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ALADDIN COMPUTER CONTROL SYSTEM†

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INTRODUCTION

Aladdin is a 1 GeV electron storage ring dedicated to synchrotron radiation research. Injection takes place at 100 MeV from a racetrack microtron via a 10 m transport line. Control and status type data is handled by three Motorola 6800 microprocessor systems. One system routes all main ring magnet controls. The second system is responsible for all injection hardware from the microtron up to and including the main ring fast kickers. The third system handles Aladdin's RF system, vacuum system, synchrotron light ports, and diagnostics. The microprocessor system is tied to a single master computer, a PDP 11/34. Normal operation of Aladdin is via the master computer, although the microprocessor systems have stand alone capability. The software developed for linking the master computer to the microprocessors and for driving the two operator stations with their color terminals and trackballs is discussed in the final section.

GENERAL LAYOUT

The three microprocessors are located in the middle of the Aladdin main ring, below grade level. This location allows the greatest flexibility with respect to cabling and debugging of hardware. The PDP 11/34 is located about 50 m away from the microprocessor systems, outside the injection shield wall, and on the ground level of the Aladdin building. The hardware communication link uses the RS 422 balanced line standard, and is optically isolated at both ends. A block diagram of the entire system is shown in Fig. 1. Appendix B is a short key to the abbreviations that are used in Fig. 1.

MICROPROCESSOR SYSTEM HARDWARE

There are three microprocessor based systems, each with stand alone capability, and each with remote access from the main computer. At the center of each subsystem is a Motorola 6800 microprocessor mounted on a board compatible with the Intel Multibus structure. This provides a unique marriage of Motorola firmware and Multibus compatible hardware. There are many manufacturers, such as Datel, that sell Multibus plug compatible analog and digital IO boards, so necessary for any accelerator control. Since the microprocessor subsystems were purchased, the vendor decided to use a Motorola based system. The vendor had much experience with Motorola systems, experience gained in design of a similar system at Fermilab.

The vendor also provided the hardware, software, and firmware to handle the transfer of information to and from the main computer via a first-in-first-out (FIFO) 128 word buffer for each data direction.

MICROPROCESSOR SYSTEM SOFTWARE

The microprocessor software is patterned after the Fermilab control system. At a 10 Hz rate, the interrupt service routine reads and stores in RAM all of the analog and digital data. This takes approximately 10ms and leaves 90 ms to handle an operator program, e.g., a magnet control program. Device control is affected in one of three ways after positioning the terminal's cursor to the displayed device field:

1. Type in the new value and interrupt the processor with the escape key.
2. Vary the device value with a knob which simulates a potentiometer control.
3. Vary the device value by using a push button to count up or count down simulating the turning of a potentiometer at a constant rate.

The software also includes an interrupt driven section which responds to single commands from the main computer. These commands can read the microprocessor memory and can set analog or digital devices.

All of the microprocessor software is written in Motorola assembly language. A section of assembly code is shown in Appendix A. As can be seen in that listing, the assembly language is easily interpreted, and the code is heavily commented. The software for the microprocessor system was developed with an eye to easily adding or changing devices. Heavy emphasis is placed on storing all of the device tables in their own EPROM's. This minimizes the EPROM changes when a device is added or changed. A fourth microprocessor system was purchased for use as a software development system, and it provides a backup in case of hardware failures.

MASTER COMPUTER HARDWARE

The main computer is a PDP 11/34 with 128 K words of 16 bit memory, full floating point hardware, two large disc drives (28 Megabytes each), and dual floppy disc drives. The dual floppy disc drives allow easy transfer of files to other DEC equipment at the facility. There are nine RS 232 serial ports on the system. Five of these ports are permanently dedicated to a fast teletype (1200 Baud) and two operator stations. Each operator station has a color terminal and trackball. The main computer also has three parallel IO ports for communication with each of the microprocessor systems.

MASTER COMPUTER SOFTWARE

Beside the obvious advantage of having similar hardware at the facility, the PDP 11/34 was chosen for its already proven operating system, RSX-11M, a multiuser, protected executive, that enabled us to immediately start developing FORTRAN software. This operating system can run several programs pseudo-simultaneously, selecting the next job to be run based on priority and IO needs. The operating system also allows the two operator stations to function either independently or as a master-slave pair. Another immediate advantage of this operating system is the sophisticated way that the executive handles IO devices. In particular, it was fairly easy to write IO drivers for each of the microprocessor systems, treating each as a high priority peripheral device.

As the heart of the Aladdin control system, the PDP 11/34 has several programs running simultaneously. One task asychronously reads and stores device data from each of the three microprocessor systems. This back-

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ground task has a high priority and takes less than 30 ms to complete a complete cycle. This task also receives operator commands to control devices, e.g. turn on a power supply. These commands originate at the tasks that handle the operator stations. The main operator-computer interface is a color terminal, trackball combination (Fig. 1).

Another low priority background program monitors the data collected from the microprocessor systems. This task looks for analog values that are out of tolerance and notifies the operator who then takes appropriate action. This program also monitors and turns off devices that have turned themselves off because of some internal malfunction.

The task that handles the operator-computer interface allows several modes of device control:

1. The operator can type in new values for an analog setting.
2. The operator can control a device (ON, OFF, etc.) by a single keystroke of the terminal keyboard.
3. The operator can attach the trackball to any analog device by a single keystroke at the terminal. The trackball has the feel of a potentiometer for "hands-on" control.
4. The operator can control motor driven devices (FORWARD, REVERSE, STOP) again by single strokes at the keyboard.

STATUS

All of the microprocessor systems have been installed and operating for 12 months with no major hardware problems. The periodic firmware changes necessitated by the installation of modified Aladdin control hardware have been easily implemented. An intermediate level control program for the master computer is operational. This program is sufficient to run the machine, but does not take full advantage of the data storage and retrieval capabilities of the PDP 11/34. The full scale control program is about 50% complete.

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Appendix A:

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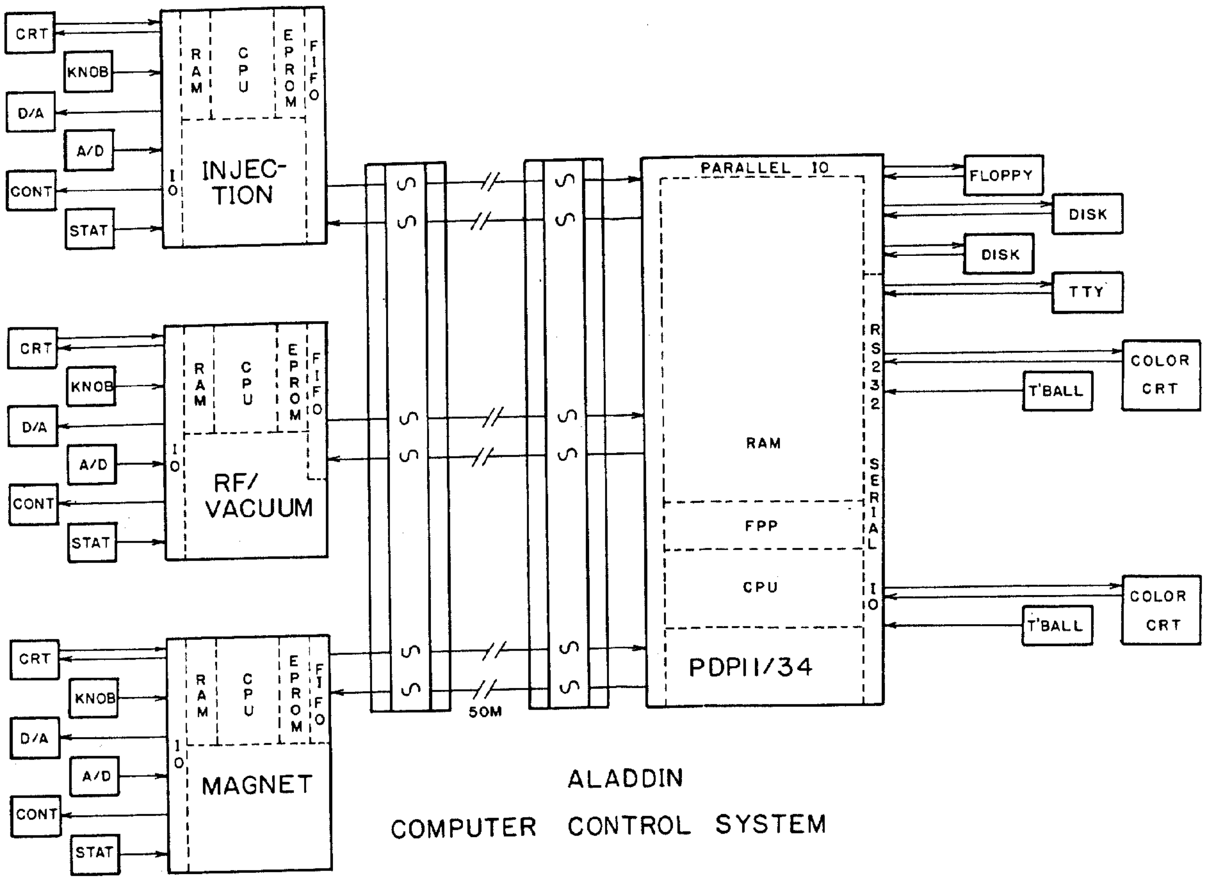
       NAM STB.
*      STATUS PAGE PROGRAM
*      DISPLAYS STATUS FOR
*      ELECTRON GUN AND MICROTRON
*
*      CREATED BY WST, 1/27/81 FROM STA. TO ALLOW 2 PAGES
*      OF STATUS
*      UPDATED BY WST, 1/27/81 TO REMOVE ALL XPORT & KI
.LOC   SET $CO
       RMBA STPTR,2 PTR TO STBL.. ENTRIES
       RMBA STP,2 PTR TO STLAST
       RMBA LASTBX,2    PTR TO LAST STATUS BYTE USED
       RMBA LASTBY,1    BYTE OF LAST STATUS BYTE
       RMBA STEMP, 1 TEMP
       RMBA STATN, 1 COUNTER
       RMBA MASK,1 STATUS MASK
*
STLAST EQU PPTRS   LAST STATUS READING TABLE
*
       ENT STATSB
*
*
STATSB IFA NE,1,STA3,  NOT INITIALIZATION
       BSR CLRLST    CLEAR LAST STATUS ARRAY
       LDX STATBL
       JSR STTLP     DISPLAY ALL BIT TITLES
STAX   RTS
*
       EXT TVM
       EXT ADDBX
*
CLRLST LDX STLAST CLEAR RECORD OF PREV STATUS
       LDA B 128 MAX BYTES USED IN TABLE
       LDA A $FF
CLRLS1 STA A 0,X
       INX
       DBNE CLRLS1
       RTS
*
       .
       .
       .
        END
```



ALADDIN

COMPUTER CONTROL SYSTEM

FIG. 1

Appendix B:

Key to Fig. 1:

CRT . . . .Terminal of the Cathode Ray Tube type.
D/A . . . .Digital to analog converters.
A/D . . . .Analog to digital converters.
CONT. . . .Digital control function.
STAT. . . .Digital status function.
IO. . . . .Input/Output.
RAM . . . .Random Access Memory (read or write).
CPU . . . .Central Processing Unit (the computer).
EPROM . . .Erasable Programmable Read Only Memory
FIFO. . . .First in first out.
FFP . . . .Floating point arithmetic Processor.
TTY . . . .Any Teletype-like typewriter.
T'BALL. . .A trackball.