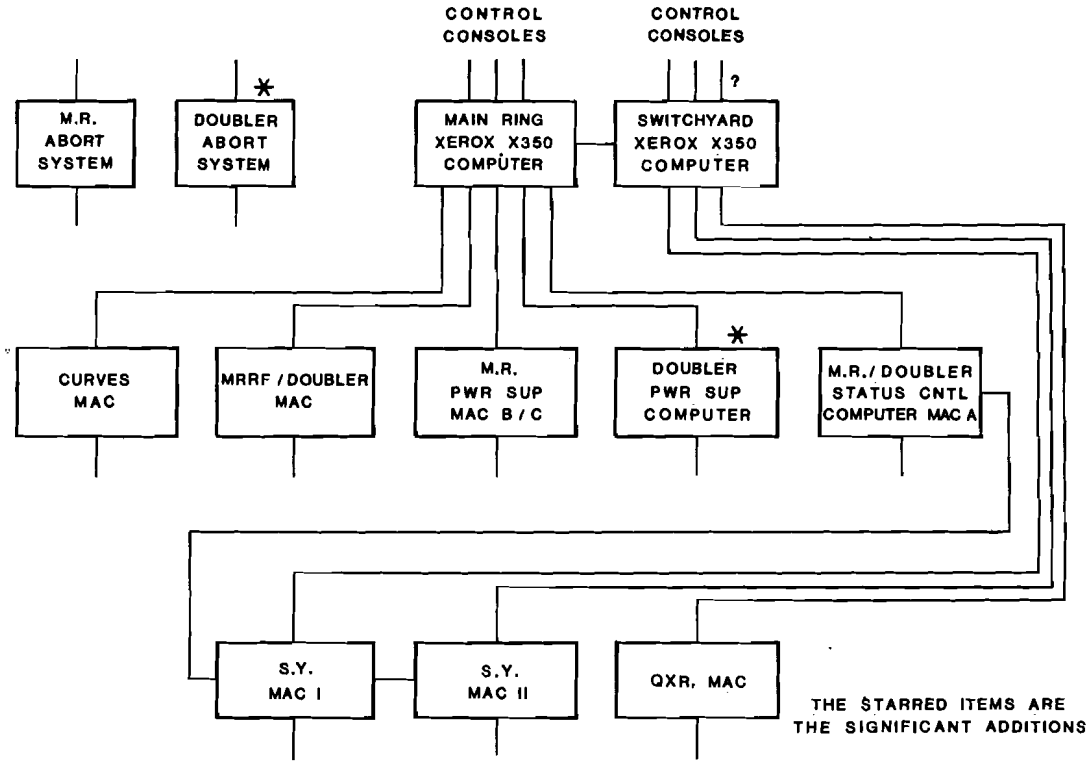

Fig. XIII-5. Proposed control configuration.