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Introduction

During the past two years the utilization of CAMAC has increased significantly. The basic specifications have been revised;[1,2] supplementary information to aid in implementing the specifications and describing preferred practice has been issued;[3] and the use of CAMAC has spread to other scientific disciplines.

There is always conflict between the immutability of a specification or standard and the changes dictated by new technology. This is especially true in a field as dynamic as computer interfacing. In the past two years we have seen how this conflict has been resolved in the case of CAMAC. The initial specifications when reduced to practice in an operating environment, proved CAMAC to be a viable system superior in many cases to existing computer interfaces. However, some shortcomings were also in evidence; for example, additional means for plug-in modules to communicate back to crate controllers were desirable. The revised 1972 CAMAC specifications called for several changes which significantly improve the module-to-controller communications. These changes are discussed elsewhere in this issue and are summarized in Appendix F of Ref. 3. It should be pointed out that these improvements do not make the earlier hardware incompatible. They may still be used!

In the future several additional innovations are beginning to be implemented or under consideration: One is dedicated controllers whereby the crate controller and the branch driver become one unit located in the crate control station. Another is transmitting data along the Branch Highway in a serial fashion. The savings in cabling over long runs and the potential for telephone-line communication are desirable goals. It has been gratifying to find that the feedback loop involving change, application and need has a remarkably short response time when one considers the number of reviewers in the decision-making channel.

Implementation

CAMAC systems or components are being employed in all the AEC national laboratories in the U.S., the predominant activity being at the National Accelerator Laboratory and the Los Alamos Meson Physics Facility. In Canada research activities employing CAMAC include the TRIUMF Accelerator in British Columbia and the University of Toronto Medical Computing Center. Several medical groups in the U.S. are also interested.

The community of astronomers has also determined that CAMAC is advantageous to them. The Kitt Peak National Observatory has one system in operation which is used for telescope control. Eight other systems are under construction and are expected to be operational by the Summer of 1973. Lick Observatory is also making use of CAMAC.

Although the majority of the present systems are used almost exclusively for data gathering, there is now a wide-spread interest in employing CAMAC for process control as well.

One pilot system is being designed for process control for aluminum refining; another system will be

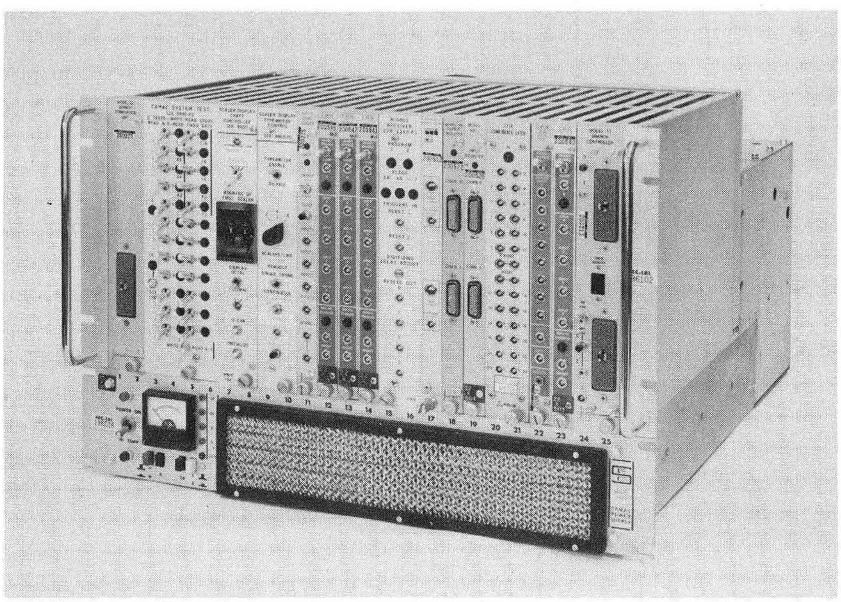

Fig. 1 Typical CAMAC Crate and Power Supply

used in the research laboratory of a glass company. Other systems will be used in the control of automated material analyzers.

Hardware

Completely wired crates are available from three domestic sources and blank modules from at least three fabricators. In addition, a number of European manufacturers offer hardware and accessories for export. A comprehensive list of all these suppliers is published in the CAMAC Bulletin, Ref. 4. Fig. 1 illustrates a commercial CAMAC crate and power supply.

Power Supplies

A typical CAMAC power supply is described in Appendix E of Ref. 3. It calls for a power output of at least 25 amperes shared between the ±6 volt supplies and at least 6 amperes shared between the +24 volt supplies with a minimum total power output of 294 watts.

Power supplies meeting these requirements are available from several manufacturers. Early tests on loaded crates indicated the need for forced air ventilation if the 70°C max temperature rating for commercial grade integrated circuits was to be maintained. The typical power supply description calls for at least 12 CFM of air to be directed into each of four sections of a crate. The air intake is visible at the front of the power supply in Fig. 1.

System Components

At least five U.S. companies and one Canadian company are presently manufacturing registers, scalers, gate circuits, multiplexers, analog-to-digital and digital-to-analog converters and similar modular components. A larger number of manufacturers are offering similar system components in Europe.

The crate controller type A-1 (or the earlier versions) is available from four U.S. and Canadian companies; five companies manufacture dedicated controllers. At least twelve European companies make controllers.

Thus, by means of either the crate controller type A-1 and the Branch Driver or the dedicated controller alone, it is possible to interface the following computers with commercial components: HP 2100, 2114, 2115 and 2116, H-316/DDP 516, PDP 8, 9, 11 and 15, Nova, Supernova and Varian 620 i, 1, f.

Relation of NIM Equipment

A number of manufacturers and laboratories have substantial investments in NIM equipment. The question arises, what of its future employment? In the U.S. we have every intention of continuing to employ the NIM system for analog and fast-logic instrumentation for several reasons. The usage of CAMAC is complimentary to NIM. The NIM system is more appropriate to use where front panel access for controls, readout and interconnecting cables is desirable; CAMAC is more appropriate where access to a dataway is required.

Another factor to be considered is the basic cost of the slot into which an experimenter plugs a NIM or CAMAC module; this may be considered the module rent or overhead. A powered NIM bin costs between $500 and $1000; if this figure is divided by the number of module positions (12), the overhead cost runs from $40 to $80 per module. The cost of a CAMAC crate, power supply and crate controller divided by the number of available module positions (23) runs $100 to $130 per module. If the additional expense of a Branch Highway and Branch Driver is included, the cost is considerably higher.

The conclusion to be drawn from this story is that if you need a dataway, use CAMAC; if you don't need a dataway, NIM is less expensive.

Housekeeping

In line with the interchangeability of plug-in crates and controllers, who is keeping track of the compatibility? Is it a fact or merely fiction? Can an experiment at the University of Hawaii take advantage of software developed at the Hahn-Meitner Institut in Berlin? The answer is yes. This is being accomplished through the combined efforts of a number of interested colleagues on both sides of the Atlantic. The ESONE Committee of European laboratories and the U.S. AEC NIM Committee have a number of parallel working groups. These working groups meet two to four times a year often in conjunction with a national technical society meeting. Close liaison and most cordial relations have been maintained among the various working groups since their inception. The present chairmen of the various working groups are listed in Table I.

The NIM and ESONE Dataway Working Groups are concerned with the overall system interrelations and operation. These two committees in conjunction with manufacturers and other users will continue to provide the system coordination throughout the CAMAC world.

What about software? Who is writing programs? Do they work? A major emphasis both in the U.S. and in Europe is now on software. Those interested in CAMAC language programs are urged to contact the chairmen of the Software Working Groups. See also Ref. 5.

The function of the Analogue Signals Working Group should be obvious.

The Mechanical and Power Supply Working Group and in Europe the Mechanics Working Group are concerned with the hardware aspects of the system. Their task is very nearly accomplished.

Summary

Is everyone going to use CAMAC? Probably not. Does CAMAC represent all the latest thinking in data handling? Again the answer is no. However, one must remember that the time from conception to delivery of a computer makes it partially obsolete before it is ever used. This is the price of progress. A similar gestation time was inevitable for CAMAC. If we were to begin today, CAMAC would be different, but at this point in time we are glad we don't have to start over again. CAMAC has proved its worth in many experimental research situations. Also CAMAC is dynamic; as new technology becomes available it will obviously be incorporated into the system. Now is the time to take it to the industrial market place. The predominant use of CAMAC should be in industrial data-acquisition and control environments.

References

1. "CAMAC - A Modular Instrumentation System for Data Handling", USAEC Report TID-25875 available from Louis Costrell, National Bureau of Standards, Washington, D. C. 20234. In Europe EURATOM Report EUR 4100e, 1972, available from Office for Official Publications of the European Communities, Luxembourg, P. O. Box 1003.

2. "CAMAC - Organization of Multi-Crate System", USAEC Report TID-25876 and EURATOM Report EUR 4600e, 1972, available from the addresses noted above.

3. "Supplementary Information on CAMAC Instrumentation System", USAEC Report TID-25877.

4. CAMAC Bulletin, published three times per year by Commission des Communautés Européenes, 29, rue Aldingen, Luxembourg.

5. "Proposal for a CAMAC Language", CAMAC Bulletin, No. 5 Supplement, Nov.1972.

TABLE I

Chairmen of CAMAC Working Groups

	USAEC NIM	ESONE
Executive Committee	Louis Costrell Center for Radiation Research National Bureau of Standards Washington, D. C. 20234	B. Rispoli CNEN Viale Regina Margherita 125 ROMA, ITALY
Dataway Working Group (DWG)	Frederick A. Kirsten Lawrence Berkeley Laboratory University of California Berkeley, CA 94720	H. Klessmann Hahn-Meitner-Institut fur Kernforschung Berlin GmbH 1 BERLIN 39, GERMANY Glienickerstr. loo
Software Working Group (SWG)	Satish Dhawan Yale University Physics Department Sloane Laboratory New Haven, Conn. 06520	I. N. Hooton Electronics and Applied Physics Division Building 347.1 Atomic Energy Research Establishment U.K.A.E.A., Harwell, DIDCOT, Berkshire, ENGLAND
Analogue Signals Working Group (AWG)	Dan I. Porat Stanford Linear Accelerator Ctr. Stanford University P. O. Box 4349 Stanford, CA 94305	Th. Friese Hahn-Meitner-Institut fur Kernforschung Berlin GmbH 1 BERLIN 39, GERMANY Glienickerstr. loo
Mechanical and Power Supply Working Group (MWG)	Dick A. Mack Lawrence Berkeley Laboratory University of California Berkeley, CA 94720	F. H. Hale Electronics and Applied Physics Division Building 347.2 Atomic Energy Research Establishment U.K.A.E.A., Harwell, DIDCOT, Berkshire, ENGLAND

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