SLAC-PUB-1875
January 1977
(I/A)

DISTRIBUTED INTELLIGENCE IN CAMAC*

Paul F. Kunz
Stanford Linear Accelerator Center
Stanford University, Stanford, California 94305

I. BACKGROUND

The CAMAC digital interface standard has served us well since 1969. During this time there have been enormous advances in digital electronics. In particular, low cost microprocessors now make it feasible to consider use of distributed intelligence even in simple data acquisition systems. This paper describes a simple extension of the CAMAC standard which allows distributed intelligence at the crate level.

First it is important to understand that by distributed intelligence I mean that there is more than one source of control in a system. A system which contains a module which never asserts a command on the Dataway is not a distributed intelligence system even if the module contains a microprocessor. It is the distributed control aspect of the system and not the sophistication of the modules which makes it a distributed intelligence system.

Using this definition of distributed intelligence, we can see that there are many examples already commercially available in CAMAC. The Jorway 72A CRT CAMAC display controller is one, when it operates on the Parallel Highway, sharing it with the Branch Driver. Other examples are the System Crate or Executive Crate of Kinetic Systems and GEC-Elliot, respectively. Both of these systems allow multiple sources of control within a CAMAC Crate by using a special Crate Controller.

Each of these examples uses different methods, incompatible with modules made by other manufacturers. The time has come for a standard method for distributed intelligence in CAMAC. This paper will describe a simple standard just now emerging from the NIM Dataway Working Group and its European counterpart.

II. REQUIREMENTS

Although the CAMAC Standard was published long before microprocessors were available, there are many features of the CAMAC Dataway which allow distributed intelligence to be easily introduced. For example, all the lines of the Dataway are driven by open collector outputs, thus allowing more than one module to assert the control lines.

There is only one basic problem: the N- and L-line structure of CAMAC. These lines go between the individual stations and the control station (N(25)) of the crate, which is occupied by the Crate Controller (CC). An alternate source of control, called an Auxiliary Crate Controller (ACC), must somehow transmit N-line information to the CC in order to perform an operation in the crate.

Auxiliary Crate Controllers need also to have access to the L-lines. Like the N-lines, the L-lines go only to the control station in the crate. The method of routing the L-signal to the ACC must be D.C., i.e., the L-signal must be presented continuously to the ACC in order to give it time to respond.

Multiple source of control also implies that there must be a priority arbitration system to insure that only one source is using the Dataway at any instant of time. The priority arbitration system must also not cause the Crate Controller to violate any established timing protocols with its Highway Driver. This is especially true in a Serial Highway System where, once a Serial Crate Controller has received a command to perform a Dataway operation, it must give a response at a precisely defined time period.

Finally, however the above requirements are satisfied by ACC's, they should be independent of the type of Highway used. That is to say that an ACC that can be plugged into a Serial Highway System can also work in a Parallel Highway System with no modifications to it.

III. THE EMERGING STANDARD

The standard emerging from the CAMAC committees defines a method of operating one or more ACC's in a single CAMAC Crate. It is based on the SGL connector of the Serial Crate Controller type L-2 (SCC-L2). This connector has five contacts for encoded N-lines. When the SCC-L2 is not performing a Dataway operation, a binary coded input to these contacts will be decoded and the appropriate N-line will be asserted by the SCC-L2. An Auxiliary Controller Bus (ACB) is connected between the SGL-connector and the ACC in the crate. Controllers will know when to yield the Dataway to the SCC-L2 by monitoring the Auxiliary Controller Lockout (ACL) signal which will be asserted a minimum of 800 ns before the SCC starts its CAMAC operation. And finally, all the L-lines are available on the even-numbered contacts of this connector.

The SGL connector is the only standard one needs to operate one ACC with an SCC-L2 in a CAMAC Crate. To install two or more ACC's, however, some additional lines must be defined. For this purpose a REQUEST-GRANT structure has been added. It works in the following way:

1. An ACC desiring to use the Dataway must first assert a signal on the REQUEST line. It may do so only if the Dataway is unoccupied, i.e., if the Dataway BUSY line is at logical 0.
2. In the ACB the REQUEST line will be connected to the GRANT line at a point upstream of the highest priority Crate Controller.
3. The REQUEST signal will then be seen as a GRANT-In signal at the highest priority Crate Controller. If this Controller is not requesting the use of the Dataway it will assert a signal on its GRANT-Out line.
4. The GRANT-Out is connected to the GRANT-In of the next Controller where the GRANT is again passed if that Controller is not requesting.
5. When the GRANT signal is received by the requesting Crate Controller it is not passed on down the chain. Instead, the Controller starts its Dataway operation by asserting Dataway BUSY.
6. The Controller asserting BUSY may perform one or more operations on the Dataway. However, in order not to interfere with the SCC-L2 operating at its highest speed, an ACC must yield the Dataway if it receives ACL before it has asserted S1 of any cycle. If it has already issued S1, then it must yield the Dataway immediately at the end of its current Dataway operation.

Unfortunately the Parallel Highway Crate Controller type A-1 (CC-A1) does not have a connector similar to the SGL connector of the SCC-L2. With a simple modification to it, a connector compatible with the ACB can be installed while retaining compatibility with existing Parallel Highway Systems. With the modifications the new Crate Controller is called the CC-A2. Another feature of the new controller is that it will use the REQUEST-GRANT protocol to gain access to the Dataway for all CAMAC operations except the Graded-L operation. The BTA-BTB handshake on the Branch Highway allows this feature to be implemented. When the CC-A2

*Work supported by the Energy Research and Development Administration.

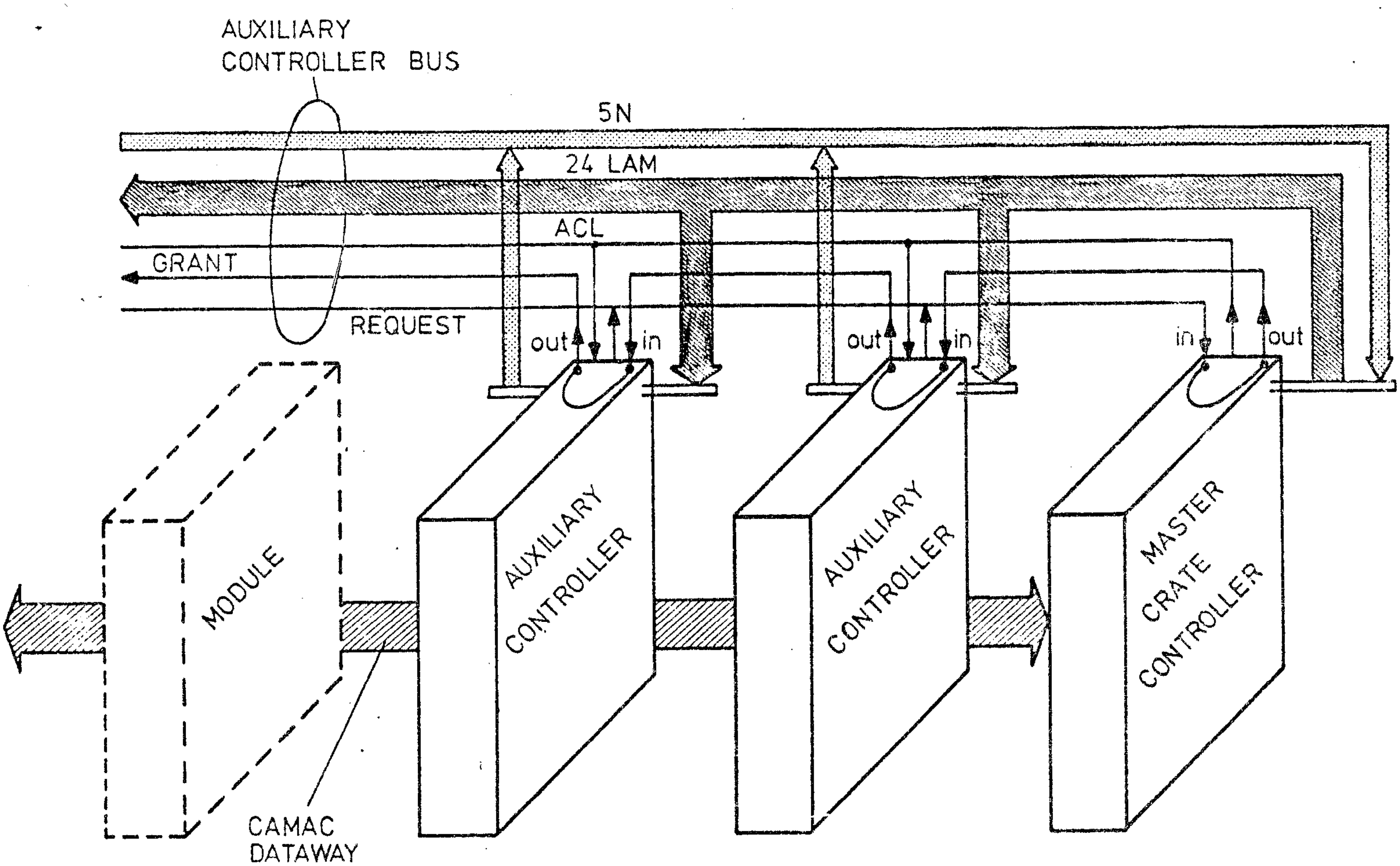
(Invited paper presented at the IEEE 1976 Nuclear Science and Scintillation and Semiconductor Counter Symposium, New Orleans, La., October 20 - 22, 1976)

receives a command from the Branch Driver, it will first gain access to the Dataway via the REQUEST-GRANT protocol. Only after gaining access and having issued S1 will it return the BTB signal. The user who puts the system together must be prepared for the possibility that the Branch Driver may have to wait for an ACC to release the Dataway before it can execute its command. This is especially true if the CC-A2 has lower priority in the crate than one or more ACC's.

IV. CONCLUSION

The use of distributed intelligence will bring exciting possibilities to our CAMAC systems. We will be able to operate binary scaler displays in one crate and wire chamber displays in another. Microprocessor-based Auxiliary Crate Controllers will be able to monitor many channels of high voltage readout and warn us when they are out of tolerance without loading down our data acquisition computers.

While this paper was being prepared, final details of distributed intelligence in CAMAC were still being discussed by the NIM and ESONE committees. Consequently, this paper does not attempt to explain the emerging standard in detail. It is expected that the standard will soon be published.



DISTRIBUTED INTELLIGENCE IN CAMAC