ANSI/IEEE Std 675-1982
(Revision of ANSI/IEEE Std 675-1979)

An American National Standard

IEEE Standard Multiple Controllers in a CAMAC[1] Crate

Sponsor
Instruments and Detectors Committee
of the
IEEE Nuclear and Plasma Sciences Society

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IEEE Standards Board

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American National Standards Institute

[1]Computer Automated Measurement and Control

Foreword

(This Foreword is not a part of ANSI/IEEE Std 675-1982, IEEE Standard, Multiple Controllers in a CAMAC Crate.)

This standard makes provision for the use of auxiliary controllers in a CAMAC crate to extend the capabilities and fields of application of the CAMAC modular instrumentation and interface system of ANSI/IEEE Std 583-1982, Modular Instrumentation and Digital Interface System (CAMAC). (Also Report EUR 4100e of the Commissions of the European Communities.) The report on which this document is based (Dept of Energy Report DOE/EV-007), was prepared by the NIM Committee of the United States Department of Energy* and the ESONE Committee of European Laboratories**. Corresponding documents are ESONE Report EUR 6500e and IEC Publication 729 of the International Electrotechnical Commission.

Auxiliary Controllers (ACs), located in several crates on a CAMAC Command Highway (Parallel Branch or Serial), can provide the user with an extremely effective distributed processing capability. This capability is useful in both data acquisition and automatic control systems where parallel processing is desirable. Auxiliary controllers can be of various degrees of sophistication, and some may include processor elements for increased autonomy from central computers.

A further extension of the AC-based CAMAC system may include a special communication channel direct from an AC to another element in the system. High-speed block transfer of data can be effected to and from the AC in such a case.

To permit use of the ACs in CAMAC crates, this report defines the hardware and protocol so as to:

1) Provide means for granting control of the Dataway to auxiliary controllers that request control and to provide a priority selection scheme to arbitrate in the case of simultaneous requests from multiple controllers.
2) Provide means for the auxiliary controller to address (a) the dedicated module address lines and (b) the dedicated interrupt request LAM (Look-at-Me) lines, all of which terminate only at the crate controller station and at the module stations to which they are dedicated.

This standard was reviewed and balloted by the Nuclear Instruments and Detectors Committee of the IEEE Nuclear and Plasma Sciences Society. Because of the board applicability of the CAMAC system, this standard was submitted for review to liaison representatives of numerous societies and committees including the Communications Society, Computer Society, Industry Applications Society, Industrial Electronics and Control Instrumentation Group, Instrumentation and Measurement Group, and the Power Generation and Nuclear Power Engineering Committees of the Power Engineering Society.

The revision of this standard was in conjunction with the 1981 review (1982 issue) of the entire family of IEEE CAMAC standards undertaken to incorporate existing addenda and corrections into the standards.

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CAMAC and NIM Standards and Reports

Title	IEEE, ANSI Std No	IEC No	DOE No	EURATOM (EUR) or ESONE No
CAMAC Instrumentation and Interface Standards*	SH08482* (Library of Congress No 8185060)	—	—	—
Modular Instrumentation and Digital Interface System (CAMAC)	ANSI/IEEE Std 583-1982	516	TID-25875† and TID-25877†	EUR 4100e
Serial Highway Interface System (CAMAC)	ANSI/EEE Std 595-1982	640	TID-26488†	EUR 6100e
Parallel Highway Interface System (CAMAC)	ANSI/IEEE Std 596-1982	552	TID-25876† and TID-25877†	EUR 4600e
Multiple Controllers in a CAMAC Crate	ANSI/IEEE Std 675-1982	729	DOE/EV-0007	EUR 6500e
Block Transfers in CAMAC Systems	ANSI/IEEE Std 683-1976 (Reaff 1981)	677	TID-26616†	EUR 4100 suppl
Amplitude Analog Signals within a 50 Ω System	—	—	TID-26614	EUR 5100e
The Definition of IML A Language for Use in CAMAC Systems	—	—	TID-26615	ESONE/IML/01
CAMAC Tutorial Articles	—	—	TID-26618	—
Real-Time BASIC for CAMAC	ANSI/IEEE Std 726-1982	‡	TID-26619†	ESONE/RTB/03
Subroutines for CAMAC	ANSI/IEEE Std 758-1979 (Reaff 1981)	713	DOE/EV-0016†	ESONE/SR/01
Recommendations for CAMAC Serial Highway Drivers and LAM Graders for the SCC-L2	—	—	DOE/EV-0006	ESONE/SD/02
Definitions of CAMAC Terms	Included in SH08482	678	DOE/ER-0104	ESONE/GEN/01
Standard Nuclear Instrument Modules NIM	—	547§	TID-20893 (Rev 4)	—

*This is a hard cover book that contains ANSI/IEEE Std 583-1982 , ANSI/IEEE Std 595-1982 , ANSI/IEEE Std 596-1982 , ANSI/IEEE Std 675-1982 , ANSI/IEEE Std 683-1976 (Reaff 1981), ANSI/IEEE Std 726-1982 and IEEE Std 758-1979 (Reaff 1981), plus introductory material and a glossary of CAMAC terms.
†Superseded by corresponding IEEE Standard listed.
‡In preparation.
§Covers only mechanical features and connector pin assignments.

NOTE — *Availability of Documents*

ANSI	Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.
IEEE	IEEE Service Center, 445 Hoes Lane, Piscataway, New Jersey 08854, USA.
IEC	International Electrotechnical Commission, 1, rue de Varembé, CH-1211 Geneva 20, Switzerland.
DOE and TID Reports	National Bureau of Standards, Washington, D.C. 20234, USA, Attn: L. Costrell.
EURATOM	Office of Official Publications of the European Communitities, P.O. Box 1003, Luxembourg.
ESONE	Commission of the European Communities, CGR-BCMN, B-2440 GEEL, Belgium, Attn: ESONE Secretariat, H. Meyer.

CLAUSE PAGE

1. Introduction 1

2. Interpretation 1

3. The Auxiliary Controller Bus and Associated Front Panel Signals 2

4. Use of the Lines on the Auxiliary Controller Bus and Associated Signals 8

4.1 Control Signals 8
4.2 Encoded-*N* Signals 10
4.3 Look-at-Me Signals 10
4.4 Other Signals 10

5. The Auxiliary Controller Bus Connector and Associated Front Panel Connectors 11

6. Signal Standards 13

6.1 Signal Standards on the ACB 13
6.2 Signal Standards for the ACB Associated Front Panel Signals 14
6.3 Signal Standards for AC Dataway Connections 14
6.4 Protection of Critical Signal Inputs 14

Annex A (Informative) 15

An American National Standard

IEEE Standard Multiple Controllers in a CAMAC Crate

1. Introduction

This standard defines a method for incorporating more than one source of control into a CAMAC crate. The standard fully conforms to the mechanical and signal standards of the CAMAC system as described in ANSI/IEEE Std 583-1982, Modular Instrumentation and Digital Interface System (CAMAC), or EUR 4100e.

In order to allow more than one Controller to access the Dataway of a CAMAC Crate, an Auxiliary Controller Bus (ACB) and priority arbitration protocol are fully defined. This permits the use of Auxiliary Controllers (ACs) in normal stations in the crate. The ACB carries encoded address information from an AC to the Crate Controller (CC) in the control station of a CAMAC crate, and carries Look-at-Me signals from the CC to the ACs. The ACB, connected between controllers, may also be used to establish priority for control of the CAMAC Dataway.

This standard is fully compatible with ANSI/IEEE Std 595-1982, Serial Highway Interface System (CAMAC), or EUR 6100e, and the ANSI/IEEE Std 596-1982, Parallel Highway Interface System (CAMAC) or EUR 4600e. It may also be used in autonomous systems (systems with no external highways) or in systems with Type U Crate Controllers (such as systems with a computer I/O bus as the highway).

Section A of the Appendix to this standard defines a Parallel Highway Crate Controller, Type *A*-2. This controller is similar to Crate Controller Type *A*-1 (as defined in Section A of the Appendix to ANSI/IEEE Std 596-1982 or EUR 4600e), except for the ACB connector and the priority arbitration protocol. When these two features are not required, Crate Controllers Types *A*-1 and *A*-2 are totally interchangeable.

Abbreviations used in this document are as follows:

AC	Auxiliary Controller
ACB	Auxiliary Controller Bus
ACL	Auxiliary Controller Lockout
CC	Crate Controller
R/G	Request Grant

2. Interpretation

This standard is a reference text describing and specifying multisource control within a CAMAC crate. It should be read in conjunction with, and is supplementary to, ANSI/IEEE Std 583-1982, ANSI/IEEE Std 595-1982, and ANSI/IEEE Std 596-1982 or EUR 4100e, EUR 6100e, and EUR 46003, respectively.

No part of this standard is intended to supersede or modify the above-mentioned standards.

In this standard there are mandatory requirements, recommendations, and examples of permitted practice.

Mandatory clauses of the standard are enclosed in a box, as here, and usually include the word “must.”

Definitions of recommended practices (those to be followed unless there are sound reasons to the contrary) include the word “should.”

Examples of permitted practice generally include the word “may,” and leave freedom of choice to the designer or user.

In order to “conform” with the specifications of this standard, an equipment or system must satisfy all the mandatory requirements in this standard, excluding the Appendix. If constructed as a CAMAC plug-in unit, the equipment must also satisfy the mandatory requirements of ANSI/IEEE Std 583-1982 or EUR 4100e.

Section A1 of this standard’s Appendix defines the Parallel Crate Controller Type *A*-2 in such a way that Type *A*-2 Controllers produced by different manufacturers will be operationally interchangeable. The main text to this standard contains a less restrictive definition of Controllers that are not necessarily interchangeable. See Section A1 of the Appendix regarding conformity with the specification of the CAMAC Crate Controller Type *A*-2.

In order to be “compatible” with the ACB, equipment need not satisfy all the mandatory requirements, but must not interfere with the full operation of all the features of Controllers which “conform” to this standard.

No part of this standard is intended to exclude the use of equipment that is compatible in the preceding sense, even if it does not conform fully to this standard or is not constructed as CAMAC plug-in units.

No license or permission is needed in order to use this standard.

3. The Auxiliary Controller Bus and Associated Front Panel Signals

The standard CAMAC crate, described in ANSI/IEEE Std 583-1982 or EUR 4100e requires the presence of a Controller to control and coordinate the activities of the crate. During a Dataway addressed command operation, the Controller establishes the necessary signals on the *B*, *N*, *A*, *F*, *S*1, and *S*2 lines to define the command operation to be performed and to define the timing of the operation. During addressed command operations involving data, the Controller transmits or receives data via the *W* or *R* lines, respectively. During unaddressed operations, the Controller establishes the necessary signals on the *B*, *S*1, *S*2, and *C* or *Z* lines. The Controller may establish the state of the *I* signal and may monitor the state of the *L*, *X*, and *Q* signals.

Each CAMAC crate has one control station, which is the only station providing access to the *N* and *L* lines. The control station and a normal station together provide access to all signal lines needed by a Controller to perform the operations described above. The Controller which occupies the control station is designated the CC of the crate. Examples of CCs are the Serial Highway Crate Controller Type *L*-2 (Section A1 of the Appendix of ANSI/IEEE Std 595-1982 or EUR 6100e) and the Parallel Highway Crate Controller Type *A*-2 (Section A1 of the Appendix of this standard).

An additional source of control within a CAMAC crate can be provided by an AC, which occupies one or more normal stations. In order to accommodate ACs, two features are required: (1) access to the *N* and *L* lines at normal stations, and (2) priority arbitration for control of the Dataway. Access to the *N* lines is necessary to allow an AC to generate a complete addressed command operation. Access to the *L* lines is necessary if an AC is to respond to Look-at-Me signals from other modules or controllers, or both. Priority arbitration protocol ensures that at any time only one Controller is permitted to have control of the crate. It also provides the means for assigning control of the Dataway on the basis of a prearranged priority.

Access to the *N* and *L* lines is provided by the ACB (see 4.2 and 4.3) via the CC. A Controller which conforms to this standard requires a connector on its rear panel for connection to the ACB, All lines on the ACB are bussed to each Controller as in Fig 1.

When an AC performs an addressed command operation, it generates the 5 bit binary code for the station number associated with the command, and transmits it via the Encoded-*N* lines of the ACB. The CC receives this Station Number code, decodes it, and places a logic “1” on the appropriate Dataway *N* line at the control station. The CC receives the 24 *L* signals at the control station and passes these signals to the ACB connector.

The minimum requirement for a CC which permits the use of ACs is that it links the Dataway *L* lines to the ACB and contains the *N*-decoder, the ACB connector, and pull-up current sources as in Fig 2.

The priority arbitration consists of two modes: Request/Grant (R/G) and Auxiliary Controller Lockout (ACL). The preferred arbitration mode is the R/G protocol.

Three signals are involved in this mode: (1) the REQUEST signal which is bussed to each Controller on the ACB and is accessible at a front panel connector on each controller; (2) the Grant signal which is daisy-chained, that is, the Grant-Out of one Controller is connected to the Grant-In of another Controller by front panel connectors; and (3) the Request Inhibit signal which is also bussed on the ACB.

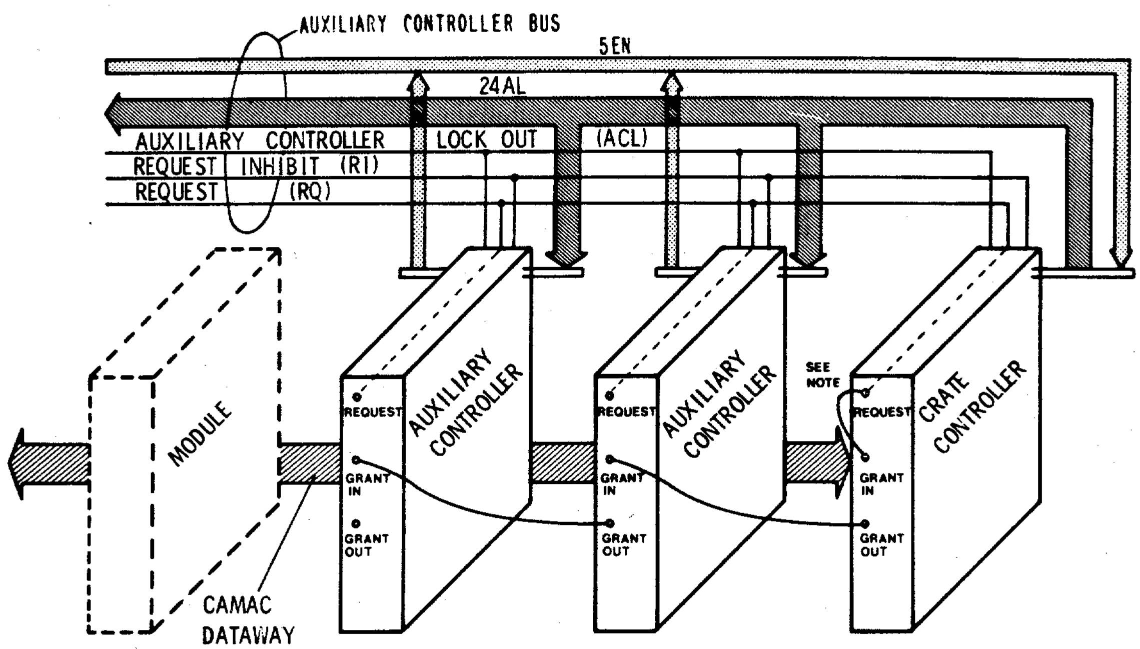


Figure 1—Multiple Controllers in a CAMAC Crate

The front panel Request signal output of the highest priority Controller will be connected to its front panel Grant-In signal input. The front panel Grant-Out signal output from this Controller is then connected to the front panel Grant-In signal input of the next highest priority Controller. The connection of Grant-Out to Grant-In is continued from Controller to Controller until it reaches the lowest priority Controller in the CAMAC crate.

The sequence of signals for a Controller to gain control of the crate is shown in Fig 3. A Controller first generates a Request and waits until it receives a Grant-In. Each Controller not generating the Request signal generates a Grant-Out when it receives a Grant-In. The Controller generating the Request signal does not generate a Grant-Out. The chaining of the Grant bus from Controller to Controller ensures that the Grant signal will propagate downstream to the highest priority Controller which is requesting control of the Dataway.

When a Controller requesting control receives Grant-In, it generates and maintains Request Inhibit to indicate that it has control of the crate, and it removes its Request signal. In response to Request Inhibit, any other Controllers also remove their Request signal outputs, thereby causing the Grant signals to be removed. When a Controller has finished its Dataway operations, it removes its Request Inhibit, and control of the crate will be given to the next Controller requesting it. At that time if two or more Controllers request control of the crate at the same time the highest priority Controller will be determined by its position on the Grant chain (Fig 1).

Gain of control of the crate by a Controller is delayed if the Dataway is already in use. If a Controller is connected to an external highway, the interface to the highway is required to accommodate this delay. An example of a highway interface that can accommodate this delay is the CAMAC Parallel Highway (ANSI/IEEE Std 596-1982 or EUR 4600e). The R/G mode is unsuitable for a Controller which can not accommodate this delay. An example is the Serial Crate Controller Type *L*-2 (ANSI/IEEE Std 595-1982 or EUR 6100e). When a Serial Highway Crate Controller Type *L*-2 is addressed by the Serial Highway it will proceed with its Dataway operation independently of the R/G protocol.

The ACL feature is provided to accommodate a Controller which cannot tolerate the delay associated with the R/G protocol. In a given crate, only one Controller (which may be either an AC or the CC) is allowed to use ACL to gain control of the crate. The ACL signal is bussed on the ACB to all other Controllers in the crate. Upon receiving this signal, a Controller which has control of the crate will either abort or complete its operation before the Controller generating ACL starts its Dataway operation (see 4.1.5). Examples of the sequences of signals that may occur with the ACL signal are shown in Fig 4A and B.

The necessary connections of the Request, Grant, Request Inhibit, and ACL lines are illustrated in Fig 1.

The Serial Crate Controller Type *L*-2, as described in the Appendix to ANSI/IEEE Std 595-1982 and EUR 6100e, does not have an ACB connector. However, its SGL-Encoder connector may be used to connect to the ACB since the signals on the ACB are a subset of those on the SGL-Encoder connector. With such an interface, the Serial Crate Controller Type *L*-2 may thus be used as a CC compatible with this standard. However, some *L*-2 controllers may not have a pull-up on the Request Inhibit line. In such instances, it will be necessary to add a pull-up on contact 17 of the SGL encoder connector of the *L*-2 and connect it to the Request Inhibit line.

The unaddressed operations, Dataway Initialize *Z* and Dataway Clear *C*, do not require use of the Encoded-*N* signals of the ACB. However, the Controller still uses one of the priority arbitration modes to gain control of the crate before issuing either of these commands. Care should be taken that a Dataway *Z* or *C* from one Controller does not adversely affect the operations of another Controller.

The Dataway Inhibit *I* is not associated with Dataway operations and may be generated at any time by either Controllers or other plug-in units. In contrast to requirements on other plug-in units (see 5.5.2 of ANSI/IEEE Std 583-1982 or EUR 4100e). Controllers capable of generating and maintaining Dataway *I* do not respond to $Z{\cdot}S2$ by generating and maintaining Dataway *I*.

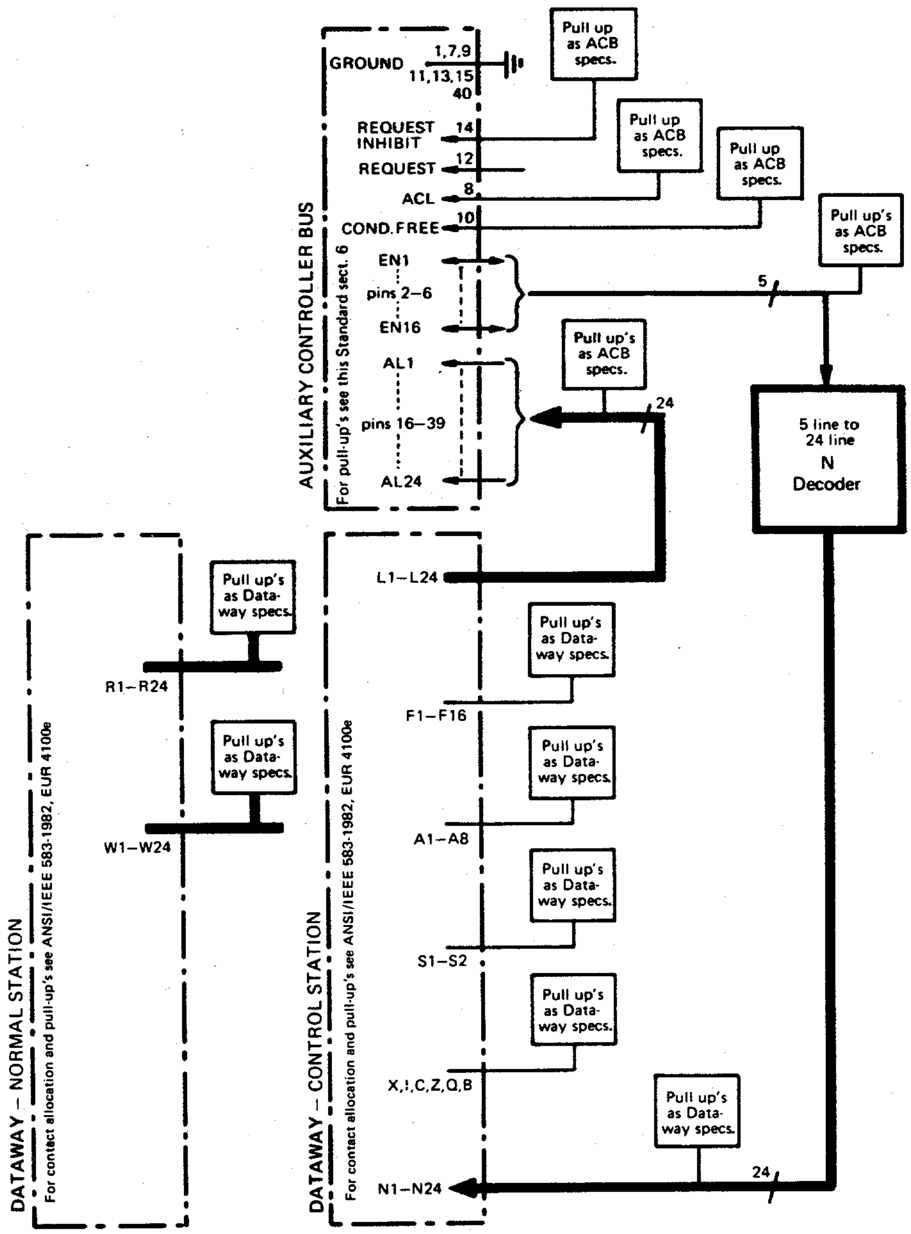


Figure 2—Crate Controller, Minimum Configuration

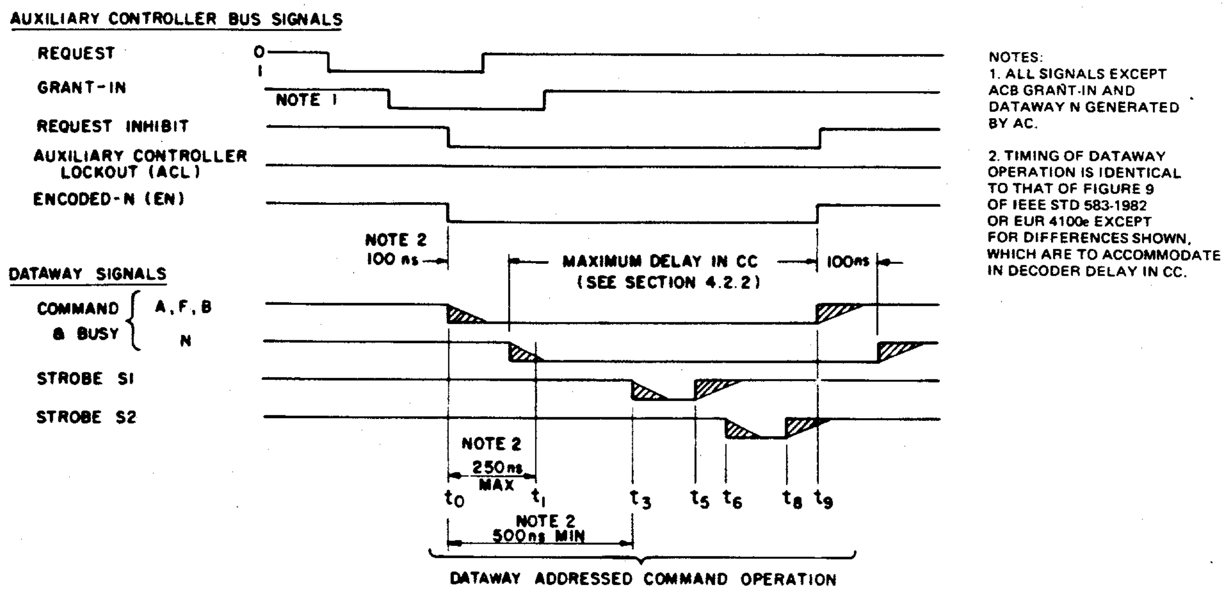
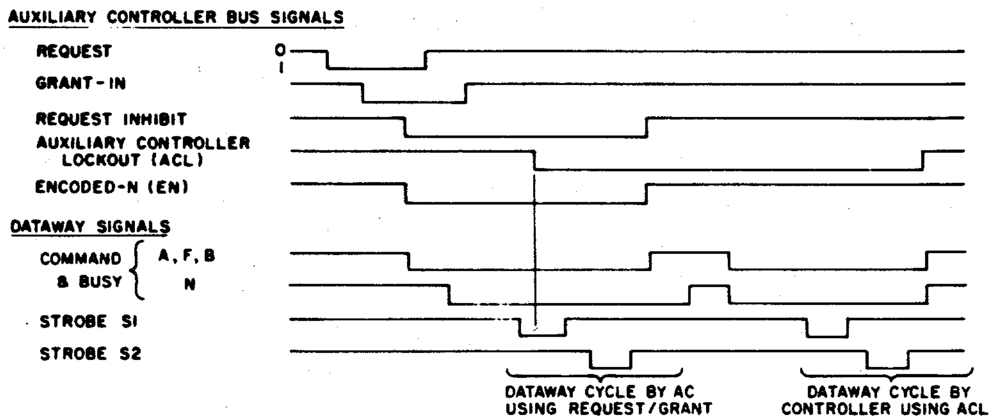
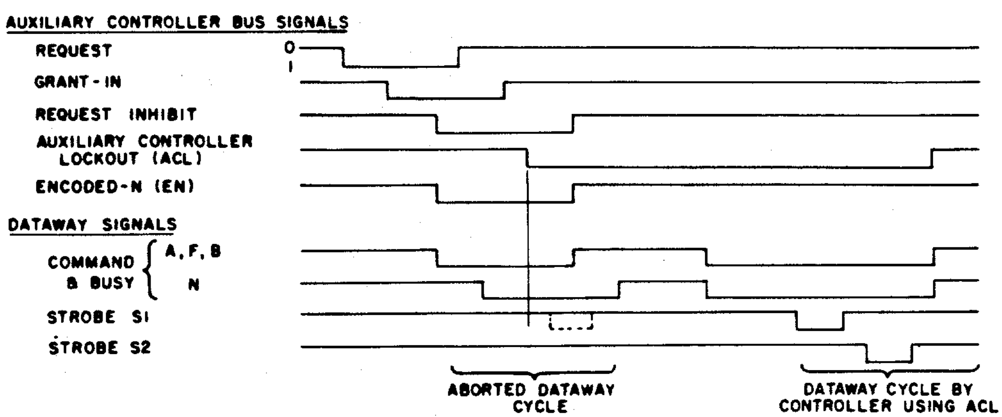


Figure 3—Sequence of Signals for an AC to Gain Control of Dataway for an Addressed Command Operation



A



B

Figure 4—Examples of Sequences of Signals that may Occur with the ACL Signal.
A—Example of a Sequence in Which Auxiliary Controller Lockout (ACL) Signal is Generated Too Late to Cause Aborting of Dataway Cycle Started by AC Using Request Grant;
B—Example of Sequence in Which a Dataway Cycle, Started by AC Using Request/Grant, is Caused to Abort by ACL Signal Generated by Another Controller

4. Use of the Lines on the Auxiliary Controller Bus and Associated Signals

Each line at the ACB connector and the associated front panel signal connectors must be used in accordance with the mandatory requirements detailed in the following sections. Table 1 shows the titles, the standard designations, and the sources of the signals defined in this section.

4.1 Control Signals

A Controller, when used in a CAMAC crate having one or more other Controllers, must not generate any Dataway signals, with the exception of the Dataway I and the L(s) of the station(s) it occupies, unless it has gained control of the crate or is addressed as a module. A Controller must gain control by generating Request in the R/G mode or ACL in the ACL mode. It should preferably gain control by the R/G mode unless there are strong technical reasons to the contrary.

Table 1—Signals Lines at the Auxiliary Controller Bus Connector and Associated Front Panel Connectors

Title	Location	Designation	Generated by	Signal Lines	Use
Request	ACB and front panel	RQ	CC or AC	1	Indicates request for control
Grant-In	front panel	GI	CC or AC	1	Indicates request is granted
Grant-Out	front panel	GO	CC or AC	1	Issued by Controller when GI is received but Controller is not requesting
Request Inhibit	ACB	RI	CC or AC	1	Indicates Controller has control in Request/ Grant mode
Auxiliary Controller Lockout	ACB	ACL	1 CC or AC	1	Indicates lockout control
Encoded-*N*	ACB	EN1, 2, 4, 8,16	AC	5	Binary coded station number
Auxiliary Look-at-Me	ACB	AL1—AL24	CC	24	24 Look-at-Me lines from modules
Conditional Free line	ACB		CC	1	Line recommended for Byte Clock in CAMAC Serial Highway systems
Ground	ACB	OV	CC or AC	7	System Ground

4.1.1 Request

In order to gain control of the crate when using the R/G protocol, a Controller must first generate a logic “1” signal on the Request signal line. It must not, however, initiate the 0→1 transition of the Request signal unless Request Inhibit and ACL are both logic “O”. If it is generating a Request, it must initiate the 1→0 transition of Request within 50 ns upon receiving either Request Inhibit = 1 or ACL = 1.

4.1.2 Grant-In and Grant-Out Signals

A Controller participating in the R/G mode must generate a Grant-Out signal as follows:

1) It must generate a logic “0” on Grant-Out whenever it receives a logic “O” on Grant-In.
2) If it is not generating the Request signal when it receives the 0→1 transition of Grant-In, it must retransmit on Grant-Out the signal it receives on Grant-In.
3) If it is generating the Request signal when it receives the 0→1 transition of Grant-In it must maintain a logic “0” on Grant-Out until it receives the next 0→1 transition of the Grant-In signal, and it must generate Request Inhibit to establish control of the crate.

If a Controller retransmits the Grant signal, it should do so with minimum delay.

4.1.3 Request Inhibit

A Controller gains control of the crate by initiating the 0→1 transition of Request Inhibit, and it maintains control of the crate until it initiates the 1-0 transition of Request Inhibit. It must maintain control of the crate for a minimum of 350 ns unless it receives ACL = 1.

The generation of Request Inhibit by a Controller will establish its control of the crate. If the Controller generates Request Inhibit = 0 between command operations, then it releases its control after each operation, thereby allowing another Controller to gain (and possibly maintain) control. If, on the other hand, the Controller maintains Request Inhibit = 1 between command operations, then the Controller will maintain control of the crate, thus allowing, for example, the execution of a block transfer with minimum delay.

4.1.4 Generation of ACL Signal

At any one time, the generation of the ACL signal must be reserved to only one Controller in a CAMAC crate. The Controller generating the ACL signal should generate ACL only after it expects to initiate a Dataway operation (for example, on the recognition of the Crate Address in a CAMAC Command addressed to it) in order to allow maximum use of the Dataway by other Controllers. The ACL signal must be maintained until the Dataway operation is complete.

A Controller generating ACL must not initiate its Dataway operation until (1) a minimum of 200 ns has elapsed since generating ACL, and (2) it receives Request Inhibit in a logic “0” state.

The Serial Highway Crate Controller Type *L*-2, will proceed with its Dataway operation independently of the state of the Request Inhibit signal. After receiving the first byte of a command addressed to it, it will generate ACL in order to gain control of the crate. A Dataway operation may take place after 4 additional bytes have been received. The minimum elapsed time could be as short as 800 ns for a Serial Highway operating at its maximum data rate of 5×10^6 bytes per second in byte-serial mode.

4.1.5 Response to ACL Signal

A Controller must not initiate a Dataway operation while it is receiving the ACL signal in the logic "1" state. A Controller must complete its Dataway operation if it receives ACL at logic "1" after it has generated strobe *S*1. A Controller must release control of the crate in response to an ACL signal before the Controller generating ACL begins its Dataway operation.

A Controller releases control of the crate by either aborting or completing the Dataway operation. When used with the Serial Highway, a Controller may assume that the Serial Highway is operating at maximum speed, in which case 800 ns are allowed for completion. Alternatively, the byte clock information (see 2.3 of ANSI/IEEE Std 595-1982 or EUR 6100e), may be used to extend its control. The latter could permit the Controller to complete several Dataway operations before releasing control.

4.2 Encoded-N Signals

4.2.1 Generation of Encoded-N Signals

In order to execute a Dataway command operation, an AC must generate the binary coded station number of the addressed station on the Encoded-*N* (EN1 — EN16) lines of the ACB. As with Dataway signals, an AC must not generate the EN signals unless it has gained control of the crate. In the timing of the Dataway command operation of an AC, the time between t_0 and t_1 (See Fig 9 of ANSI/IEEE Std 583-1982 or EUR 4100e) must take into account delays caused by decoding of the EN signals in the CC.

4.2.2 Response to Encoded-N Signals

A CC must repond to the binary coded station numbers on the EN lines whenever it does not have control of the crate. In a CC, each of the Station Number codes *N*(1) through *N*(24) must be decoded to produce a signal on the corresponding Dataway line *N*1 through *N*24 with a delay of 100 ns maximum.

4.3 Look-at-Me Signals

The CC must retransmit the Look-at-Me (*L*1—*L*24) signals from the control station of the Dataway to the Auxiliary Look-at-Me (AL1—AL24) contacts of the ACB connector.

4.4 Other Signals

The Conditional Free line is reserved for use as the Byte Clock signal in Serial Highway systems.

5. The Auxiliary Controller Bus Connector and Associated Front Panel Connectors

Each Controller must have a double row post header ACB connector with 40 0.64 mm by 0.64 mm pins on 2.54 mm centers, AMP No 87272-1, AMP No 4-825457-0, 3M No 3495-1002, or an equivalent connector that is fully mateable with AMP No 86896-2 and 3M No 3417-3000. The connector body must be mounted at the rear of the Controller, above the Dataway connector. Contact 1 must be lower right (when facing the tips of the pins), and there must be an indication at the rear of the controller that this is so. Contact 1 must be located 130.4 mm to 133.4 mm above the Dataway plug horizontal datum. Note however that (1) no part of the connector shall extend beyond 188.6 mm above the Dataway plug horizontal datum, and (2) any portion of the connector below 126.6 mm from this datum must be contained within the 290 mm maximum horizontal dimension of the plug-in. (see Figs 4 and 5 of ANSI/IEEE Std 583-1982 or EUR 4100e.) The assignment of the signal lines of the ACB is given in Table 2.

A Controller which uses the Request/Grant protocol to gain control of the crate must have, in addition, three coaxial connectors Type 50CM (see ANSI/IEEE Std 583-1982 or 4.1 of EUR 5100e) on the front panel. The three connectors must be labeled and used as follows:

1) There must be a connector for the Request signal output. This signal must be the same at all times as the Request signal on the ACB.
2) There must be a connector for the Grant-In signal input.
3) There must be a connector for the Grant-Out signal output.

Table 2—Contact Assignments on Auxiliary Controller Bus Connector*

Contact	Usage	Contact	Usage
1	Ground (OV)	2	Encoded-*N* EN1
3	Encoded-*N* EN2	4	Encoded-*N* EN4
5	Encoded-*N* EN8	6	Encoded-*N* EN16
7	Ground (OV)	8	ACL
9	Ground (OV)	10	Conditionally Free
11	Ground (OV)	12	Request RQ
13	Ground (OV)	14	Request Inhibit RI
15	Ground (OV)	16	AL1
17	AL2	18	AL3
19	AL4	20	AL5
21	AL6	22	AL7
23	AL8	24	AL9
25	AL10	26	AL11
27	AL12	28	AL13
29	AL14	30	AL15
31	AL16	32	AL17
33	AL18	34	AL19
35	AL20	36	AL21
37	AL22	38	AL23
39	AL24	40	Ground (OV)

*Contact 2 is across from contact 1, contact 4 is across from contact 3, etc.

Table 3—Current Signal Standards and Pull-Up Current Sources for the Auxiliary Controller Bus Connector and Associated Front Panel Connnectors*

Signal standards at connector	Aux Cont Lockout, Request Inhibit	Aux LAM	Request Grant-In/Out	Encoded-*N* Cond Free
Line at "1" state at 0.5 V Minimum Current Sinking Capability (current drawn from line by unit generating the signal)	For CC 6.4 mA For AC 16.0 mA	3.2 mA	16.0 mA	16.0 mA
Line at "1" state at 0.5 V Maximum Load Current (current fed into line by unit receiving the signal)	0.4 mA per unit (6.4 mA maximum)	0.4 mA per unit (3.2 mA maximum)	12.8 mA	11.2 mA
Line at "0" state at 3.5 V (maximum current drawn from line by CC without sinking pull-up)	100 µA	100 µA	100 µA	100 µA
Line at "0" state at 3.5 V (minimum current fed into line by CC with sinking pull-up)	2.5 mA	2.5 mA	2.5 mA	2.5 mA
Location of pull-up for current, I_p, at 0.5 V: 6 mA $\le I_p \le$ 9.6 mA	CC	CC	Grant-In	CC

*A characteristic impedance termination is being considered for the Request line and the Request/Grant connections. This could increase the current sinking requirements noted in this table.

6. Signal Standards

Signal outputs from Controllers onto all ACB lines must be delivered through intrinsic OR gates. Each line must be provided with an individual pull-up current source to restore the line to the "0" state in the absence of an applied "1" signal. The rise and fall times at signal outputs must not be less than 10 ns, in order that cross-coupling of signals is not excessive.

Signal outputs from Controllers onto all Dataway lines must conform fully with the mandatory requirements of ANSI/IEEE Std 583-1982 or EUR 4100e.

6.1 Signal Standards on the ACB

All signals on the ACB must conform to the signal voltage standards shown in Table 5 of ANSI/IEEE Std 583-1982 or EUR 4100e and the standards for pull-up current sources in Table 3 of this standard.

The standards for pull-up current sources on the ACB are derived from Table 6 of ANSI/IEEE Std. 583-1982 or EUR 4100e and correspond with those for compatible current sinking logic devices (for example, standard TTL and DTL for units generating signals and low power Schottky TTL for units receiving signals). They also correspond with those of the SGL-Encoder connector of Serial Crate Controllers (see Section 14 of ANSI/IEEE Std 595-1982 or EUR 6100e). These standards impose an upper limit on the number of ACs in a single CAMAC crate. This limit is 8 ACs, and it is derived from the current sinking capability and load current on the AL lines. If an SGL-Encoder unit is attached to the SGL-Encoder connector it may impose a more severe restriction on the number of ACs. If some ACs do not receive the AL signals, then the limit on the number of ACs is imposed by the load current on the Dataway (see 6.3).

Table 4—Signal Standards for Q, R, and X at the Auxiliary Controller Dataway Connector

Condition at Dataway Connection	Absolute Limit
Line in “1” state at +0.5 V (maximum current fed into line by AC receiving signal)	0.4 mA
Line in “0” state at +3.5 V (maximum current drawn from line by each AC)	100 μA

6.2 Signal Standards for the ACB Associated Front Panel Signals

The Request, Grant-In, and Grant-Out front panel signals must conform to the signal voltage standards shown in Table 5 of ANSI/IEEE Std 583-1982 or EUR 4100e and the standards for pull-up current sources in Table 3 of this standard.

6.3 Signal Standards for AC Dataway Connections

All signals at the CAMAC Dataway-interface to an AC must conform to Table 6 of ANSI/IEEE Std 583-1982 or EUR 4100e, with the exception of the signals *Q*, *R*, and *X*. The *Q*, *R*, and *X* signals must conform to standards contained in Table 4 of this standard.

The signal standards for the CAMAC Dataway interface impose a limit of 12 ACs in a single CAMAC crate. However, if other units fully compatible with ANSI/IEEE Std 583-1982 or EUR 4100e receive *Q*, *R*, or *X* signals from the Dataway, then the limit on the number of ACs may be lower. Such a unit may present a current load on the Dataway as much as that of 4 ACs.

6.4 Protection of Critical Signal Inputs

The Grant-In and Request Inhibit signal inputs should be protected against spikes introduced by cross-coupling from other ACB or Dataway signal lines. This protection should be chosen in accordance with the specific design of the controller. It will usually include an integrating time constant of approximately 50 ns on the Grant-In, and an integrating time constant of approximately 50 ns that is effective on the positive-going 1-to-0 edge of the Request Inhibit input of each controller.

The purpose of this protection is to prevent more than one controller gaining control of the Dataway because of spikes or other unintentional transient signal excursions.

Annex A

(Informative)

(This Appendix is not a part of ANSI/IEEE Std 675-1982, IEEE Standard, Multiple Controllers in a CAMAC Crate.)

A.1 Specification of CAMAC Crate Controller Type A-2

A.1.1 CAMAC Crate Controller Type A-2

In order to conform with the specifications for CAMAC Controller Type *A*-2, a crate controller must have all the mandatory features defined in this Appendix. It must have no other features that would affect its interchangeability with any other Type *A*-2 Crate Controllers, taking into account the effect of such interchange on both hardware and software. It must be fully interchangeable with one conforming to Fig A-1, although it need not have identical structure, internal signals (shown without the prefix B in Fig A-1) or logical expressions.

With respect to the communications protocol via the Branch highway, Crate Controller Type *A*-2 (CCA-2) is interchangeable with Crate Controller Type *A*-1 (CCA-1) as defined in Section A1 of the Appendix of ANSI/IEEE Std 596-1982 or EUR 4600e. In practice the Branch Highway cycle times may differ because of the priority arbitration logic used by the CCA-2.

In order to accommodate the use of ACs, the CCA-2 differs from the CCA-1 by having an ACB connector, and its associated features as described in ANSI/IEEE Std 675-1982 or EUR 6500e (Sections 1-6 of this standard). Differences between this Appendix and Section A1 of the Appendix of ANSI/IEEE Std 596-1982 or EUR 4600e are indicated by a vertical bar in the left-hand margin of this Appendix.

A.1.2 Other Crate Controllers

It is recommended that other crate controllers should be interchangeable with Crate Controller Type *A*-2 in respect to those features that they have in common, although they need not have all the mandatory features of Crate Controller Type *A*-2 and may have additional features.

A.1.3 General Features

The crate controller must conform fully with the mandatory requirements of ANSI/IEEE Std 583-1982 or EUR 4100e, and ANSI/IEEE Std 596-1982 or EUR 4600e (Sections 1-7 of that standard). It is mandatory that all signal inputs at the Branch Highway ports of Crate Controller Type *A*-2 must satisfy the lower input current standard (± 0.3 mA) shown in Table 8 of ANSI/IEEE Std 596-1982 or EUR 4600e.

Crate Controller Type *A*-2 must not occupy more than three stations. It should preferably be a double-width unit that engages with the Dataway at the control station and the adjacent normal station.

In addition to the two front panel connectors for the Branch Highway ports (see Section A.1.4), the CC must have a rearmounted connector for a link to an optional separate LAM-Grader unit (See Section A.1.9).

The CC must conform fully with the mandatory requirements of ANSI/IEEE Std 675-1982 or EUR 6500e (Sections 1-6 of this standard). In addition to the rear-mounted LAM-Grader connector, the CC must have a rear-mounted connector for a link to the ACB.

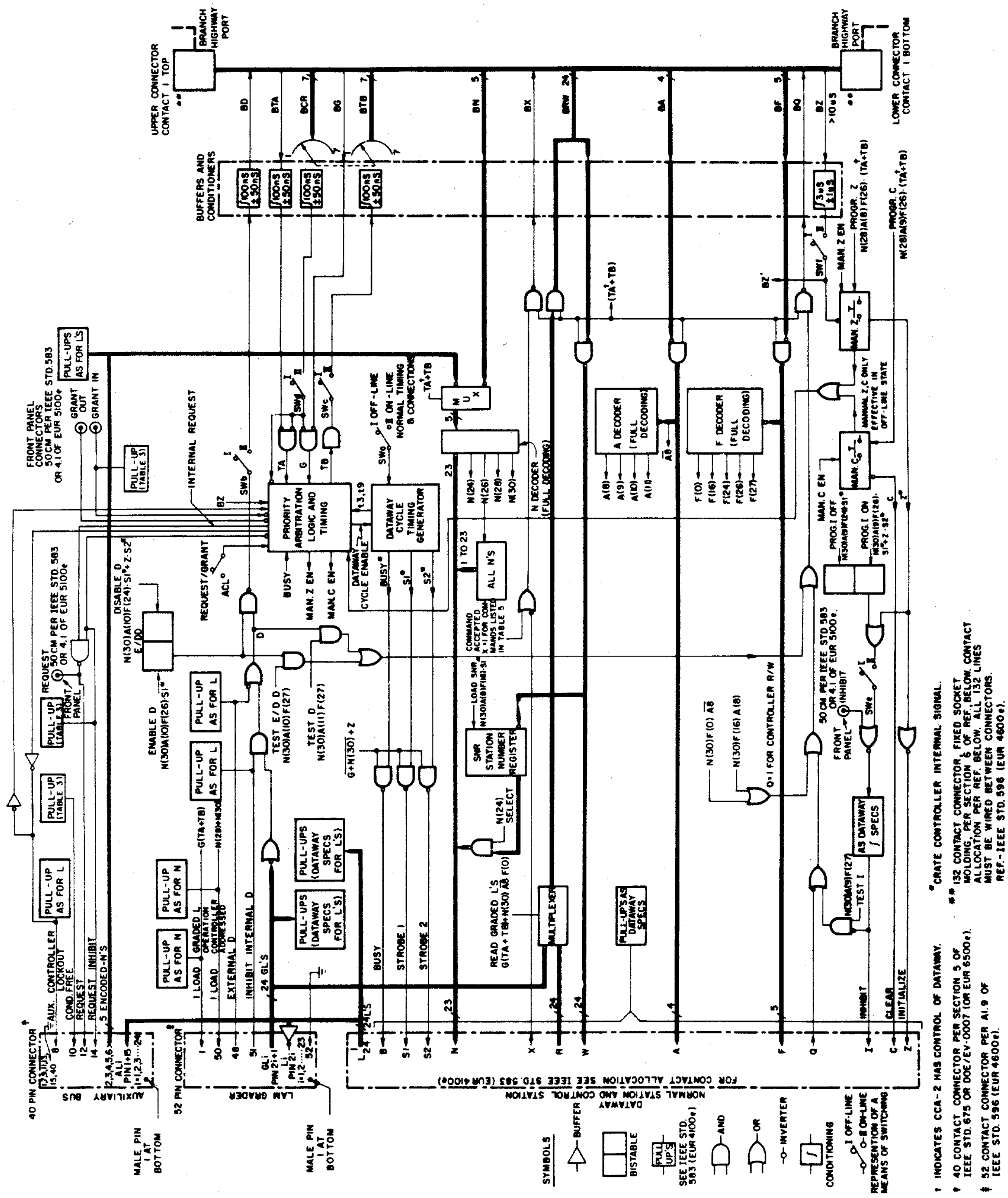


Figure A-1—CAMAC Crate Controller Type A-2 (Double Width Unit)

A.1.4 Front Panel

The CC must have all the following front panel features, and no others that would affect interchangeability (for example, the addition of indicators for test purposes is permitted).

1) There must be two connectors for Branch Highway ports, as defined in Section 6 of ANSI/IEEE Std 596-1982 or EUR 4600e, mounted with the correct orientation and with all corresponding contacts joined.
2) There must be a means of indicating the selected crate address (1–7). There may be limited access at or through the front panel to the means of changing the crate address.
3) There must be a means of selecting off-line status of the CC (see A.1.10).
4) There must be a coaxial connector for the Inhibit signal input. The type of connector is as specified in 4.2.5 of ANSI/IEEE Std 583-1982 or 4.1 of EUR 5100e. The signal standards are as specified in 7.2.1 of ANSI/IEEE Std 583-1982 or EUR 4100e.
5) There must be two push buttons, or equivalent manual controls, for Initalize and Clear. These are only effective in the off-line state, and the front panel layout or markings should indicate this.
6) There must be three coaxial connectors for the Request and Grant signals. These connectors must conform fully with the mandatory requirements of ANSI/IEEE Std 675-1982 or EUR 6500e (Section 5 of this standard).
7) There must be a means of indicating the state of the (R/G)/ACL control option (see A.1.7). There may be a limited access at or through the front panel to the means of changing this control option.

A.1.5 Dataway Signals

The Crate Controller Type *A*-2 must gain control of the crate in accordance with the mandatory requirements of 4.1 of this standard.

A.1.5.1 Data Signals

When the CC is on-line, addressed, and in control of the crate during a Read command operation with a station number other than *N*(30), it must retransmit the signals from the 24 Dataway Read lines through intrinsic OR outputs to the BRW lines. Crate Controller Type *A*-2 must have gates between the *R* and BRW lines so that this transfer of Read data occurs only when the crate controller is on-line, addressed, and in control of the crate, for example when $BCR_i \cdot (BTA + \overline{BTB}_i) = 1$.

During Write operations with station number other than *N*(30) it must retransmit the signals from the 24 BRW lines to the Dataway Write lines. Crate Controller Type *A*-2 must have gates between the BRW and *W* lines so that this transfer of Write data occurs only when the crate controller is addressed, on-line, and in control of the crate.

The gates between the *R* and *BRW* lines and between the BRW and *W* lines may further limit the transfers to Read operations $\overline{BF16}\cdot\overline{BF8} = 1$ and Write operations $BF16\cdot\overline{BF8} = 1$, respectively. However, the CC is permitted to generate signals on the Dataway Write lines during any operation for which it has control, but other units connected to the Dataway can only rely on the presence of such signals during Dataway Write operations.

A.1.5.2 Command Signals

The Branch Highway command signals BN, BA, and BF should be conditioned in the crate controller, for example, by integration or by staticizing at a time related to BTA 0→ 1 (the 0 to 1 transition of BTA), in order to protect the Dataway command lines from the effects of crosstalk into Branch Highway command lines.

The subaddress and function signals from the BA and BF lines must be retransmitted by the CC on the Dataway *A* and *F* lines during all command mode operations when the controller is on-line, addressed, and in control of the crate.

In a double-width CC each of the Station Number codes *N*(1) through *N*(23) must be decoded in the CC to produce a signal on the corresponding Dataway line *N*1 to *N*23. The Station Number code must be decoded from the BN lines of the Branch Highway port connector whenever the CC is in control of the crate in response to a Branch Highway operation. At all other times the Station Number codes must be decoded from the EN lines of the ACB connector.

Station Number codes *N*(26) through *N*(30) received from the Branch Highway port connector (but not necessarily the ACB connector) must be decoded to address internal features of the CC.

Command operations with *N*(26) must generate Dataway signals on all the lines *N*1 through *N*23. Command operations with *N*(24) generate Dataway signals on *N*1 through *N*23 as determined by the contents of 23 bit Station Number Register (SNR). This register is loaded from BRW1-BRW23 by the command $N(30)\cdot A(8)\cdot F(16)$. The bit of the SNR that is loaded from BRW1 controls the state of *N*1, etc. The register is not reset by the Dataway Initialize signal *Z*.

A triple-width controller may alternatively have a 22 bit SNR decode *N*(1) through *N*(22), and generate signals on Dataway lines *N*1 through *N*22.

A.1.5.3 Common Control Signals

The Dataway Initialize signal Z must be generated in response to the command $N(28) \cdot A(8) \cdot F(26)$ and to the Branch Initialize signal (see 4.5.1 of ANSI/IEEE Std 596-1982 or EUR 4600e). It must also be generated in response to the manual Initialize control, but only when the CC is in the off-line state.

The Dataway Clear signal C must be generated in response to the command $N(28) \cdot A(9) \cdot F(26)$. It must also be generated in response to the manual Clear control, but only when the CC is in the off-line state.

The Dataway Initialize Z and Clear C signals must not be generated until the crate controller is in control of the crate and must be generated with the timing specified for unaddressed operations in ANSI/IEEE Std. 583-1982 or EUR 4100e, Fig 10. They must be associated with a sequence including B and $S2$ signals, also with the time specified in ANSI/IEEE Std 583-1982 or EUR 4100e, Fig 10. The sequence is permitted to include $S1$ but this is not mandatory, and other units connected to the Dataway must not rely on the generation of $S1$ with Z and C.

The Dataway Initialize Z signal must be generated in response to the Branch Initialize signal only when the CC is in control of the crate and the Branch Initialize signal is in the logic "1" state. (Note that Crate Controller Type *A*-2 could fail to generate Dataway Initialize Z in response to Branch Initialize while an auxiliary controller is performing continuous Dataway operations.)

The Dataway Inhibit signal I must be initiated when an on-line crate controller generates Dataway Initialize Z, and must reach a maintained "1" state not later than time t_3 (see ANSI/IEEE Std 583-1982 or EUR 4100e, Fig 10). When some other unit generates Initialize (accompanied or not by Inhibit), an on-line crate controller must not generate Inhibit in response to Dataway Z gated by $S2$. The Inhibit signal must be generated in response to the command $N(30) \cdot A(9) \cdot F(26)$. In these cases the Inhibit signal must be maintained by the crate controller until reset by the command $N(30) \cdot A(9) \cdot F(24)$. It must also be generated while the front panel Inhibit signal is present.

The command $N(30) \cdot A(9) \cdot F(27)$ must produce a $Q = 1$ response if there is a "1" state signal on the Dataway Inhibit line.

A.1.5.4 Patch Connections

Crate Controller Type *A*-2 must not use the patch pins of the Dataway stations that it occupies.

A.1.5.5 Arbitration Methods Used by the Crate Controller

Crate Controller Type *A*-2 must provide for both the R/G and ACL methods of gaining control of the crate. Either the ACL method or the R/G method will be used depending on the state of the (R/G)/ACL option control. If the state of this control is "1" the ACL method must be used. If the state of the control is "0" the R/G method must be used. When the crate controller is using the R/G method, it must respond to an ACL signal on the ACB (see 4.1.5 of this standard).

A.1.6 Demand Handling

A.1.6.1 Branch Demand

The Branch Demand signal BD must be derived, subject to the following conditions, from the OR combination of an External Demand signal from contact 48 of the LAM-Grader connector and an Internal Demand signal which is the OR of the 24 GL signals received via the LAM-Grader connector.

The output of the Branch Demand signal to the BD line must be disabled by the command $N(30) \cdot A(10) \cdot F(24)$ or by the Dataway Initialize signal Z with $S2$ when generated by the CC. It must be enabled by the command $N(30) \cdot A(10) \cdot F(26)$. The command $N(30) \cdot A(10) \cdot F(27)$ must give a $BQ = 1$ response if the output of the BD is enabled. The command $N(30) \cdot A(11) \cdot F(27)$ must give a $BQ = 1$ response if the OR of the Internal and External Demands is in the “1” state, even if the output of BD is disabled.

The Internal Demand signal must be inhibited by the “1” state of the Inhibit Internal D signal from contact 51 of the LAM-Grader connector.

A.1.6.2 Graded-L

In response to a Graded-L Request signal BG = 1, accompanied by $BCR_i = 1$, the CC must gain control of the crate. It must generate the Graded-L operation signal on contact 1 of the LAM-Grader connector. It must accept the Graded-L signals GL1-GL24 from the LAM-Grader connector and transmit them to the BRW lines (GL1 to BRW1, etc).

The crate controller must also accept the Graded-L signals from the LAM-Grader connector and transmit them to the BRW lines in response to command mode operations with $N(30) \cdot A(0\text{-}7) \cdot F(O)$ (see A.1.9.4).

In both cases the GL information must be transferred from the LAM-Grader to the BRW lines with minimum delay, and the signals must not appear on the Dataway Read lines.

A.1.6.3 Pull Up for GL and L Lines

Pull up current sources in accordance with ANSI/IEEE Std 583-1982 or EUR 4100e, Table 6, must be provided on all GL lines of the LAM-Grader connector and all AL lines of the ACB connector in the CC. The L lines of the LAM-Grader connector must be isolated from the Dataway L lines and must not be provided with pull-up current sources, thus allowing a simple LAM Grader to form wired- OR combinations of L signals without affecting the AL lines on the ACB.

A.1.7 Timing Requirements

The initiation of any operation by the CC is determined by the Branch Highway signals BCR_i, BG, BZ, and BTA and the signals associated with ACB (Request, Grant, ACL, and Request Inhibit).

Before responding to any Branch Highway operation, the crate controller must first gain control of the crate. It must initiate the process of gaining control of the crate when it detects $BCR_i = 1$. It must maintain control of the crate, by generating Request Inhibit or ACL, until it detects $BCR_i = 0$.

If the Branch Driver generates $BCR_i = 0$ between command operations, the CC will release the crate after each operation allowing auxiliary controllers to gain control (and possibly maintain control) of the crate. If on the other hand, the Branch Driver maintains $BCR_i = 1$ between command operations, then the CC will maintain control, thus allowing, for example, the execution of a block transfer with minimum delay.

In command mode operations with Station Number codes other than *N*(30), the CC generates Dataway Strobe signals *S*1 and *S*2 with timing related to that of the Branch timing signals BTA and BTB as defined in A.1.7.1.

Command operations with Station Number code *N*(30) do not generate, *S*1, *S*2, or *B* signals on the Dataway lines (see A.1.7.3).

In Graded-*L* operations there are no Dataway Strobe or *B* signals, and the timing must take into account the signal delays in any non-Dataway connections to a LAM-Grader unit. These timing requirements are defined in A.1.7.2 and A.1.9.3.

The internal timing generator of the CC must be protected against spurious signals on the BTA and BCR lines.

One method of protection, shown in Fig A-1, is to condition the incoming signals from the BTA line and the selected BCR line by integration with a time constant of 100 ± 50 ns. Another method is to condition the internal signal TA which controls the timing generator. Transitions of the BTA and BCR signals are detected by the CC after a delay (shown in Figs 3 and 4 of IEEE Std 596-1982 or EUR 4600e) due to this protection.

A.1.7.1 Command Mode Operations with Dataway S1, S2, and B.

The following timing conditions must be satisfied when the crate controller responds to a command mode branch operation which requires a Dataway operation with signals *S*1, *S*2, and B. In this section the times t_0, t_3, t_5, etc, refer to the corresponding key points on Fig 9 of ANSI/IEEE Std 583-1982 or EUR 4100e.

During Phase 1 of the operation, the Branch Driver generates the command signals BF, BA, and BN along with the signals BCR_i of the addressed CCs. The CC must initiate the process of gaining control of the crate with minimum delay when it detects the 0→1 transition of BCR_i (see Section 4 of this standard).

In Phase 2 of the operation, after actions by the Branch Driver and the CC during Phase 1, the CC detects BTA = 1, accompanied by BG = 0, BCR_i = 1, and the appropriate command signals. It must then initiate the required Dataway *N* and command signals, thus starting the Dataway operation at t_0, either when it detects BTA = 1 or at the appropriate time after it has gained control of the crate, if this occurs later (see Section 4 of this standard.)

At t_3, which is 400(+200/–0) ns after t_0, the CC must initiate the 0→1 transition of the Dataway Strobe *S*1, and the Branch timing signal transition BTB_i 1→0. At t_5, which is 200(+100/–0) ns after t_3, the 1→0 transition of the Strobe *S*1 must be initiated.

In Phase 4, the CC initiates the 0→1 transition of Strobe *S*2 at t_6, which is either when it detects BTA = 0 or when the interval $t_5 — t_6$ is 100(+100/–0) ns, if this occurs later.

At t_8 which is 200(+100/–0) ns after t_6, the 1→0 transition of *S*2 must be initiated.

At t_9, which is 100(+100/–0) ns after t_8, the CC must initiate the 1→0 transitions of the Dataway signals *N* and *B*, and must isolate the Dataway *Q* and *R* lines from the Branch Highway BQ and BRW lines respectively. It must then initiate the Branch timing signal transition BTB_i 0→1. When the CC detects BCR_i = 0, it must initiate the 1→0 transition of the Request Inhibit signal or the ACL signal if the latter is in use.

A.1.7.2 Graded-L Operations

The CC must satisfy the following timing conditions during Graded-*L* operations with BG = 1 and BCR_i = 1. In Phase 1 of the operation, the Branch Driver generates the command signal BG along with the signals BCR_i of the addressed CCs. The CC must initiate the process of gaining control of the crate with minimum delay when it detects the 0→1 transition of BCR_i. In Phase 2 it must initiate Branch timing signal transition BTB_i 1→0 within 400(+200/–0) ns after detecting BTA = 1 or 400(+200/–0) ns after gaining control of the crate, if this occurs later. At the same time it must be presenting to its BRW outputs the GL information received via the LAM-Grader connector (see A.1.9.3). In Phase 4 it must remove the GL information from its BRW outputs with minimum delay after detecting BTA = 0, and initiate the signal transition BTB_i 0→1. The CC must maintain control of the crate until it detects BCR_i = 0, and it must then initiate the 1→0 transition of the Request Inhibit signal or the ACL signal if the latter is in use.

A.1.7.3 Command Mode Operations without Dataway S1, S2, or B

Command mode operations addressed to *N*(30) are concerned with internal features of the crate controller and with reading Graded-*L* information via the LAM-Grader connector. The crate controller must not generate signals on the Dataway *S*1, *S*2, *B*, or *R* lines.

The timing of these operations must follow the requirements for command mode operations (see A.1.7.1) with the exception that the *S*1, *S*2, and *B* signals are not generated on the Dataway lines, although there may be equivalent internal signals.

A.1.8 Commands Implemented by Crate Controller Type A-2

Crate Controller Type *A*-2 must recognize and implement the commands summarized in Table A-1 and must not use any other commands. When addressed with any of these commands it must generate BX = 1. The five Function codes *F*(0, 16, 24, 26, 27) must be fully decoded in the CC.

The CC must generate BQ = 1 in response to all commands that read from or write to its registers, or the LAM-Grader connector. In Crate Controller Type *A*-2 the two commands to which this applies are *N*(30)· *A*(0-7)·*F*(0) and *N*(30)·*A*(8)·*F*(16).

A.1.9 LAM-Grader Connector

The rear-mounted connector for a link to an optional separate LAM-Grader unit must be a 52 contact Cannon Double-Density fixed member with pins (Type 2DB52P), or equivalent type fully mateable with the free member with sockets, Cannon Type 2DB52S. It must be mounted at the rear of the CC above the Dataway connectors within the area for free access (see ANSI/IEEE Std 583-1982 or EUR 4100e, Fig 3), with Contact 1 lowermost. The 52 contacts are assigned as shown in Table A-2.

The LAM Grader accepts *L* signals from the CC via the LAM-Grader connector. It generates Graded-*L* GL signals and, optionally, the External Demand signal. It may include gates, mask registers, etc, for processing the *L* signals, or may merely consist of passive interconnections between the contacts of the LAM-Grader connector. It may interact with the crate controller in the following ways:

1) Branch Demand. Crate Controller Type *A*-2 derives the Branch Demand BD signal from the Graded-*L* signals (and, optionally, the External *D* signal) which it receives via the LAM-Grader connector.
2) Graded-*L* Operations. The CC generates the Graded-*L* Operations signal on Contact 1 to indicate that it requires Graded-*L* signals.

If the LAM Grader responds to this signal it must satisfy the timing requirements of A.1.9.3.

3) Command Mode Operations. In response to Branch commands with *N*(28) or *N*(30) the CC generates the Controller Addressed signal on Contact 50. This allows the LAM Grader to be treated as a detached part of the CC that can be addressed independently of its location in the crate. The presence of Dataway Busy *B* distinguishes operations with *N*(28) from those with *N*(30). The Controller Addressed signal with Dataway *A*(0-7), but without *B*, indicates that the CC requires Graded-*L* signals. In conjunction with a Dataway operation and *B* the Controller Addressed signal may be used, for example, to access registers in the LAM Grader.

> If the LAM Grader responds to the Controller Addressed signal it must satisfy the timing requirements of A.1.9.4.
>
> The Graded-*L* Operation signal on Contact 1 must be in the logic "1" state when the CC is on-line, in control of the crate, and $(BTA + \overline{BTB}_i) \cdot BG \cdot BCR_i = 1$.
>
> The Controller Addressed signal on Contact 50 must be in the "1" state during command mode operations to *N*(28) or *N*(30) when the CC is on line, in control of the crate, and $[N(28) + N(30)] \cdot (BTA + \overline{BTB}_i) \cdot \overline{BG} \cdot BCR_i = 1$.

Equivalent conditions for the generation of these two signals, Controller Addressed and Graded-*L* operation, are shown in Fig A-1 in terms of the internal (nonmandatory) signals of a particular implementation of Crate Controller Type *A*-2.

Table A-1—Branch Commands Implemented by CAMAC Crate Controller Type A-2

Action	Command *N*	Command *A*	Command *F*	Response
Generate Dataway *Z*	28	8	26	BQ=0
Generate Dataway *C*	28	9	26	BQ=0
Read GL	30	0–7	0	BQ=1
Load SNR	30	8	16	BQ=1
Remove Dataway *I*	30	9	24	BQ=0
Set Dataway *I*	30	9	26	BQ=0
Test Dataway *I*	30	9	27	BQ=1 if I=1
Disable BD output	30	10	24	BQ=0
Enable BD output	30	10	26	BQ=0
Test BD output enabled	30	10	27	BQ=1 if BD enabled
Test demands present	30	11	27	BQ=1 if demands present

Table A-2—Contact Assignments for LAM-Grader Connector of Crate Controller Type A-2

Contact	Usage	Contact	Usage
1	Graded-*L* operation	2	*L*1
3	GL1	4	*L*2
5	GL2	6	*L*3
7	GL3	8	*L*4
9	GL4	10	*L*5
11	GL5	12	*L*6
13	GL6	14	*L*7
15	GL7	16	*L*8
17	GL8	18	*L*9
19	GL9	20	*L*10
21	GL10	22	*L*11
23	GL11	24	*L*12
25	GL12	26	*L*13
27	GL13	28	*L*14
29	GL14	30	*L*15
31	GL15	32	*L*16
33	GL16	34	*L*17
35	GL17	36	*L*18
37	GL18	38	*L*19
39	GL19	40	*L*20
41	GL20	42	*L*21
43	GL21	44	*L*22
45	GL22	46	*L*23
47	GL23	48	External *D*
49	GL24	50	Controller Addressed
51	Inhibit Internal *D*	52	Ground (OV)

All mandatory timing requirements refer to signal conditions at the LAM-Grader connector on the CC. The interval between the initiation of a signal by the CC and the receipt of an established response from the external unit thus includes delays due to both the external unit and its linking cable.

A.1.9.1 Signal Standards

All signals via the LAM-Grader connector must satisfy 7.1 of ANSI/IEEE Std 583-1982 or EUR 4100e. This signal standard for *N* signals applies to the Graded-*L* operation signal on Contact 1, and also to the Controller Addressed signal on Contact 50. All other signals including External *D* on Contact 48 and Inhibit Internal *D* on Contact 51, follow the standard for *L* signals.

A.1.9.2 Timing — Branch Demand

The maximum overall delay between the time when an *L* signal at the control station of the CC reaches a maintained "1" or "0" state and the time when the BD signal at the Branch Highway port of the same CC reaches a corresponding maintained "1" or "0" state is defined in 4.4.1 of ANSI/IEEE Std 596-1982 or EUR 4600e. When the CC is used in conjunction with an external LAM Grader the component of this delay due to the CC must not exceed 250 ns.

A.1.9.3 Timing — Graded-L Operations

The interval between the generation of the Graded-*L* operation signal, accompanied by *L* signals, and the establishment of corresponding Graded-*L* signals must not exceed 350 ns.

A.1.9.4 Timing — Command Mode Operations

The interval between the generation of the Controller Addressed signal (accompanied by *L* signals, and in conjunction with Dataway signals *F*(0), *A*(0–7), *B* = 0) and the establishment of corresponding Graded-*L* signals must not exceed 350 ns.

The external unit must present identical GL information in response to the Graded-*L* operation signal and to the Controller Addressed signal with *A*(0), *F*(0), and *B* = 0. Subaddresses *A*(1–7) may be used to access different selections of GL information.

If the external unit responds to command mode operations with *N*(28)·*A*(0–15), *B* = 1, and an *F* code, it must satisfy the normal timing requirements of ANSI/IEEE Std 583-1982 or EUR 4100e for a CAMAC module and is permitted to make data transfers via the Dataway *R* and *W* lines.

A.1.10 Off-Line State

The off-line state is selected by means of the off-line manual control on the front panel of the CC. In this state the controller does not respond to command or Graded-*L* Request signals on the Branch Highway, and does not generate Branch timing or demand signals on the Highway.

The following minimum conditions must be observed in the off-line state:

1) The front panel manual controls for Initialize and Clear must be effective. (They must be ineffective in the on-line state.)
2) The front panel Inhibit signal input must continue to be effective. Dataway Inhibit must only be generated in response to the front panel Inhibit input.
3) The CC must not respond to BTA = 1. It must not generate Dataway *B, N, S*1 or *S*2 signals in response to BTA = 1 with BG = 0, or access the Graded-*L* information in response to BTA = 1 with BG = 1.
4) The CC must not generate "1" state outputs to the BTB, BD, BRW, BQ, or BX lines. An off-line crate is thus prevented from interfering with Branch operations.
5) The CC must not respond to BZ = 1.
6) The CC must not take any action that would interfere with the control or use of the Dataway by ACs.

The following additional condition is recommended in the off-line state:

7) In the absence of power to the CC, all inputs and outputs via the Branch Highway ports should be free to assume either the "0" state or the "1" state, as required by other units connected to the Branch, and should not impose abnormal current loadings.

A.1.11 Dataway Inhibit I in Off-Line State

It is mandatory in ANSI/IEEE 583-1982 or EUR 4100e (5.5.2) that units generating Initialize *Z* must also generate *I*. Units that can generate and maintain *I* must maintain *I* = 1 until specifically reset. See 5.5.2 of ANSI/IEEE Std 583-1982 or EUR 4100e. Both those requirements are met by Crate Controller Type *A*-2 in the on-line state. However, A.1.10(2) of this standard specifically prohibits the generation of *I* = 1 in the off-line state other than in response to the front panel Inhibit input. The off-line state has been defined in such a way that an AC can control the Inhibit *I* signal while the CC is off line. Section A.1.10(2) is primarily intended to prevent the generation of maintained *I* = 1 by Crate Controller Type *A*-2 when it is in the off-line state.

To be consistent with this aim:

1) Crate Controller Type *A*-2 should generate *I* as defined in A.1.5.3 and A.1.10 (and as shown in Fig A-1).
2) Any auxiliary means of generating *I* (other than ACs) in an off-line crate should conform to 5.5.2 of ANSI/IEEE Std 583-1982 or EUR 4100e by generating *I* = 1 in response to *Z*·*S*2. It should preferably maintain *I* = 1 and provide a means of resetting it.

A.1.12 Auxiliary Controller Bus Connector

Crate Controller Type *A*-2 must have a rear mounted ACB connector of the type defined in Section 5 of this standard and with the contact assignment of signal lines given in Table 2 of this standard.