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**MICROPROCESSOR-BASED CONTROL FOR INDEPENDENTLY-PHASED RF LINAC CAVITIES**

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MICROPROCESSOR-BASED CONTROL FOR  
INDEPENDENTLY-PHASED RF LINAC CAVITIES\*

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Abstract

A microprocessor based system has been built to control the RF amplifiers associated with independently phased linac cavities. The system has an 8080A at each amplifier station, together with associated ROM, RAM, I/O, etc. At a central NOVA 3 computer an additional 8080A system is incorporated in the interface to the NOVA I/O bus. The NOVA interface is connected by a bus of eighteen twisted pairs to each amplifier station, providing bilateral transmission between each station and the NOVA. The system architecture, bus protocol, and operating characteristics are described.

Introduction

The Low-Beta Linac being built at Argonne National Laboratory (ANL) as a part of the Ion Beam Fusion effort involves a number of accelerating stations each with its own power amplifier. The number of accelerating stations is not fixed and may be as large as 64. There is a general requirement on the system that the amplitude and phase of the exciting voltage at each accelerating station must be controlled independently, but also the relationship between the exciting voltage at each accelerating cavity and at all the others must be carefully controlled to provide good accelerating characteristics. The overall accelerator system has a NOVA 3/12 computer which accordingly, is a convenient point to control the relationship between the accelerating stations. The system described in this paper provides a microprocessor based controller at each accelerating station, a microprocessor based interface to the NOVA 3/12, and an 18 pair bilateral bus from the interface to each of the remote stations. Figure 1 shows a block diagram of the system.

Remote Station Configuration

Figure 2 shows a block diagram of the remote station controller. There are 18 tri-state receiver-drivers to tie to the 18 pair bus. I/O from the bus together with driver-receiver enable commands are provided by 8255 programmable ports. An 8080A microprocessor is used with 8228 bus controller for decoding and driving the data bus and the R/w and chip enable levels to ROM and RAM. Memory consists of 2 K bytes of ROM and 500 bytes of RAM. The 2 K ROM is adequate for the logic envisioned for the remote station controller. The program is identical for each Remote Station ROM with the exception of the Station Identification word which identifies the station to the NOVA interface. Five hundred bytes of Read/Write memory are provided to store data from the station, commands from the NOVA, stack pointer, etc. Sixteen analog inputs are multiplexed by a 12 bit A/D and the data is input through 8255 programable I/O ports together with the convert command to the A/D and the done level from the A/D. The I/O to the phase and amplitude commands for the power amplifier are provided by 8255 programable I/O ports, 12 bit D/A's and AD 301 buffer amplifiers.

NOVA Interface Configuration

Figure 3 shows the block diagram of the NOVA interface. Levels from the NOVA I/O bus are conditioned, the device select lines are decoded, and the done, busy, etc. are handled in the standard fashion. Data for programmed I/O transfers is buffered in a register file with a capacity of four words. The intention was that three of the four words would be used for DATA I/O A, B, and C. The register file buffer allows the NOVA and the interface to be completely asynchronous. Levels relating to device select, done, reset, data, interrupt request, and acknowledge are tied to 8212 I/O ports. The interface is managed by an 8080A and 8228 and again 2 K bytes of ROM and 500 Bytes of RAM are provided. The 18 pair bilateral bus to the Remote stations terminated at tri-state driver-receivers. The driver-receivers are tied to the interface data bus by 8212 I/O ports.

Bilateral Bus

The function of the various pairs of the bus connecting the NOVA interface with the Remote Station Controllers is as follows:

1. Eight pairs designated for the eight bit data words transferred on the bus.
2. Six pairs designated for the station identification word defining which station is involved with the NOVA interface in a data transfer.
3. One pair designated a send level used in handshaking between remote station and NOVA interface.
4. One pair designated a receive level used in handshaking between remote station and NOVA interface.
5. One pair designated busy level used to prevent other stations from trying to use the bus when data is being transferred.
6. One pair designated LAM level used to inform the NOVA interface that a remote station requests service.

Features of the System

Some of the more salient features of the system are as follows:

1. The system is completely asynchronous between the NOVA and interface, and between the interface and remote stations.
2. Up to 64 remote stations can be used as the system is currently implemented. The station is identified only by a word in the local ROM and to add a new station requires only clipping it to the bus.
3. Only programmed I/O transfers and program interrupts can be used between the NOVA and interface. This is not much of a limitation, though, since data transfer rates are very low.
4. The remote stations do not interrupt the 8080A on the NOVA interface. The system could have been organized that way, but is seemed adequate to have the 8080A check the LAM level periodically.
5. The software to support data transfers between the NOVA interface and the remote stations resides in the ROM memory in the interface and the remote stations. This software allows any remote station to request service from the interface or for the interface to initiate data transfer to any remote station. There is complete handshaking.

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6. The system is designed so that each remote station provides an amplitude and phase command to its power amplifier and inputs 16 analog variables from its local environment. One analog input is from the phase comparator, however, the other 15 could be beam profile monitors, magnet current transducers, temperature sensors, or whatever. The remote station can be used therefore to acquire data from its local environment to be sent back to the NOVA or to alert the NOVA in the event some variable is out of range. Another capability that has been discussed is that the system can tune itself. For example using local beam monitors the first station can time its amplitude and phase to obtain some desired set of beam conditions

The NOVA then allows the second station to tune itself and so on. There is enough memory on the NOVA interface so that the NOVA itself would not even have to be involved in the timing, but the 8080A on the interface could manage it.

7. The NOVA interface is constructed on a standard Data General frame assembly using wirewrap techniques. This is shown in Fig. 4. The +12 V for the ROM's is obtained from the +15 V with a regulator mounted to the frame. The 18 pair bus is carried through empty pins on the back panel connector.

8. The remote station controller is constructed on a three layer board using the middle foil as a ground plane. The board is shown in Fig. 5.

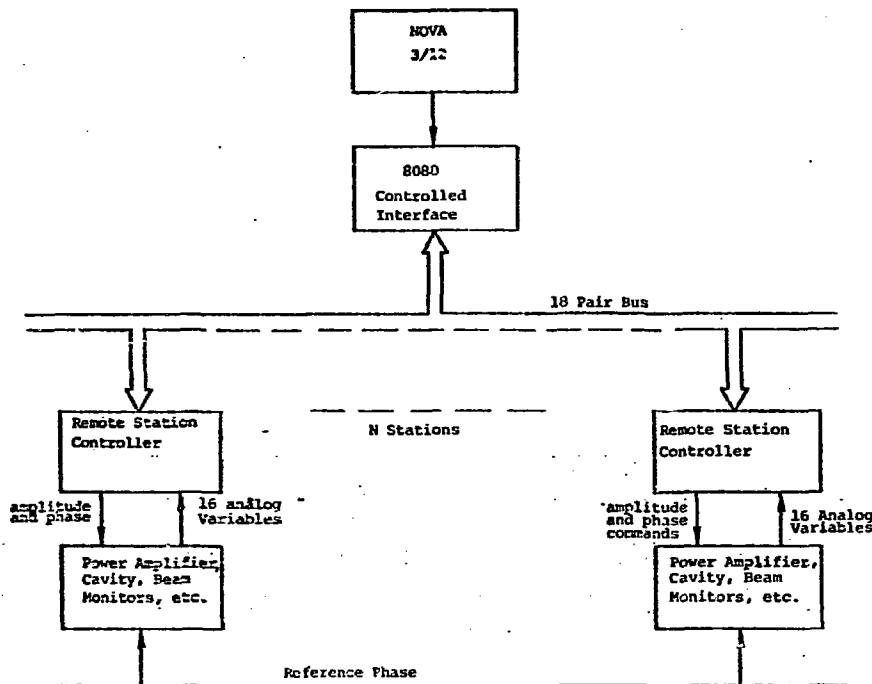


Fig. 1 Block Diagram of Microprocessor-Based Control System for Independently Phased RF Linac Cavities.

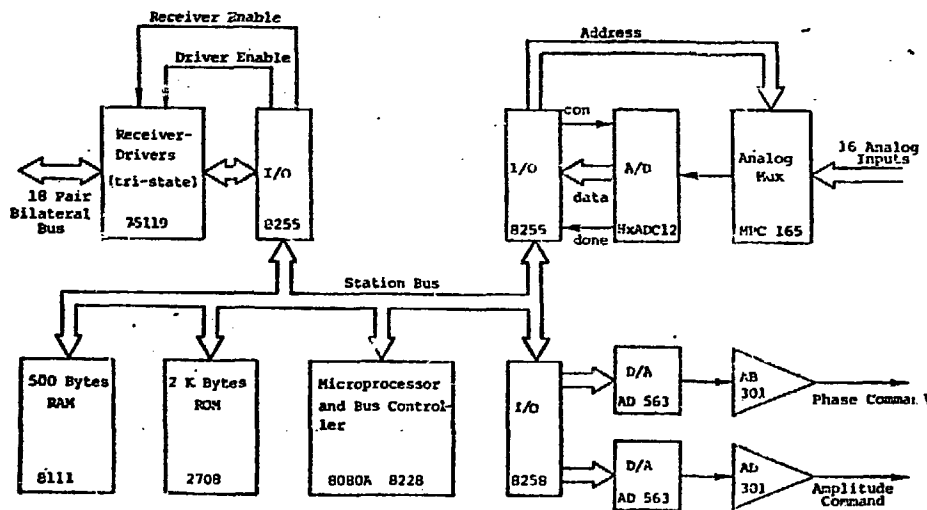


Fig. 2 Remote Station Controller

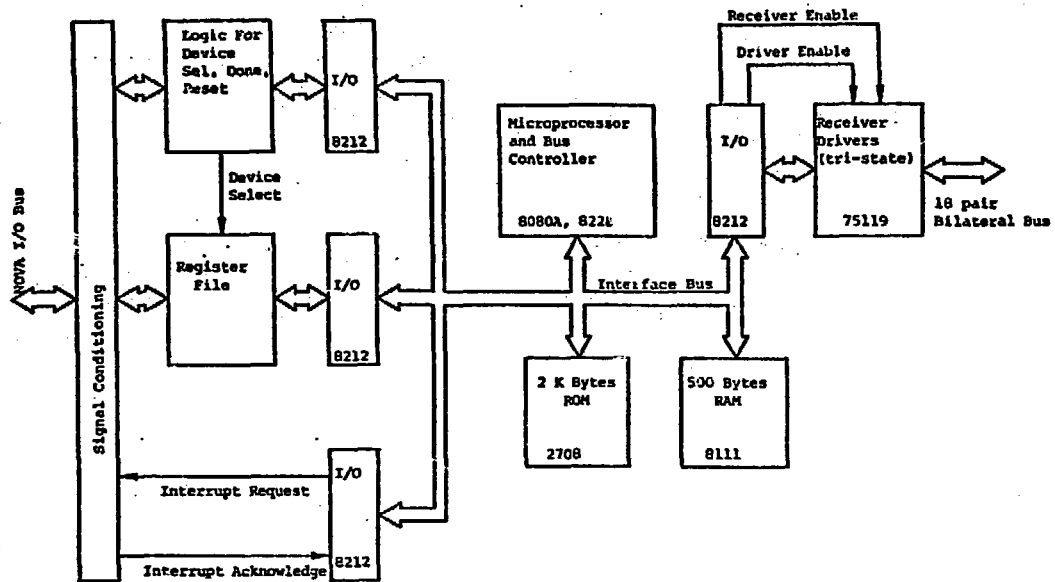


Fig. 3 Block Diagram of NOVA Interface

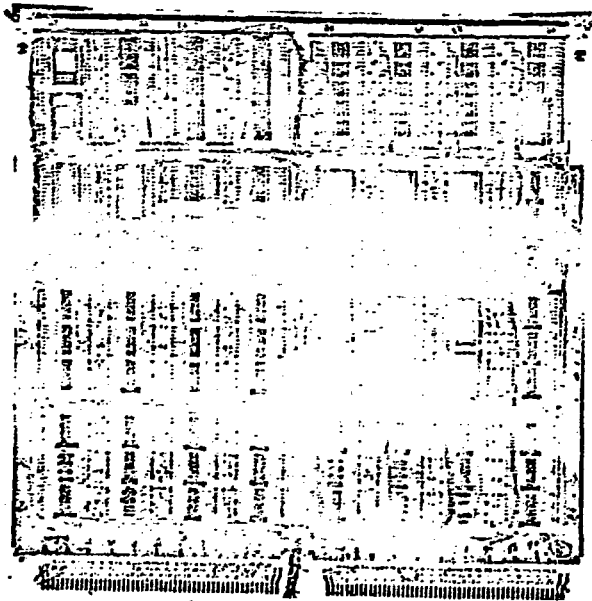


Fig. 4 NOVA Interface

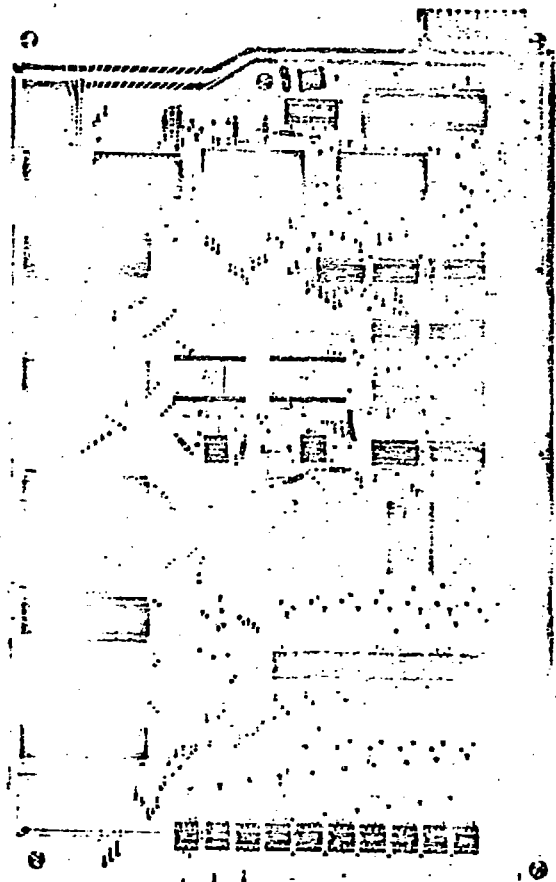


Fig. 5 Remote Station Controller