Title
ALGEN A MICROPROGRAMMABLE CAMAC BRANCH DRIVER/(CONTROLLER

Author
Oakes, Alan E.

Publication Date
1971-11-01

Presented at IEEE Nuclear Science Symposium,
San Francisco, Ca., Nov. 3-5, 1972

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November, 1971

AEC Contract No. W-7405-eng-48

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A MICROPROGRAMMABLE CAMAC BRANCH DRIVER/CONTROLLER

Alan E. Oakes
Lawrence Berkeley Laboratory
Berkeley, California

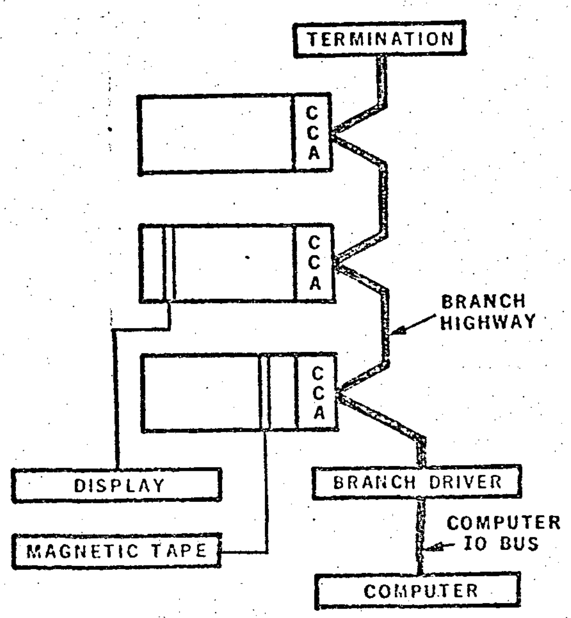
Summary

The computer and Branch Driver are the two most expensive devices associated with a typical CAMAC system. This paper describes a device which has been designed to replace both the computer and the Branch Driver of many systems - at less than half the cost.

Algen (a contraction of algorithm generator) may also be used with a computer, serving as a unique Branch Driver which can relieve the computer program of many "housekeeping" duties.

Comparison of a Computer-Driven System With an Algen-Driven System

A typical multicrate CAMAC system operated by a computer is shown in Fig. 1. Each crate contains a Crate Controller Type A and a number of data-source modules like scalers or A/D converters. Two of the crates also contain data-sink modules -- a CRT display controller module and a magnetic tape controller module. The computer, through its interface, the Branch Driver, directs the flow of information from the data-source modules to the data-sink modules.



XBL 7110-1584

Fig. 1. A three-crate CAMAC system driven by a computer. CCA: Crate Controller Type A.

An identical CAMAC system operated by Algen is shown in Fig. 2. Like the computer, Algen generates a sequence of commands to control the flow of information in the CAMAC system.

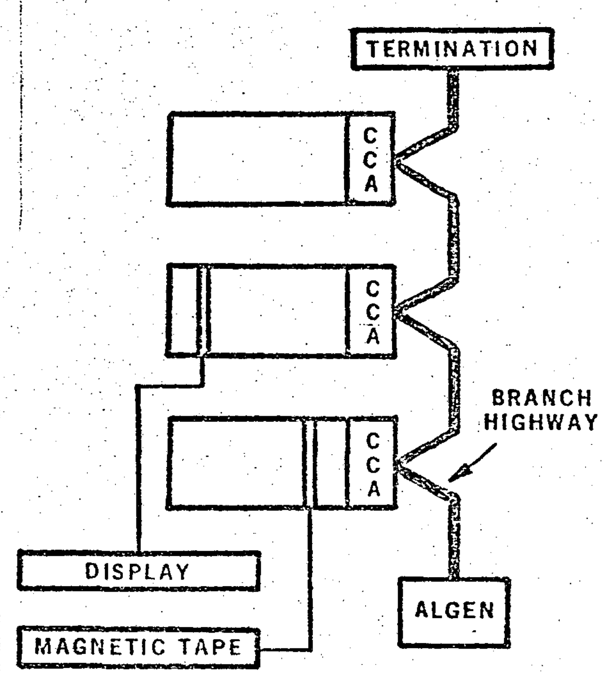


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Fig. 2. A three-crate CAMAC system driven by Algen.

An imaginary task assigned to the two systems may help clarify their differences and similarities. Imagine a high-energy physics experiment which requires that following each nuclear event, the contents of all the data-source modules must be read sequentially and stored on magnetic tape. In addition, the contents of a few scalers must be transferred periodically to the CRT module for display.

The computer-driven system and the Algen-driven system both go about their tasks in the same fundamental fashion. Both have a sequence of operations stored in memory. Both can respond to changes in the CAMAC system with conditional jump instructions. Both are single-address machines. The program in either machine may be changed by the experimenter to adapt to modifications in the experiment. The memory of each machine may contain a number of programs in addition to the one for the task at hand.

Beyond these fundamental similarities, however, the two machines are radically different. The computer is a general-purpose machine with enormous arithmetic and computational powers. Its small word size probably necessitates using two computer words to form a single CAMAC command. The general-purpose nature of its instruction set requires a number of "housekeeping" instructions to set up each CAMAC command. To perform our imaginary task, the computer would require a program of one hundred or more instructions. The average "deadtime" between successive CAMAC commands would be about 10-20 microseconds.

Algen is a special-purpose machine with no arithmetic or computational powers in the traditional sense. It is designed especially to operate CAMAC systems. Its 32-bit word size can accommodate, in a single instruction: a 17-bit CAMAC command, a 5-bit op code, and a 6-bit address for a conditional jump that depends on the Q response. Its special-purpose nature allows a set of relatively powerful instructions requiring only a few "housekeeping" instructions to set up each CAMAC command. And these are accomplished at TTL speed. To perform our imaginary task, Algen would require a program of about twenty instructions, approximately 1/3 of the available memory. The average "deadtime" between successive CAMAC commands would be about one microsecond.

The "list" prices of computer-Branch Driver combinations start at $7,400 ($5,000 computer, $2,400 Branch Driver -- the least expensive to the author's knowledge). However, it has been the author's experience that computers are seldom purchased for $5,000. Important and useful options are normally added that raise the price. Then once the computer is delivered, setup and programming expenses begin. The reader, from his own experience, can probably arrive at a figure for the true cost of a small computer. The $2,400 Branch Driver operates via the accumulator under program control. Direct Memory Access Branch Drivers cost between $5,500 and $10,000.

The cost of fabricating Algen in Lawrence Berkeley Laboratory shops is estimated to be under $2,700 (see Appendix). There are no options to raise the price. Algen is designed to plug directly into the Branch Highway so there will be essentially no setup costs. And the programming expense is minimal since the programs are short.

Use as a Machine-Independent Branch Driver

Algen's memory and internal registers are connected together by a bus. This bus extends to the Branch Highway at one end and to two I/O connectors at the other. It will be possible to interface any computer to one of these I/O connectors with only a small fraction of the logic required for a complete Branch Driver. The amount of logic depends upon the degree of sophistication desired. An interface built on a single-width CAMAC module should be enough to convert Algen into a powerful Branch Driver that would operate via a Direct Memory Access port on a small computer. When used as a Branch Driver, Algen's programs would share control of the CAMAC system with the computer program. Ideally Algen would perform the mandane "housekeeping" chores and direct all module-to-module transfers, disturbing the computer only when absolutely necessary.

Use as An Interface Between CAMAC and Non-CAMAC Data Bussing Systems

Many facilities have considerable investments in non-CAMAC data-bussing systems. At Lawrence Berkeley Laboratory, for instance, there are hundreds of data-source modules and a large number of recording and display device controller modules built to NIDBUS systems specifications. To prevent the loss of this investment when converting to CAMAC, ways must be found to transmit data from non-CAMAC data-source modules to the recording devices in a CAMAC system and vice-versa. One of Algen's I/O connectors would be an ideal location for an interface. Only about ten chips would be required for a two-way interface between a NIDBUS (or similar) system and a CAMAC system via Algen.

Memory

Algen was made economically feasible by the introduction of Medium Scale Integration, in particular by the development of an inexpensive reprogrammable high-speed non-volatile amorphus semi-conductor memory. Algen's 8-chip memory is organized into 64 words by 32 bits. It costs $480 at the present time -- down from $1,200 when introduced less than a year ago. It is designed in Algen to be alterable in an off-line basis and operates on-line as a read-only memory. The memory is guaranteed to be capable of 600 complete reprogrammings. Since the average experiment at LBL now lasts about six months, that allows 30 complete reprogrammings per experiment for a ten-year life.

Physical Construction

The first Algen will be constructed in a 5-3/4" x 19" relay rack chasis (see Fig. 3) because of the large amount of front panel space needed; but after operational experience is gained, it may be found that the front-panel components can be reduced in number and condensed enough to fit on the front panel of a CAMAC module. Towards that end, the logic for Algen will be mounted on four CAMAC cards (see Fig. 4).

The Branch Highway Signal Driver and Logic card was designed by Sypko Andreae to be used in all LBL Branch Drivers now under construction or contemplated. It will contain all of the logic to handle the BTA-BTB conversations, Branch Demands, Graded-L cycles, BQ's and BZ's. It will also contain the Branch Highway signal drivers and two data registers (Algen will use only one).

The two Control Logic and Registers cards will contain the instruction decoder, time-state generator, registers; and all other logic to interpret and execute the instructions in Algen's instruction set.

The Memory card will have two sections attached together by a card-edge connector (as shown in Fig. 4). The memory itself will be on the front section. The address decoders and sense amplifiers will be on the rear section. The memory will be programmed by removing the memory section of this card and inserting it in the Memory Programmer (a separate chasis).

Conclusion

Algen will be able to operate many multicrate CAMAC systems -- freeing computers for other tasks. The cost of Algen is expected to be less than half the cost of a computer and Branch Driver. With a small amount of additional logic, Algen can serve as a Branch Driver or as a two-way interface between a CAMAC system and a non-CAMAC data-bussing system.

At the time of this writing the design work has been completed and fabrication will begin shortly.

Acknowledgment

I would like to thank Fred Kirsten for proposing that I design a CAMAC controller and for his continuing encouragement and counsel.

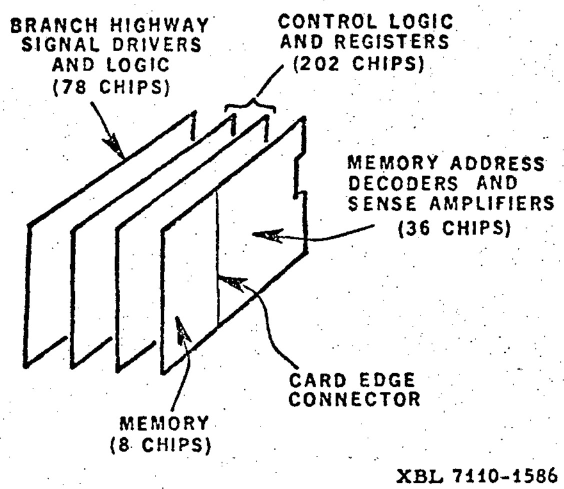

Fig. 3. Physical Layout.

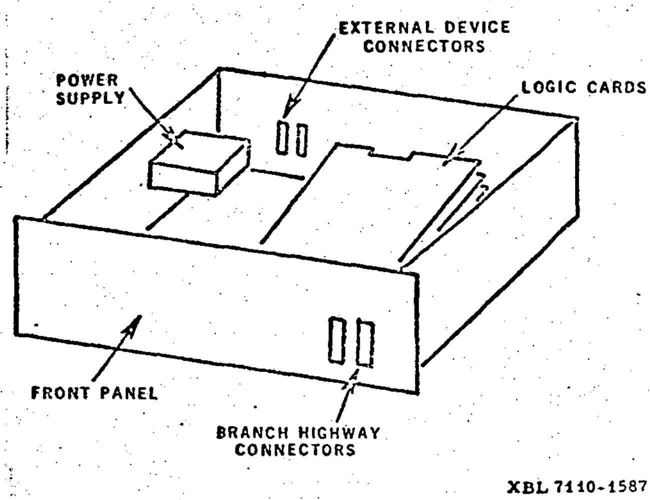

Fig. 4. Logic Cards.

Appendix - Cost Analysis

Branch Highway Card	
Chips	$ 75
Card	45
Sockets	40
Labor (semiautomatic wiring machine)	88
Labor (programming to produce paper tape for wiring machine)	120
Total	$ 368
Control Logic Cards (each)	
Chips	$ 110
Card	45
Sockets	50
Labor (semiautomatic wiring machine)	88
Labor (programming to produce paper tape for wiring machine)	120
Total (each)	$ 413
	x2
Total (both)	$ 826
Memory Card	
Memory chips	$ 480
Decoding & sensing chips & components	43
Card	45
Sockets	22
Card edge connector	5
Labor (semiautomatic wiring machine)	$ 44
Labor (programming to produce paper tape for wiring machine)	60
Total	$ 699
Front Panel	
LED's, switches, etc.	$ 59
Labor (wiring & silk screening)	176
Branch Highway connectors	50
Labor (wiring Branch Highway connectors)	220
Total	$ 505
Rear Panel	
External device connectors	$ 16
AC receptical & fuse holder	2
Labor (wiring & silk screening)	88
Total	$ 106
Chassis	$ 20
Power Supply	$ 50
Memory Programmer (separate chassis)	
Parts & Labor	$ 115
GRAND TOTAL	$2,689

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UNIVERSITY OF CALIFORNIA
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