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REPORT ON ESONE-CAMAC DATAWAY WORKING GROUP MEETING OF MAY 20-22, LONDON, ENGLAND*

by

Ray S. Larsen

Stanford Linear Accelerator Center
Stanford University
Stanford, California

1. BACKGROUND

CAMAC is a digital hardware system developed in Europe under the auspices of the ESONE Committee (European Standards on Nuclear Electronics) and described fully in Euratom Publication EUR4100e. Over a period of about 1-1/2 years, the USAEC NIM (Nuclear Instrument Module) Committee has studied the system and in March 1970 formally endorsed CAMAC as a system desirable and appropriate for use in data-handling applications in its US member-laboratories. This decision resulted from the fact that most laboratories represented on the NIM Committee were enthusiastic in support of the system and some were actively making plans for implementation.

At the time of the NIM Committee endorsement, a further extension of the CAMAC standardization was underway: whereas the original CAMAC document described a hardware system which consisted of a single crate, or bin, of equipment and an associated crate controller, the further standardization would define a method of connecting several crates via an external "branch highway" into a special "branch driver" to a system controller or computer. This additional standardization has been under study since late 1969, and a draft description, to be issued later as EUR4600e, was released in January 1970.

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A meeting of the Dataway Working Group was scheduled for May 20-22, 1970 in London to finalize the above mentioned draft specification of the branch highway. The chairman of the NIM Committee, L. Costrell, and other members of the Executive Group felt that in view of the NIM Committee's new obligation as a CAMAC liason group for United States laboratories and industry, a NIM representative should attend this meeting both to report on the NIM Committee's recent action, and to obtain up-to-date details of the development of the branch highway standard for the benefit of those United States laboratories currently working on CAMAC systems. The meeting was held at the UKAEA building on Charles II Street, Picadilly, London, on May 20, 21 and 22, 1970.

To date CAMAC hardware is most highly developed at CERN, Harwell and Rutherford, where a number of CAMAC systems interfacing high-energy experiments to various computers are already in operation. These laboratories have developed individual styles of crate and system controllers, manual controllers, interface and command modules, in order to build multi-crate systems. The new EUR4600e specification, it is hoped, by defining both a general-purpose crate controller and the external data highway, will help to standardize future multi-crate systems.

2. ATTENDEES

Members of the ESONE-CAMAC Dataway Working Group in attendance at the London meeting were as follows:

Chairman - H. Klessman, Hahn-Meitner Institute, Berlin

Secretary - R. Barnes, UKAEA, Harwell, England

Members:

H. Meyer, Euratom, Brussels

P. Van den Berg, Reactor Center, Petten, Netherlands

I. Hooten, UKAEA, Harwell, England

R. Patzelt, OSA, Seibersdorf, Vienna, Austria

M. Cawthraw, SRC, Rutherford, England

F. Iselin, (Chairman ESONE), CERN, Switzerland

P. Poynting, CERN, Switzerland

A. Peatfield, SRC Daresbury, England

J-L. Lecomte, CEA Grenoble, France

M. Sarquiz, Saclay, France

J. Ottis, Karlsruhe, Germany

W. Heep, Karlsruhe, Germany

W. Wawre, Hahn-Meitner Institute, Berlin

NIM Representative - R. Larsen, SLAC, Stanford, USA

3. AGENDA

The main purpose of the meeting was to resolve some important technical questions of the CAMAC Branch Highway in order to clear the way for formal adoption of the EUR4600e specification at the forthcoming meeting of the ESONE General Assembly in Geneva next October.

The basic Branch Highway configuration is shown in Figure 1. In this system, up to 7 CAMAC crates time-share a single highway to a branch driver, which in turn communicates with a computer or system controller. The dataway consists of a 66 twisted-pair cable which contains addressing, control, and data transmission lines. Each crate communicates with its internal dataway through a crate controller (CCA)* which is to be specified in detail in the forthcoming EUR4600e.

Two basic types of operation are possible: one, under program control the computer can interrogate any or all parts of the system, writing data into or receiving data out of any particular module; and two, through a look-at-me (LAM) system, autonomous transfers can be arranged where the service demand originates in the hardware rather than the computer. In the latter case, a separate LAM signal

*See Appendix I.

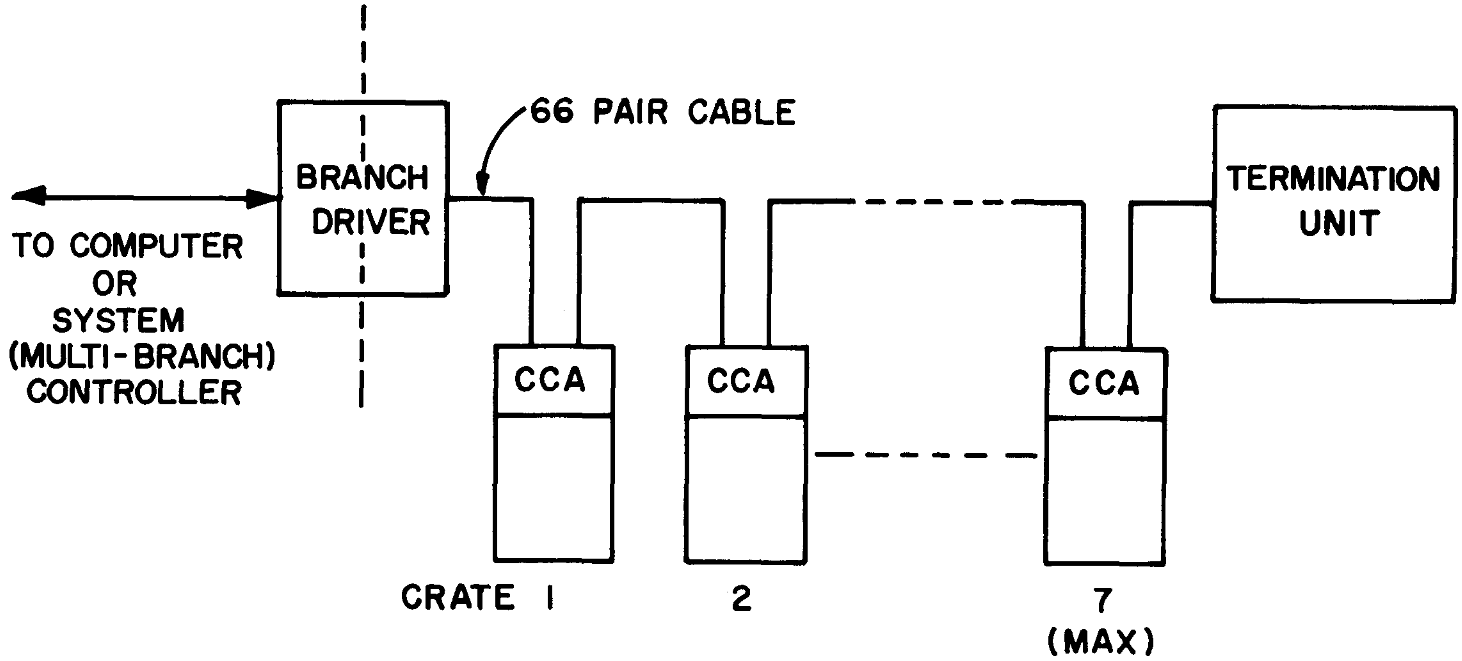


FIG. 1 BASIC BRANCH HIGHWAY

line is brought from each module in the crate to a special connector on the rear of the crate controller, and thence to an external LAM priority sorter. LAM signals for the entire system may then be collected through the dataway by the computer and dealt with according to programmed priorities. For a complete description of the system, a rough draft of EUR4600e is available from L. Costrell, National Bureau of Standards, Washington, D. C.; a revised final draft should be available by July 31, 1970.

Prior to the meeting it was indicated by Iselin of CERN that a possible subject for discussion was the specification of a special control highway and system crate to allow (a) easy handling of a multiplicity of branches and (b) simple communication between a number of (command) sources within a single branch system. The existing system has been criticized for lack of flexibility in this regard. This matter was effectively dissociated from the existing specification being considered, however, and was not discussed in the general meeting.

As part of the agenda, the writer provided a discussion of the NIM Committee position paper on CAMAC (see App. II) and reported briefly on the major CAMAC activities in the United States.

4. PROBLEM AREAS

The main questions unresolved at the time of the meeting were

(a) Multiplicity and method of selection of crate address (BCR) and timing response (BTB) lines

(b) Specification of data levels on Branch Highway lines, with a view to both short- and long-haul branches.

For item (a), two possible schemes were under active consideration. The first of these involved switch selections of 1 of 7 parallel BCR and BTB lines in each crate, with a front-panel selection of crate address on the crate controller. The second scheme was to rotate these lines in each controller, such that a switch was unnecessary. There are significant pros and cons for each approach, depending on the intended usage of the system.

For item (b), the main problem concerned the adequacy of noise margins in systems having branches of longer than about 10 meters. Since the logic levels specified were originally based on TTL manufacturers' numbers, and since the minimum resistance of the branch cable is specified by the maximum wire size of the crate controller double-density connector,[1] at a certain cable length the noise margin becomes critically low because of line drops in the low-voltage (current-sinking) state. Both the limitations of single-ended systems and the applicability of balanced systems came under discussion.

A third activity of the meeting concerned a detailed review of the CCA controller logic diagram, and finally, a brief review of areas of the existing draft specification which would require revision.

5. RESULTS

The main results of the meeting are summarized as follows:

5.1 After lengthy discussion of the opposing schemes, it was decided that crate identification (BCR) and response (BTB) lines would be run in parallel to each of 7 possible crate controllers on a branch, with selection made by a double-pole rotary switch. The main disadvantage is that for remote locations, there is no way of knowing whether more than one crate is connected to the same switch position. It was also decided that the switch should be "hidden" and not operable without removing the module from the crate; and that there would be a front panel visual indication of the setting. Thus, one will have to discern by direct observation or by some undefined electrical test procedures that crates

1. Hughes Aircraft Company WSS 0132 S00 BN 000 and mating connector

are properly addressed. In general, some members of the Working Group were much concerned about remote systems on one branch sharing a single computer; while others felt that a single branch (up to 7 crates) would be essentially dedicated to a single experiment, if not to a single computer.

5.2 Concerning voltage levels of the branch highway, the main changes are summarized below:
(Ref Table XI, EUR4600e Draft)

	'0' STATE		'1' STATE	
	WAS	NOW	WAS	NOW
Inputs Must Accept From the Connection	+ 2.0 to + 5.5V	+ 2.4 to + 5.5V	0 to + 0.8V	0 to + 1.2V
Outputs Must Generate Into the Connection	+ 3.0 (Min) + 3.V (Recommended) to + 5.5V	+ 3.5 to + 4.5V	0 to + 0.5V (Max) + 0.3V (Recommended)	SAME

TABLE XI - Static Voltage Levels for Branch Highway Signals

All levels are specified to be <u>at</u> the CCA Hughes connector.

The higher threshold of 1.2V reflects the Committee's concern over noise margins using standard TTL current sinking logic. Patzelt and Wawre had studied the problem and pointed out that with a minimum '1' state offset of 0.3 to 0.4V (manufacturer's typical specification), the old level of 0.8V left only 0.4 to

0.5V for total line drops plus noise transients. This was considered inadequate and the margin is now raised to 0.8 to 0.9 volts.

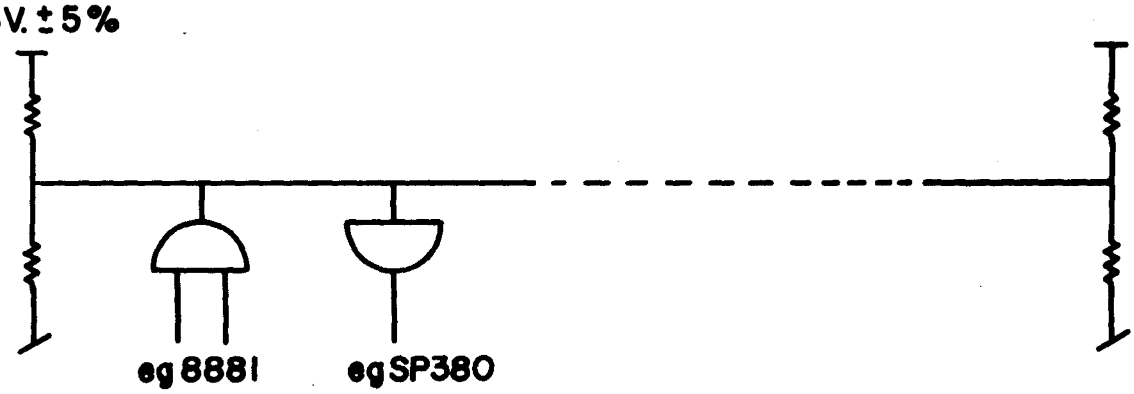
The acceptance level of +2.4 volts minimum was felt adequate in view of increased specified drive levels.

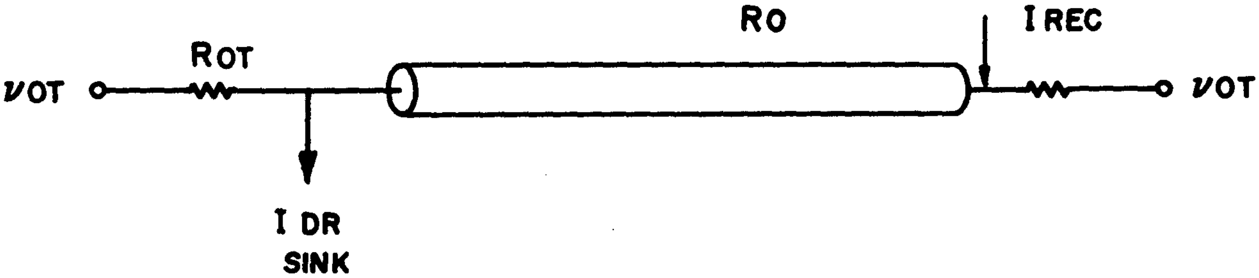
The new drive level of +3.5 to +4.5 volts has a higher minimum but a lower maximum. The maximum was lowered to 4.5V so as not to exceed the current load ratings of certain receivers when driven at maximum voltage levels. The new threshold levels are obtainable with certain units such as Utilogic SP380 (Signetics) or with selected standard units. In general it was felt that drivers are no problem, but receivers may be critical.

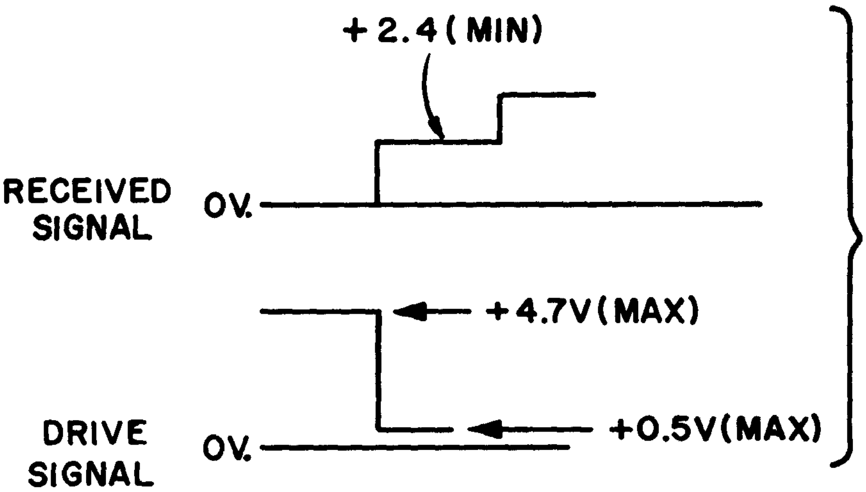
Much discussion was devoted to a design of a matched line similar to that of the PDP-11 Unibus. An example result by Patzelt and Wawre is shown in Fig. 2. Patzelt and Wawre showed that if one allows ranges on both voltage levels and characteristic resistance R_o of the twisted pair lines, then the terminating resistors must be selected probably to 1% tolerance. This result was roundly criticized and discussed. More work is being done in this area and it is hoped that the final draft will give some guidance in the design of actual systems. This matter of course is most important for long-haul branches, and where maximum speed of operation is desired. (Since with a single-ended system the impedance of twisted pairs in the large cable may vary considerably, it is not obvious to the writer that a well-matched system can be designed which will be optimum for all pairs.)

For very long branches, it was agreed that a pure balanced system is necessary, and the specification should point this out. This means that branch drivers and crate controllers will be connected to junction boxes which will contain bilateral balanced line drivers and receivers, which for the moment would be to the individual's specification.

For normal short-haul branches, standard or selected standard TTL receivers should be quite adequate. The first 20 crate controllers being built by Elliott for CERN and Daresbury will use standard or selected standard TTL input gates.







Z_O MIN = 70 Ω TO 90 Ω MAX

ν_{OT} = 4.5 ± 0.2V

I SINK DR MAX = 100 mA STATIC
130 mA DYNAMI

ν_O DR LOW ≤ 0.5V

I IN REC HIGH ≤ 1.6 mA
LOW ≥ 1.6 mA

ν IN REC HIGH ≥ 2.4
LOW ≤ 1.2

∴ R_{OT} = 107 ± 1%

PATZELT & WAWRE
ESONE 5/21/70

FIG. 2 - SAMPLE CALCULATION — MATCHED LINE

5.3 The CCA logic diagram (revised) was reviewed. BM, BTC and BTD lines have been deleted from the diagram. Some minor changes in gating, buffers and symbology were made. (These changes were made later on the Master at CERN, and copies were returned to the United States. Reprints are available through L. Costrell.) The logic received a very critical review by Poynting, Cawthraw, Lecomte and others, and it is felt that the present diagram represents a very reliable guide for circuit development.

5.4 The specification as mentioned earlier will undergo considerable revision in certain sections, particularly those relating to multicrate operations. Since this document will extend only to the output part of the branch driver, the entire subject of multibranch systems is deferred for later discussion.

5.5 A meeting was set for Brussels for July 20-22 (a) to review a final draft of EUR4600e and (b) to establish a Software Working Group. The latter was suggested by Hooten of Harwell and it appeared that the major laboratories would send one or two representatives. (Dhawan of Yale is expected to attend.) If time permits at the Brussels meeting, it is hoped to discuss multi-branch systems, which is a particularly appropriate subject also for the new Software group.

5.6 Report on United States Activities

The author gave a summary of (a) the recent endorsement action of the NIM Committee and (b) general United States Laboratory and Industry activities. The NIM action may be viewed as a more or less complete endorsement of EUR4100e describing the basic dataway crate system; but should not be viewed as an automatic endorsement of all future developments of CAMAC under the ESONE Committee. Since NIM speaks only for a specific group of laboratory-users, it cannot make a general endorsement of the suitability of CAMAC for uses other than those in practice or envisaged in those particular institutions. However, it is still in the best interests of the United States laboratories to collaborate on further developments presently taking place in the ESONE group, if only for the reason that the investment in a parallel development would be prohibitively costly and time-consuming.

Industrial developments in the United States are minimal so far. Some hardware is available from Nuclear Specialties of San Leandro, principally because of the stimulation of the LRL group. LRL should have a mother-board design available from a commercial job-shop quite soon.

LeCroy and Jorway are both offering scaler systems in CAMAC. SLAC and LRL have collaborated on a CAMAC scaler specification, and SLAC has received 40 dual units from Jorway. In the meantime, the only complete bins available are from Nuclear Enterprises, the United States outlet for Harwell crates. Dhawan of Yale is having a crate controller built by Jorway, and since the London meeting, has also tried to interest DEC in building a system controller for the PDP-15 computer.

6. CONCLUSIONS

The Branch Highway specification appears very nearly complete, and a draft will probably be released in July. There appear to be several major points which the NIM Committee should consider in detail, as soon as the final draft specification is available:

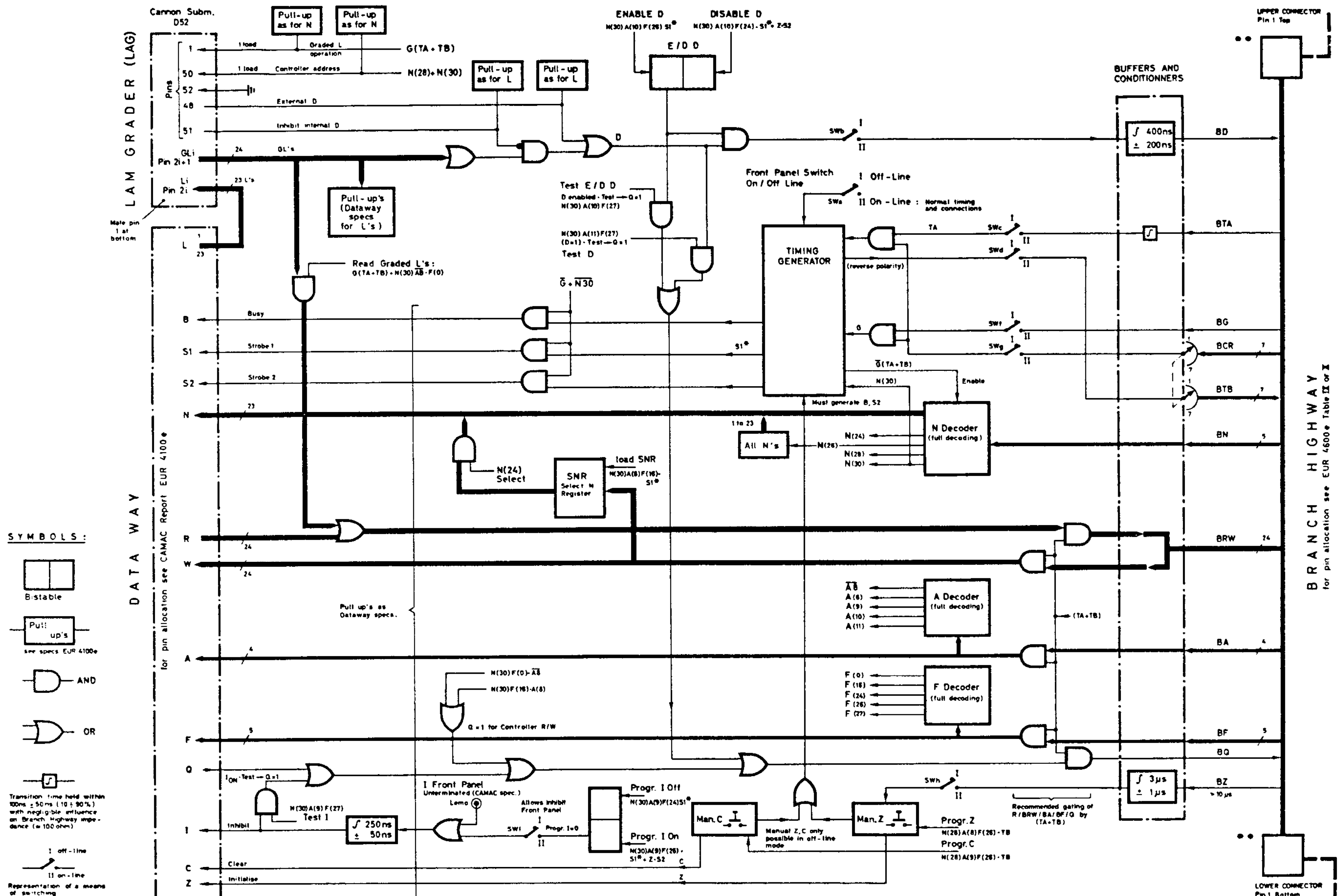
1. Are the voltage, current and resistance specifications for the branch sufficiently well defined in view of intended usage in United States laboratories to warrant endorsement? Are matched or balanced lines of sufficient importance to warrant a separate standard?

2. Is the branch concept itself, in the absence of a specification for multi-branch systems, too restrictive for common uses where

autonomous off-line functions (e.g., display refreshment) are desired without involving the system controller or computer?

3. Should NIM at this point form parallel working groups to investigate these and future problems (e.g., software), so that further NIM interactions with ESONE may be more of an interchange of ideas rather than the present "observer" function?

At the moment, the CCA specification is essential to any system; thus a major result of this latest meeting is that a logic diagram exists upon which crate controller designs can reliably be initiated. The specification of EUR4600e of course is required to fill in the necessary details, and this should be available by the end of July, 1970.



CAMAC CRATE CONTROLLER TYPE A

(diagram shown for double-width unit)

APPENDIX I

STATEMENT OF THE NIM COMMITTEE REGARDING CAMAC

This writeup has been prepared to clarify the position of the NIM Committee regarding the CAMAC System.

A number of laboratories represented on the NIM Committee are planning to utilize a "dataway system" to complement the widely used NIM system. A dataway system receives its instructions and communicates the data primarily through a dataway (bus) structure and has a minimum of local controls and readouts. NIM modules are in some instances used for such purposes by various arrangements such as daisy-chained harnessed connectors that mate with corresponding connectors mounted on the modules. Dataway type outputs have been thus routed from NIM modules to computers and to peripherals and this can be expected to continue and to expand since the laboratories have on hand many tens of thousands of useful NIM modules, since there is a wide variety of high quality NIM modules readily available from commercial sources and for other reasons. However, NIM was not conceived as a dataway system and does not basically make provision for dataway type operations.

It is reiterated that many laboratories will utilize NIM modules, or NIM hardware, with added connectors, for dataway type operations. However, references herein to dataway systems are to systems incorporating built-in dataways, specifically designed for dataway operation, oriented toward communication with computers and peripherals and, in general, utilizing high density packaging. Thus, dataway systems, as referred to here, do not include NIM systems that are adapted to dataway type operations. The term "data bin" is used to refer to bins (or crates) of dataway systems.

Dataway systems in use have been devised by individual laboratories and manufacturers. A dataway system can provide benefits such as have resulted from NIM only if such a system is standardized and receives wide acceptance. The use of different dataway systems in various laboratories will create problems similar to those that existed prior to the NIM standardization. Proliferation of different dataway systems will result in duplication of effort, inefficient utilization of design talent and discouragement of commercial production as a result of the wide variety of low volume units that is inescapable where a number of non-compatible systems divide the potential market.

The NIM Committee concludes as follows:

(1) There will be a proliferation of dataway systems unless there is dataway system standardization.

(2) Dataway system standardization can provide benefits similar to those provided by the NIM standardization.

(3) Standardization and wide acceptance of a dataway system makes feasible commercial production of data bins and data modules.

(4) Design of a standard dataway system is an ambitious undertaking requiring consideration of many details and considerable system philosophy and involving a very substantial expenditure of effort and funds.

(5) Though each person and each group designing a system would arrive at a different result, CAMAC is a well thought out dataway system that can prove very useful. The very considerable effort and expense referred to in item (4) above have already been expended on the CAMAC system.

(6) The CAMAC system is the only dataway system that seems likely to receive wide acceptance by the laboratories at this time.

(7) Extension of the use of a standard dataway system outisde the nuclear field can provide added benefits to the nuclear instrumentation field both in making useful "non-nuclear" modules available to us and in its implications for volume production.

(8) CAMAC is considered to be a dataway system complementary to NIM and, as such, the NIM Committee endorses the CAMAC System as it is presently constituted in EURATOM publication EUR4100e and intends to cooperate with and maintain contact with the ESONE CAMAC Committee. There are some details of the CAMAC specification that the NIM Committee is studving further and which we plan to discuss with the ESONE CAMAC Committee, and with regard to which the NIM Committee will be prepared to provide guidance to U. S. laboratories and manufacturers. Also, the BNC connector, in accordance with American National Standards Institute Publication USAS N3.3-1968, is adopted as an alternate standard connector instead of U. S. Mil Spec C22557 (see 4.3.3 of EUR 4100e).