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IEEE Standard Parallel Highway Interface System (CAMAC*)

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IEEE Standard Parallel Highway Interface System (CAMAC*)

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

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Foreword

[This foreword is not a part of IEEE Std 596-1976, Parallel Highway Interface System (CAMAC).]

The interface system on which this standard is based was developed by the ESONE Committee of European Laboratories with the collaboration of the NIM Committee of the U. S. Energy Research and Development Administration (ERDA). This standard is supplementary to IEEE Std 583-1975 Modular Instrumentation and Digital Interface System (CAMAC), and is based on ERDA Reports TID-25876, March 1972 (corresponding to ESONE Report EUR 4600e) and TID-25877. The mandatory features in this standard are identical to those in the preceeding reports and in the corresponding publication of the International Electrotechnical Commission (IEC) that is currently being processed. A serial highway interface system, also intended for use with IEEE Std 583-1975, is defined in IEEE Std 595-1976, Serial Highway Interface System.

This standard was reviewed and balloted by the Nuclear Instruments and Detectors Committee of the IEEE Nuclear and Plasma Sciences Society. Because of the broad applicability of this standard, coordination was established with numerous IEEE Societies, Groups, 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.

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IEEE Standard Parallel Highway Interface System (CAMAC*)

1. Introduction

The Dataway defined in IEEE Std 583-1975, Modular Instrumentation and Digital Interface System, is the basis for all CAMAC* systems. It provides the means of interconnection between modules and a crate controller within one crate. This standard defines the CAMAC Parallel Highway Interface System for interconnecting up to seven CAMAC crates (or other devices) and a system controller. The Parallel Highway, so called because the data bits are transmitted along the Highway in parallel, is capable of handling higher data rates than nonparallel highways. However, in some applications, for example, where there are long distances between crates or where simplicity of interconnections is particularly important, the Serial Highway of IEEE Std 595-1976, Serial Highway Interface System (CAMAC), may be more suitable.

This standard defines the signals, timing, and logical organization of the connections from crate controllers and Parallel Highway Drivers to the Parallel Highway through a standard connector. The internal structures of crate controllers and Parallel Highway Drivers, and the physical construction of the Parallel Highway System are defined only where they affect compatibility between parts of the system.

An appendix defines in more detail those features of the crate controller that affect hardware and software compatibility. The appendix can be used as a formal specification of a standard crate controller, Crate Controller Type A-1 (CCA-1), or as a general recommendation to promote uniformity between crate controllers.

Since a number of Parallel Highways can be used to assemble a large system (as discussed in Section 3), a CAMAC Parallel Highway, together with its connected equipment and its

Driver, is designated a CAMAC Branch. The CAMAC Parallel Highway Driver is thus commonly referred to as the CAMAC Branch Driver. Associated terms are Branch Demand, Branch Address, Branch Initialize, Branch operation, etc. The use of these designations is continued in this standard. Where the meaning is clear, shortened terms, usually with the prefix CAMAC omitted, are also used.

2. Interpretation

This standard is a reference text describing and defining the CAMAC Parallel Highway Interface System (CAMAC Parallel Highway System). It should be read in conjunction with, and is supplementary to, IEEE Std 583-1975. No part of this standard is intended to supersede or modify IEEE Std 583-1975.

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

Mandatory clauses of the specification are enclosed in a box, as here, and usually include the word *must*.

Definitions of recommended or preferred practice (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 specification of the CAMAC Parallel Highway System, 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 IEEE Std 583-1975.

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Section A1 of this standard's appendix defines Parallel Crate Controller Type A-1 in such a way that operationally interchangeable units can be produced by different manufacturers. See Section A1.1 of the Appendix regarding conforming with the specification of the CAMAC Crate Controller Type A-1.

The single letter designations *A*, *B*, *C*, *D*, and *E* (prefixed in some cases by "CC") are reserved for future use in connection with this standard and are not to be used until assigned.

In order to be *compatible* with the CAMAC Parallel Highway System, equipment need not satisfy all the mandatory requirements but must not interfere with the full operation of all the features of the Parallel Highway System and crate controllers (including Type A-1) as defined in this standard.

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

3. The Branch

A multicrate CAMAC system consists of one or more *Branches*, each having a *Branch Highway* which is the means of interconnection between a *Branch Driver* and *crate controllers*. During each *Branch operation* the Branch Driver can communicate with a maximum of seven crate controllers. All Branch Drivers and crate controllers have standard *Branch Highway ports*¹ by which they are connected to the Highway. Each port consists of a 132-contact connector (for 65 signals and their individual return lines, plus cable shield) with defined contact allocations and signal conventions. Each crate controller has two identical internally linked ports in order to allow the Branch to have the chain configuration shown in Fig 1. Other configurations are possible, such as that shown in Fig 2, where the Branch Driver is not

¹ In the sense that a *port* is 'an entrance or exit of a network, etc.'

IEEE STANDARD PARALLEL HIGHWAY

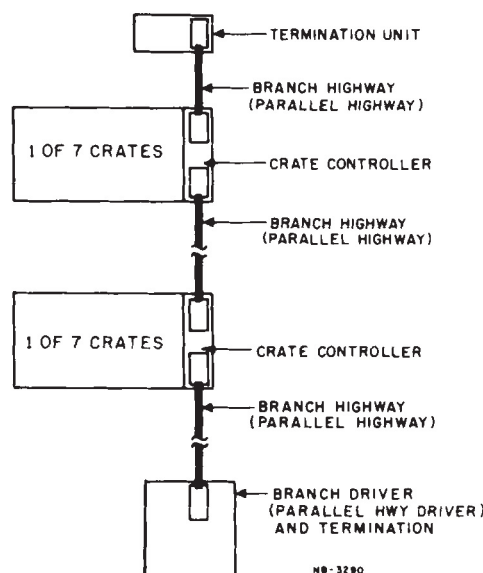
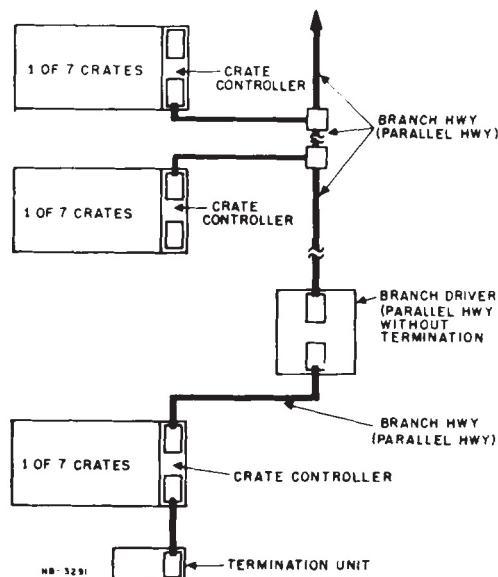


Fig 1
CAMAC Branch: Chain Configuration

at the end of the Branch and some crates are connected by only one port.

In addition to their normal *on-line* state, crate controllers have an *off-line* state which allows them to remain physically connected to the Branch while ignoring (and not impeding) all Branch operations. If required, the Branch Driver can recognize which crate addresses are associated with on-line crate controllers.

Fig 2
CAMAC Branch: Example of an Alternative Configuration



The basic mode of operation of the Branch is the *command mode*. The Branch Driver, which is typically associated with a system controller or computer, issues a command during each Branch operation. This command includes crate address information to select one or more crate controllers. Each addressed crate controller accepts the command from the Branch Highway and generates the corresponding Dataway command (station number, subaddress, and function). During *read* operations data signals are generated by a module on the Dataway Read lines, transferred to the data lines of the Branch Highway by the crate controller, and accepted by the Branch Driver. During *write* operations the Branch Driver generates data signals on the Branch Highway, and these are transferred to the Dataway Write lines by the crate controller, and accepted by a module. During other command operations there is no transfer of read or write data via the Branch Highway.

The Branch has two *demand handling* features which allow the Branch Driver to respond to Look-at-Me (LAM) signals from modules. For single-level demand handling, which merely indicates the presence of demands without identifying them, the crate controllers combine the LAM signals to form a common *Branch Demand* signal. For multilevel demand handling, which allows the Branch Driver to identify twenty-four different demands, there is the *Graded-L mode* of Branch operation. The Branch Driver issues a Graded-L Request (typically as the result of receiving the Branch Demand signal) and each on-line crate controller responds by selecting or rearranging its LAM signals to form a 24 bit Graded-L word. The Graded-L words from all crates are combined on the Branch Highway and presented to the Branch Driver.

At a Branch Highway port the *Data* lines are used in the command mode for information transfers in either direction between crate controllers and the Branch Driver. These lines are also used to convey the pattern of demands in the Graded-L mode.

Transfers in either mode through a Branch Highway port are controlled by interlocking *timing signals*, which automatically adjust the timing of each Branch operation to suit the actual transmission delays and controller performance that are encountered.

Initialize is the only *common control* signal that is transmitted through the Branch Highway port to the Dataway.

Highway Length Limitations (Supplementary Information). The standard Branch Highway uses a single-ended (unbalanced) mode of signal transmission. This mode gives reliable transmission in systems where the total length of the Highway is not excessive. The Branch Highway length can be extended considerably by the use of single-ended to balanced converters. This subject is discussed in Section A2 of the appendix.

4. Use of Lines at a Branch Highway Port

Each line at a Branch Highway port 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. Lines at a port are distinguished from corresponding lines in the Dataway by the prefix *B*, for example, the function code is carried by *F* lines in the Dataway and *BF* lines at a Branch Highway port.

4.1 Command

The command signals are used to control operations in the command mode, at which time the signal on the *BG* line (see Section 4.4.2) must be in the 0 state. They are transmitted by the Branch Driver on the *BCR*, *BN*, *BA*, and *BF* lines at the Branch Highway port (see following text).

4.1.1 Crate Address *BCR1*—*BCR7*

The seven crate controllers that can be addressed during any Branch operation must each be associated with a different *BCR* line (although all Branch Highway ports have provision for all seven *BCR* lines).

Each crate controller must therefore include means, such as a switch or patch connection, for selecting the appropriate *BCR* line (referred to as *BCR_i*). The assignment of *BCR* lines to crates is not necessarily related to the physical arrangement of

Table 1
Signal Lines at Branch Highway Ports

	Title	Designation	Generated by	Signal Lines	Use
Command	Crate Address	<i>BCR1 — BCR7</i>	Branch Driver	7	each line addresses one crate in the branch
	Station Number	<i>BN1, 2, 4, 8, 16.</i>	Branch Driver	5	binary coded station number
	Subaddress	<i>BA1, 2, 4, 8.</i>	Branch Driver	4	as on Dataway <i>A</i> lines
	Function	<i>BF1, 2, 4, 8, 16.</i>	Branch Driver	5	as on Dataway <i>F</i> lines
Data	Read/Write	<i>BRW1 — BRW24</i>	Branch Driver <i>W</i> or Crate Controller <i>R, GL</i>	24	for Read data, Write data, and Graded- <i>L</i>
Status	Response	<i>BQ</i>	Crate Controller	1	as on Dataway <i>Q</i> line
	Command Accepted	<i>BX</i>	Crate Controller	1	as on Dataway <i>X</i> line
Timing	Timing <i>A</i>	<i>BT A</i>	Branch Driver	1	indicates presence of command, etc
	Timing <i>B</i>	<i>BTB1 — BTB7</i>	Crate Controller	7	each line indicates presence of data, etc, from one crate controller
Demand Handling	Branch Demand	<i>BQ</i>	Crate Controller	1	indicates presence of demand
	Graded- <i>L</i> Request	<i>BG</i>	Branch Driver	1	requests Graded- <i>L</i> operation
Common Control	Initialize	<i>BZ</i>	Branch Driver	1	as on Dataway <i>Z</i> line
Reserved		<i>BV6 and BV7</i>		7	for future requirements
Free		<i>BV1-BV5</i>		5	for non-standard user requirements

NOTE: An individual return line is provided for each signal line. Two lines are provided for a connection to the shield, if any, of the Branch Highway cable.

Table 2
Station Number Codes Used in Crate Controllers

<i>N</i> Code	Use	<i>B, S1, and S2</i>	Remarks
<i>N</i> (0)	reserved		
<i>N</i> (1) — (23)	address the corresponding normal station	yes	normal stations occupied by the controller need not be addressed
<i>N</i> (24)	address preselected normal stations	yes	
<i>N</i> (26)	address all normal stations	yes	
<i>N</i> (28)	address crate controller only	yes	
<i>N</i> (30)	address crate controller only	no	no Dataway operation
<i>N</i> (25, 27, 29, 31)	reserved		

crates within the Branch. The Branch Driver is permitted to generate signals simultaneously on more than one *BCR* line in order to select several crates for the same operation.

It is recommended that the crate controller should include a means of protection against spurious signals on the selected *BCR* line. For example, the incoming *BCR* signal or an

internal signal derived from it may be conditioned by integration.

It will be seen later, in Section 4.3, that each crate controller is associated with not only one of the *BCR* lines but also the corresponding one of seven *BTB* lines.

The Branch is not in a valid operating condition if more than one on-line crate controller is connected to the same *BCR* line. A means of reducing the risk of this occurring is suggested in Section 5.4.

4.1.2 Station Number BN1, 2, 4, 8, 16

Signals on these five lines indicate the binary coded station number to be used within the selected crate or crates, and are decoded in the crate controller. In a crate controller the 32 codes are allocated as shown in Table 2.

At least one normal station is occupied by the crate controller, and there are station number codes to address the remaining 23 normal stations individually. In addition there are codes to multiaddress all normal stations or those stations indicated by the contents of a *Station Number Register* (SNR). Two further station number codes address the controller and its extensions irrespective of their location in the crate.

4.1.3 Subaddress BA1, 2, 4, 8

Signals on these four lines must be retransmitted on the Dataway Subaddress lines (A1, 2, 4, 8) by an addressed crate controller whenever it is on line during a command mode operation.

4.1.4 Function BF1, 2, 4, 8, 16

Signals on these five lines must be retransmitted on the Dataway Function lines (F1, 2, 4, 8, 16) by an addressed crate controller whenever it is on line during a command mode operation.

4.2 Data and Status**4.2.1 Read and Write BRW1 — BRW24**

These twenty-four lines are used in command mode read operations to transmit data from the addressed crate controllers to the Branch Driver, with *BRW1* corresponding to the Dataway *R1*, etc. They are also used in command mode write operations to transmit data from the Branch Driver to the crate controllers, with *BRW1* corresponding to the Dataway *W1*, etc. In the Graded-*L* mode they are used to transmit the pattern of demands from all on-line crate controllers in the Branch to the Branch Driver. The generation of 1 state

outputs to these lines is restricted to Branch Drivers during command mode write operations and to addressed on-line crate controllers during Graded-*L* operations and command mode read operations.

4.2.2 Response BQ

During a command mode operation with an associated Dataway operation each crate controller that is on line and addressed must generate *BQ* corresponding to Dataway *Q* ($BQ = Q$). During a command mode operation that tests the status of a feature of the crate controller, without a Dataway operation, the crate controller must generate the appropriate *BQ* response. At all other times crate controllers must generate $BQ = 0$. The signal on the *BQ* line at the Branch Driver is the OR combination of the signals from all crate controllers.

4.2.3 Command Accepted BX

During a command mode operation with an associated Dataway operation each crate controller that is on line and addressed must generate *BX* corresponding to Dataway *X* ($BX = X$). During all other command operations the crate controller must generate $BX = 1$, if it accepts the command and $BX = 0$ if it does not accept the command. The signal on the *BX* line at the Branch Driver is the OR combination of the signals from all crate controllers.

4.2.4 Command Accepted BX Response to Graded-*L* Request BG. The generation of *BX* by Crate Controller Type A-1 is fully defined for command mode operations (Sections 4.2.3 and A1.8). Graded-*L* operations, however, are generally multiaddressed, in which case the *BX* signal at the Branch Driver is an unreliable indication that all crates have responded to the operation. Therefore, the Command Accepted *BX* response to a Graded-*L* Request *BG* is not defined. For the guidance of designers, it is recommended that:

- (1) When Crate Controller Type A-1 is addressed in a Graded-*L* operation, it should generate $BX = 0$
- (2) During a Graded-*L* operation the Branch Driver should not respond to the state of the *BX* line.

4.2.5 Command Accepted X and BX Disabling (Supplementary Information). CAMAC computer interfaces, whether crate controllers or Branch Drivers, that include provisions for monitoring the Command Accepted X or BX response should also include a mode of operation in which an X (or BX) = 0 response does not result in an automatic system alarm. This mode is necessary to permit "normal" operation of a system that includes early plug-in units that do not have provision for generating or transmitting the Command Accepted signals. Such plug-in units always "respond" with $X = 0$. When performing an Address Scan block transfer the combination $Q = 0$, $X = 0$ should not result in an automatic system alarm.

4.3 Timing BTA , BTB_1 — BTB_7

The timing of all command mode and Graded- L Branch operations is controlled by Branch timing signals. The Branch Driver initiates operations by signals on the common BTA line, and each addressed crate controller responds with a signal on its individual BTB line. All seven BTB lines are provided at each Branch Highway port, but each crate controller uses the line BTB_i , corresponding to the line BCR_i , by which it is addressed.

Each on-line crate controller must generate $BTB_i = 1$ when it is not addressed. The Branch Driver (and other crate controllers) can thus distinguish between BTB lines associated with on-line crates ($BTB_i = 1$) and off-line or absent crates ($BTB_i = 0$) (see Section 5.4).

The Branch Driver generates $BTA = 1$ to indicate that it is presenting a command or Graded- L request at its port, and maintains the signal until it has accepted the resulting BRW or BQ information. Each crate controller generates $BTB_i = 0$ when it has established data or BQ information during Branch operations.

The timing signals must be generated through intrinsic OR outputs and must have 10-90 percent signal transition times in the range 100 ± 50 ns.

It is recommended that the crate controller should include a means of protection against spurious signals on the BTA line. For example, the incoming BTA signal or an internal signal

derived from it may be conditioned by integration.

The full timing sequence is described in Section 5.

4.4 Demand Handling. LAM L signals from units in any part of the Branch typically demand that an appropriate command or sequence of commands be generated. The Branch therefore has two demand handling features, one associated with the Branch Demand signal and the other with the Graded- L Request signal.

4.4.1 Branch Demand BD

Each crate controller can generate a demand signal, as any logical function of the L signals on the Dataway, through an intrinsic OR connection to the common Branch Demand line BD . No restriction is placed on the time at which the BD signal may change, and therefore its 10-90 percent transition time must be in the range 100 ± 50 ns. The delay between the time when an L signal at the control station of the crate controller reaches a maintained 1 or 0 state and the time when the BD signal at the Branch Highway port of the same crate controller reaches a corresponding maintained 1 or 0 state must not exceed 400 ns.

This maximum delay may be due partly to the crate controller and partly to some other unit involved in processing the L signals (for example, the LAM Grader associated with Crate Controller Type A-1. The maximum delay due to Crate Controller Type A-1 is defined in Section A1.9.2 of the appendix.

4.4.2 Graded- L Request BG

The Branch Driver initiates Graded- L mode operations by generating the Graded- L Request signal BG , accompanied by BCR signals to all on-line crates. Each addressed crate controller generates a 24-bit Graded- L word on the BRW lines, and the Branch Driver reads the OR combination of these words. The Dataway L signals in each crate are graded, to select the relevant signals and assign them to the appropriate bits of the Graded- L word.

The grading process may, for example, be organized so that the Branch Driver reads a