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*Computer Automated Measurement and Control

Nov 28, 1975

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Correction Sheet

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Page 5 *Insert the following listing after Table 10,*
Fig K5.4.3.5 Single Module, Single Address Block Transfers 27

Page 6 *Delete completely the following line*
Fig K5.4.3.5 Single Module, Single Address Block Transfers 27

Page 12 *Bottom right and top of page 13 delete the sentence reading:*
The fixing screw has a jacking action which can be used to draw the plug-in unit further into the crate.

Page 21 *Table 4 For Codes F(8) — F(11)*
Delete the line: Function using the *R* or *W* lines
Insert: Functions not using the *R* or *W* lines

Page 23 *Fig K5.4.1A NOTES (3)*
Delete: The method shown is probably the simplest.
Insert: (3) Some form of *L* inhibiting is required. See Section 5.4.1.3.

Page 24 *NOTE (2)*
Delete: A15
Insert: (2) Although A(15) is shown, choice of subaddress for Test Look-at-Me is arbitrary. All other subaddresses shown are those recommended in Section 5.4.1.2.

Page 25 *5.4.1.3 Last Paragraph*
Delete: 4100 C
Insert: Units conforming to this standard and to the earlier requirement in EUR 4100e (1969) can generally be used together in systems where the improved performance is not required.

Page 28 *5.4.3.4 5th line*
Delete: 0 = 1
Insert: **5.4.3.4** *Use of Q for Block Transfers: Stop-on-Word mode, Supplementary Information.* If a module contains a register intended to be accessed in Stop-on-Word mode, it generates Q = 1 on each read or write operation while the block of data is being transferred, except that it generates *Q* = 0 on the last data transfer within the block.

Page 29 *5.5.2*
The first paragraph is mandatory and should be enclosed in a block.

Page 34 *7.1.1*
This paragraph is mandatory and should be enclosed in a block.
7.1.2
The first paragraph is mandatory and should be enclosed in a block.

Page 35 *Bottom of page*
Delete: NOTE
Insert: NOTE 1:

(over)

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Page 38 *Table 7, Lower right*

Delete: 119 μA minimum

Insert: 100 μA minimum

Page 46 *Figure 5, Bottom of 5.5*

Delete: **Mounting face, commonly**

Insert: **Mounting face, commonly coincides with socket vertical datum**

Page 50 *Fig 10 Note (4)*

Delete: (4) Other times as in Fig 17

Insert: (4) Other times as in Fig 9

Page 56 *Insert:* **Table C1 (continued)**

Insert the above directly over Contact Assignments

Page 60 *Table C3* **Table C3**

Delete: **Contact Arrangement for Preferred 52 Pin Auxiliary Connector**

Insert: **Contact Arrangement for Preferred Auxiliary Connectors**

Page 65 *Note 7*

Delete: (7) Optional feature, Section *T*.

Insert: (7) Optional feature, Section D20.

Page 66 *Note 6*

Delete: (6) PG25 and PG27 are preferred power supply connectors of Appendix AC.

Insert: (6) PG26 and PG27 are preferred power supply connectors of Appendix C.

Page 72 *Table 4 For Codes F(8) — F(11)*

Delete: Functions using the *R* or *W* lines

Insert: Functions not using the *R* or *W* lines

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IEEE Standard Modular Instrumentation and Digital Interface System (CAMAC*)

Sponsor

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 583-1975, Standard Instrumentation and Digital 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 based on ERDA Reports TID-25875, July 1972 (corresponding to ESONE Report EUR 4100e) and TID-25877. The mandatory features and the dimensions in this document are identical (see note) to those in the reports mentioned above and in Publications 482 and 516 of the International Electrotechnical Commission (IEC).

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 instrumentation and interface system, coordination was established with numerous IEEE Societies, Groups, and Committees, including the Communications Society, Control Systems 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. This review and coordination resulted in valuable suggestions that have been incorporated into the standard.

At the time of approval of this standard, the membership of the Nuclear Instruments and Detectors Committee of the IEEE Nuclear and Plasma Sciences Society was as follows:

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D. E. Persyk, *Vice-Chairman* **Louis Costrell,** *Secretary*

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R. L. Butenhoff	T. R. Kohler	H. A. Thomas
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D. C. Cook	W. W. Managan	F. J. Walter
J. F. Detko	G. L. Miller	H. R. Wasson

Note: The Figs 1–11 are the same as in the earlier basic documents while those prefixed by the letter K are supplementary illustrations.

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IEEE Standard Modular Instrumentation and Digital Interface System (CAMAC*)

1. Introduction

This standard is intended to serve as a basis for a range of modular instrumentation capable of interfacing transducers and other devices to digital controllers for data and control. It consists of mechanical standards and signal standards that are sufficient to ensure physical and operational compatibility between units regardless of source.

The standard fully specifies a data bus (Dataway) by means of which instruments and other functional modules can communicate with each other, with peripherals, with computers, and with other external controllers as shown in Fig K1A. This serves to drastically reduce both the variety and quantity of interfacing required in a single installation and provides a considerable degree of computer independence. The multiplicity of computer dependent and instrument dependent interfaces shown in Fig K1B is typically replaced by a single computer dependent interface as in Fig K1C with one side of the interface speaking the computer language and the other side the standardized Dataway language. It will be noted that the Dataway is strictly a digital interface.

A single crate as shown in Fig K1A can typically accommodate up to twenty-three separate modules plus controller. Both single-crate systems and multiple-crate systems can be assembled. Fig K1D shows a multiple-crate system in which data is transferred in parallel, utilizing a parallel highway and a parallel highway driver. Fig K1E shows a serial system in which data is transferred bit or byte serial. The parallel system is especially useful where very high data rates are encountered, whereas the serial system is advantageous for industrial control and other applications where long distances are involved such that wiring cost is an important consideration. Standard parallel and serial highway configurations based on Figs K1D and K1E are being processed.

Maximum benefit is derived from using this standard as a whole. Selected portions may find application in additional areas. Other devices and buses, such as that of IEEE 488, can be readily incorporated into the system through an interfacing module.

2. Interpretation

> Statements that specify mandatory aspects of the system are enclosed in blocks such as this. They are usually accompanied by the word *must*.

The word *should* indicates a recommended or preferred practice which is to be followed unless there are sound reasons to the contrary.

The word *may* indicates a permitted practice, leaving freedom of choice to the designer.

Appendix E defines the various CAMAC categories.

3. Basic Features

This specification is intended to serve as a basis for a range of modular instrumentation capable of linking transducers and other devices with digital controllers or computers. It consists of mechanical standards and signal standards that are sufficient to ensure compatibility between units from different sources of design and production.

The basic features of the system are as follows:

(1) It is a modular system, with functional units which can be combined to form equipment assemblies.

(2) The functional units are constructed as plug-in units and are mounted in a standard crate.

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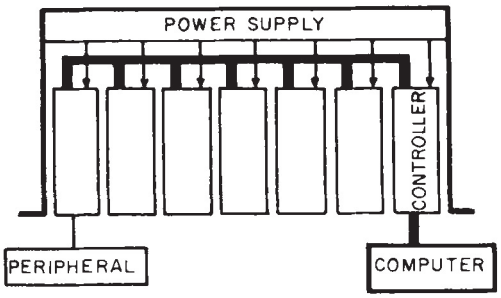


Fig K1A
Standard Arrangement. Data bus (Dataway) is heavy black line going to all modules

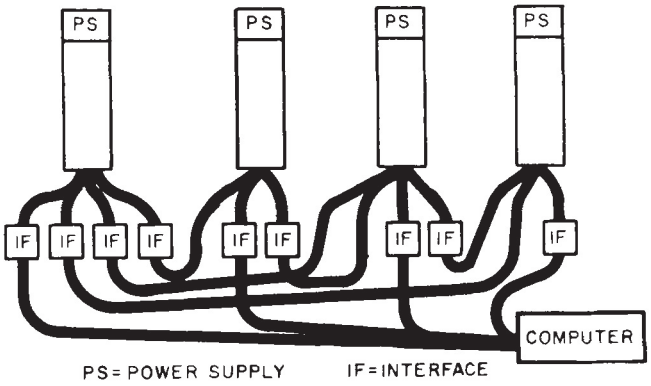


Fig K1B
Multiplicity of Interfaces Required by Nonstandard Arrangements

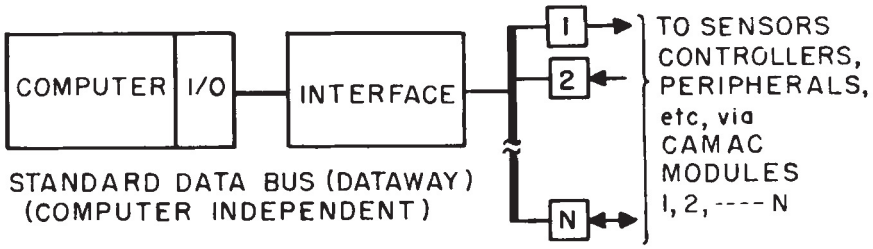


Fig K1C
Typical System With Standard Data Bus (Dataway) and Dedicated Interface

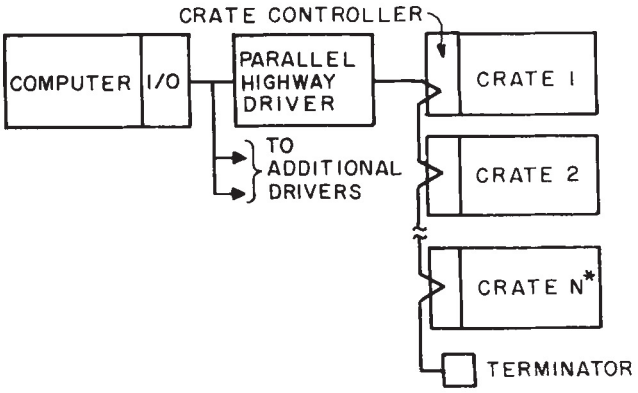


Fig K1D
Parallel Highway System
*Typically N = 7 max

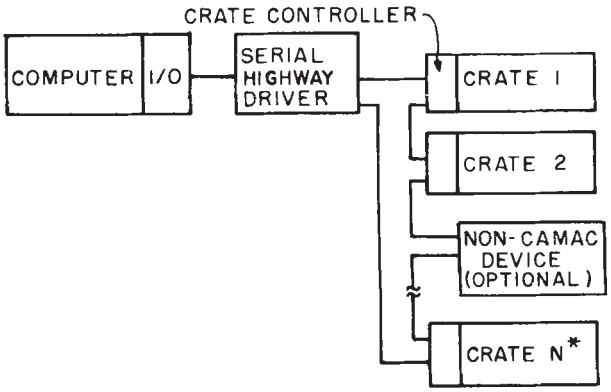


Fig K1E
Serial Highway System
*Typically N = 62 max

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(3) The mechanical structure is designed to exploit the high-component packing density possible with integrated circuit packages and similar devices.

(4) Each plug-in unit makes direct connection to a standard Dataway. This highway forms part of the crate and conveys digital data, control signals, and power. The standards of the Dataway are independent of the type of plug-in unit or computer used.

(5) The system has been designed so that an assembly consisting of a crate and plug-in units can be connected to an on-line digital computer. However, the use of a computer is entirely optional and no part of this specification depends upon its presence in the system.

(6) External connections to plug-in units may conform to the digital or analog signal standards of associated transducers, computers, etc, or to the recommended standards given in this standard.

(7) Assemblies of crates may be interconnected by means of parallel or serial highways.

(8) No license or other permission is needed in order to use this standard.

4. Mechanical Characteristics

CAMAC is a modular system. Equipment assemblies are formed by mounting appropriate plug-in units in a standard chassis or crate. Each plug-in unit occupies one or more mounting stations in the crate. At each station there is an eighty-six contact connector socket giving access to the CAMAC Dataway, a data highway which forms part of the crate. The Dataway consists mainly of bus lines for data, control, and power.

Drawings for the manufacture of CAMAC compatible crates and plug-in units can be derived from the definitive dimensions given in Figs 1-3 for crates, Fig 4 for plug-in units, and Fig 5 for Dataway connector plugs and sockets.

Recommended dimensions for ventilated crates, NIM adaptors, and printed wiring cards for plug-in units are given in the nonmandatory Figs 6-8, respectively.

All dimensions in these figures are in millimeters unless indicated otherwise.

4.1 The Crate. The crate mounts in a 19 inch rack and has up to twenty-five stations for plug-in units on a pitch of 17.2 mm. Each station has upper and lower guides for the runners of a plug-in unit, an eighty-six contact Dataway connector socket, and a tapped hole for the fixing screw of a plug-in unit. Modules conforming to the NIM specification (Type N Module of IEC Publ 482), also, ERDA Report TID - 20893 (see Bibliography) can be mounted in the crate on their basic pitch of 34.4 mm (see Section 4.3).

> Unless indicated otherwise, all crates must conform to Fig 1-3 and those parts of Fig 5 defining the connector socket.

Sections 4.1.1 and 4.1.2 are comment on these figures.

4.1.1 ***Dimensions.*** Fig 1 shows the front view of a basic twenty-five station crate which occupies the minimum height of $5U$ (U = 44.45 mm). Crates may have less than twenty-five stations, which, as indicated by Note 3 on Fig 1, need not be positioned symmetrically.

The lower cross-member has holes tapped ISO·M4 pitch 0.7 for the fixing screws of CAMAC plug-in units, and intermediate holes tapped UNC 6-32 for the lower fixing screws of NIM units. The upper cross-member may also have holes for the fixing screws of NIM units. The positions of these holes for CAMAC and NIM units, relative to the left-hand edge of the front aperture, are given in Fig 1 by the formulas for dimensions z and w, respectively.

The positions of the centers of the guides, also relative to the left-hand edge of the aperture, are given by the formula for dimension x in Fig 1. Detail A shows the entry into a guide. The dimensions of the lead-in are not specified.

Detail B gives dimensions specified for 19 inch rack-mounting equipment by the International Electrotechnical Commission in IEC Publ 297 and also specified in Electronic Industries Association Std RS - 310-B (ANSI C83.9-1972).

Fig 2 is a plan view of the lower guides in the crate. In order to remove any heat generated in the plug-in units, it is necessary to provide adequate ventilation through the bottom and top of the crate. The unobstructed area between adjacent guides, both at the top and bottom of the crate, is not permitted to be less than 15 cm^2 and should preferably be distributed over the full depth of the crate from the front cross-members to the Dataway assembly. If crates such as that shown in Fig 1 with height $5U$ (U = 44.45mm per IEC Publ 297), are mounted above or below other equipment

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(including other similar crates), it may be necessary to use intermediate deflectors, etc, to ensure adequate ventilation. Alternatively, the crate may be extended to include additional ventilation features, as described in Section 4.1.3.

Fig 3 is a sectioned side view on the offset line *d*–*d* in Fig 1, passing through the center of an upper guide and a ventilating space between lower guides. The front faces of the upper and lower cross-members constitute the vertical datum of the crate. This datum is set back from the front face of the crate by a distance *e*, typically between 3 and 4 mm, so that the front panels of plug-in units do not project beyond the front of the crate. The backs of the crate-mounting flanges are typically, but not necessarily, aligned with the datum.

The front ends of the upper and lower guides may be set back from the vertical datum. The guides extend sufficiently far toward the rear of the crate to ensure that the connector plug of a plug-in unit is guided into the entry of the connector socket.

The minimum overall depth of the crate provides mechanical protection for the Dataway assembly. The side panels are shorter than the frontal height of the crate (see dimensions *a* in Figs 1, 3, and 6, to permit the use of typical runners for supporting the crate in the rack. This reduction in height extends at least to within 25 mm of the rear face of the rack-mounting flanges of the crate.

The running surface of the lower guide constitutes the crate horizontal datum. The Dataway assembly is not permitted to extend upward more than 135 mm from this horizontal datum, so that there is unrestricted access to the upper part of the rear of plug-in units.

The positions of the connector sockets are defined with respect to the three datum lines of the crate. The center lines of the sockets are defined with respect to the left-hand edge of the front aperture by dimension *y* in Fig 1. The vertical datum of the sockets is shown relative to the vertical datum of the crate in Figs 2 and 3, and the horizontal datum of the sockets relative to the horizontal datum of the crate in Fig 3.

SUPPLEMENTARY INFORMATION: The design of the rear of the crate should be such as to protect the Dataway from damage. At the same time, in the space above the Dataway, access must be provided to the rear of the plug-in units. Fig D5 of Appendix D shows a typical interface housing unit to provide this protection and to accommodate a typical power supply. (See also Appendix D.)

4.1.2 *Dataway Connector Sockets.* The Dataway connector sockets have two rows of forty-three contacts on a pitch of 0.1 in (2.54 mm). Mandatory and recommended dimensions of the sockets are given in Fig 5, together with additional commonly used dimensions upon which the designs of many existing crates and Dataway assemblies have been based.

The vertical datum of the connector sockets is the nominal position of the leading edge of the connector plug of a plug-in unit fully inserted into the crate. The position of the vertical datum is defined in (5.5) of Fig 5 with respect to other functional features of the socket. In some commonly used sockets the plane of the mounting face coincides with the vertical datum of the connector socket, but this is not necessarily so.

The maximum forward projection of the connector socket in front of the vertical datum is shown in (5.5) of Fig 5. The shapes of the straight or curved chamfers that guide the connector plug into the socket are shown in (5.6), (5.7), (5.8) of Fig 5. Within the minimum width shown for each chamfer the angle between any tangent to the chamfer and the line of entry of the connector plug does not exceed 60°.

If the front aperture of the crate extends to the inner surface of the right-hand side panel (as in Figs 1 and 2), the adjacent connector socket cannot exceed the recommended width of 12 mm. Elsewhere, sockets up to the maximum width of 17.2 mm can be used.

The dimensions of the contacts of the connector socket are shown in (5.4) of Fig 5. The position of each edge is defined by a dimension *d*, *D* relative to the horizontal datum of the socket, and is completely independent of the positions of all other edges on both rows of contacts.

Alternatively, a connector socket with point contacts may be used, in which case the distance between each point contact and the horizontal datum of the connector socket is (2.56 + 2.54*k*) ±0.13.

4.1.3 *Optional Features of the Crate.* The height of the crate may be extended by an integral number of *U* units (*U* = 44.45 mm), in Fig

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6, in order to provide an entry for cool air, which then flows up between the guides, and an exit for any warm air that may be rising from equipment below.

A crate may have fewer than twenty-five stations. The width of the front aperture is $17.2s^{+0.3}_{-0.0}$ mm for s stations, and formulas given in Fig 1 are used for locating the guides, connector socket, etc, at each station.

Power supply units may be mounted at the rear of a CAMAC crate. The overall depth of a crate with rear-mounted power supplies may be limited by the depth of the rack. A recommended maximum depth of 525 mm is shown in Fig 3. A power supply unit is not allowed to extend upward above the maximum height of the Dataway assembly. It should not obstruct the entry or exit of the ventilating air flows in a crate such as that shown in Fig 6. The width of a rear-mounted power supply is limited to 447 mm.

4.2 Plug-In Units. Basically a plug-in unit consists of a front panel with fixing screw, top and bottom runners that slide in the guides of the crate, and an eighty-six contact Dataway connector plug. The connector plug is typically an integral part of a printed-wiring card but may be a separate male connector mounted at the rear of the plug-in unit. A plug-in unit may occupy more than one station and, if so, may have more than one set of runners and more than one connector plug.

> Unless indicated otherwise, all plug-in units must conform to Fig 4 and those parts of Fig 5 defining the connector plug.

The following sections are comments on these figures.

4.2.1 ***Dimensions.*** The horizontal datum of a plug-in unit is the edge of the lower runner. The vertical datum is the rear face of the front panel. The upper and lower parts of the rear face should be in contact with the cross-members of the crate when the plug-in unit is fully inserted. Note 4 of Fig 4 therefore requires that the upper and lower 11 mm of the rear face of the front panel be free of projections, other than the fixing screws.

Fig 4 shows the dimensions of single-width and double-width plug-in units and gives general formulas for the front-panel widths of units.

It is recommended that the fixing screw should also provide a jacking action to assist in overcoming the withdrawal forces of the connector socket. The fixing screw of a single-width plug-in unit is located on the center line of the front panel. If a multiple-width unit has only one fixing screw, and this has a jacking action, the screw should be positioned to give the most effective pull for withdrawal of the plug-in unit (hence it should be at the same station as a single connector or approximately symmetrical with respect to two or more connectors).

Above the maximum height of the Dataway assembly there can be projections at the rear of the plug-in unit, extending more than 290 mm from the vertical datum. Below this height, in order to provide clearance for the connector socket, only the connector plug is allowed to extend beyond 290 mm.

There should be adequate ventilation through the bottom and top of each plug-in unit to remove any heat generated within the unit.

4.2.2 ***Dataway Connector Plug.*** The dimensions of the connector plug are shown in (5.1), (5.2), (5.3) of Fig 5.

The full eighty-six contacts are always present and extend to the extreme edge of the plug. In order to avoid the risk of damage to the contact plating of connector sockets by exposed abrasives in the substrate of the connector plug contacts must not expose substrate.

Chamfers are provided at the top and bottom of the connector socket and are therefore not needed at the top and bottom corners of the connector plug where the maximum permitted chamfer is 1 × 1 mm. For at least 13 mm from the edge of the plug the contacts are straight and plated.

SUPPLEMENTARY INFORMATION: A chamfer of approximately 0.1 mm × 0.1 mm is preferred on the top and bottom corners of the Dataway connector plug to further reduce the possibility of momentary mismating of the edge connector with the Dataway connector socket. Mismating can result in destruction of the circuits when plug-in units are inserted in energized crates. It will be noted that the Dataway connector socket includes an entrance ramp.

The dimensions of the contacts of the connector plug are shown in (5.3) of Fig 5. The position of each edge is defined by a dimension h, H relative to the horizontal datum and is completely independent of the position of all other edges on both sides of the plug. The lowest contact on each side of the plug may be extended to the horizontal datum in order to reduce the impedance of the 0 V line.

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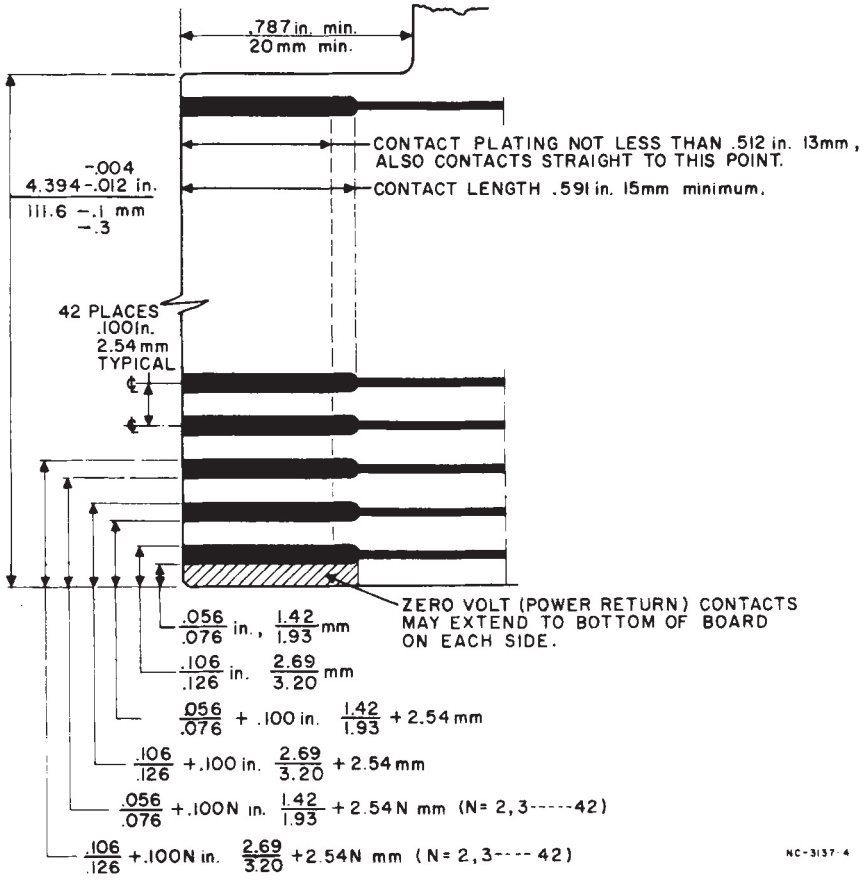


Fig K4.2.2
Typical Dataway Connector Plug

SUPPLEMENTARY INFORMATION: Fig K4.2.2 shows details of a typical Dataway connector plug derived from Figs 5 and 8.

4.2.3 ***Insertion of the Plug-In Unit into the Crate.*** In the initial stages of insertion the plug-in unit is supported by the lower guide in the crate. The upper runner, although within the guide, has some vertical clearance. When the plug-in unit is fully inserted, the connector plug is located by the connector socket, and the front panel is supported by the securing screw. The top and bottom runners are then within the guides and approximately parallel to them, but both have some vertical clearance. The transition between these two states is described in detail below.

The dimensions of the guides and runners (Figs 1 and 4) ensure that the plug-in unit moves freely and is guided so that the leading edge of the connector plug enters the chamfers of the connector socket. The lower corner of the leading edge of the plug comes into contact with the chamfer at the bottom of the connector socket. Further insertion of the plug-in unit lifts the connector plug until its lower edge rests on the horizontal datum face of the connector socket. Even a connector plug with the maximum permitted 1 × 1 mm chamfer will have been lifted into correct alignment before any electrical contact occurs between the connector plug and socket. The position of maximum insertion without electrical contact, even with a maximum thickness plug, is defined in (5.5) of Fig 5 with respect to the vertical datum of the connector socket.

Before this point has been reached it will have been possible to engage the fixing screw in the corresponding tapped hole in the lower cross-member of the crate. This can be facilitated by having a tapered end to the screw, so that the front panel is lifted into the correct alignment. The fixing screw has a jacking ac-

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tion which can be used to draw the plug-in unit further into the crate.

Further insertion of the plug-in unit brings the contacts of the plug and socket into engagement, and the insertion force of the connector is encountered. The recommended maximum insertion and withdrawal forces are 80 N for each connector plug. Forces in excess of this can cause difficulty in inserting and withdrawing the plug-in unit and can also result in damage.

Fig 5, (5.5), defines, with respect to the vertical datum of the connector socket, the line beyond which there is reliable contact between corresponding contacts on the plug and socket, even with a plug of minimum thickness.

Finally, when the plug-in unit is fully inserted in the crate, the leading edge of the connector plug is nominally at the vertical datum of the connector socket and the lower datum face of the front panel of the plug-in unit is in contact with the lower cross-member of the crate. However, the forces due to the connector socket and fixing screw are not in line and tend to lift the connector plug off the horizontal datum of the socket, in which case there may be clearance between the upper datum face of the front panel and the upper cross-member. Fig 5, (5.5), ensures that there is adequate clearance beyond the extreme position of the connector plug, by defining a minimum distance between the vertical datum of the socket and any internal obstruction.

4.2.4 *Printed-Wiring Card.* Fig 8 gives recommended dimensions for a printed-wiring card suitable for use with typical (but not necessarily all) commercially available frameworks for plug-in units conforming to this standard.

4.2.5 *Other Connectors.* Connectors or other components such as switches may be mounted on the front panel or at the rear of the plug-in unit. Rear mounted components must be located above the maximum height limit of the Dataway assembly.

For subminiature coaxial connectors the Type 50CM in accordance with Fig 12 is strongly recommended.

There may, however, be special circumstances requiring the use of other connectors in order to suit a specific external equipment with which the plug-in unit is closely associated.

SUPPLEMENTARY INFORMATION: *Digital Signal Classes and Standard Markings for Coaxial Connectors.* Appendix B provides information for the guidance of users.

Auxiliary Connectors. Preferred auxiliary connectors for some applications, together with recommended contact assignments, are described in Appendix C. These connectors are useful for communicating from and to plug-in units. This list is not intended to be restrictive since it is recognized that connectors must be suitable for the applications.

4.3 Adaptor for NIM Units. Plug-in units conforming to the NIM specification (Type N Module of IEC Publ 482) can be inserted into the guides of a CAMAC crate. In order to supply power to a NIM unit, which is shorter than a CAMAC plug-in unit, an adaptor is required between the Dataway connector socket and the connector on the NIM unit. The essential dimensions of such an adaptor are given in Fig 7.

4.4 The Dataway. Communication between plug-in units takes place through the Dataway. This passive multiwire highway is incorporated into the crate and links the Dataway connector sockets at all stations. The Dataway consists of signal lines and power lines, as shown in Table 1.

The extreme right-hand station, as viewed from the front of the crate, has the special role of control station. The data lines in the Dataway are accessible at the remaining normal stations, but not at the control station.

Most signal lines are bus lines linking corresponding contacts of the Dataway connector sockets at all normal stations and, in some cases, the control station. There are also individual lines, each linking one contact at a normal station to one contact at the control station. At each station there are contacts for unspecified uses. Two of these contacts are linked across all normal stations to form free bus lines. The remainder are available as patch contacts, but do not have specified Dataway wiring. The Dataway construction may extend these patch contacts, and others associated with the individual lines and certain bus lines, to more readily accessible patch points to which patch connections can be attached.

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Table 1
Standard Dataway Usage

Title	Designation	Contacts	Use at a Module
Command			
Station Number	*N*	1	Selects the module (individual line from control station)
Subaddress	*A* 1, 2, 4, 8	4	Selects a section of the module
Function	*F* 1, 2, 4, 8, 16	5	Defines the function to be performed in the module
Timing			
Strobe 1	*S*1	1	Controls first phase of operation (Dataway signals must not change)
Strobe 2	*S*2	1	Controls second phase (Dataway signals may change)
Data			
Write	*W*1–*W*24	24	Bring information to the module
Read	*R*1–*R*24	24	Take information from the module
Status			
Look-at-Me	*L*	1	Indicates request for service (individual line to control station)
Busy	*B*	1	Indicates that a Dataway operation is in progress
Response	*Q*	1	Indicates status of feature selected by command
Command Accepted	*X*	1	Indicates that module is able to perform action required by the command
Common Controls			*Operate on all features connected to them, no command required*
Initialize	*Z*	1	Sets module to a defined state (Accompanied by *S*2 and *B*)
Inhibit	*I*	1	Disables features for duration of signal
Clear	*C*	1	Clears registers (Accompanied by *S*2 and *B*)
Nonstandard Connections			
Free bus lines	*P*1, *P*2	2	For unspecified uses
Patch contacts	*P*3–*P*5	3	For unspecified interconnections. No Dataway lines
Mandatory Power Lines			*The crate is wired for mandatory and additional lines*
+24 V dc	+24	1	
+ 6 V dc	+ 6	1	
− 6 V dc	− 6	1	
−24 V dc	−24	1	
0 V	0	2	Power return
Additional Power Lines			*Lines are reserved for the following power supplies:*
+200 V dc	+200	1	Low current for indicators, etc
+ 12 V dc	+ 12	1	
− 12 V dc	− 12	1	
117 V ac (Live)	ACL	1	
117 V ac (Neutral)	ACN	1	
Clean Earth	*E*	1	Reference for circuits requiring clean earth
Reserved	*Y*1, *Y*2	2	Reserved for future allocation
Total		86	

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Table 2
Contact Allocation at a Normal Station
(Viewed From Front of Crate)

Bus line	Free Bus line	*P*1	*B*	Busy	Bus line
Bus line	Free Bus line	*P*2	*F*16	Function	Bus line
Individual patch contact		*P*3	*F*8	Function	Bus line
Individual patch contact		*P*4	*F*4	Function	Bus line
Individual patch contact		*P*5	*F*2	Function	Bus line
Bus line	Command Accepted	*X*	*F*1	Function	Bus line
Bus line	Inhibit	*I*	*A*8	Subaddress	Bus line
Bus line	Clear	*C*	*A*4	Subaddress	Bus line
Individual line	Station Number	*N*	*A*2	Subaddress	Bus line
Individual line	Look-at-Me	*L*	*A*1	Subaddress	Bus line
Bus line	Strobe 1	*S*1	*Z*	Initialize	Bus line
Bus line	Strobe 2	*S*2	*Q*	Response	Bus line
Twenty-four Write Bus lines		*W*24	*W*23		
*W*1 = least significant bit		*W*22	*W*21		
*W*24 = most significant bit		*W*20	*W*19		
		*W*18	*W*17		
		*W*16	*W*15		
		*W*14	*W*13		
		*W*12	*W*11		
		*W*10	*W*9		
		*W*8	*W*7		
		*W*6	*W*5		
		*W*4	*W*3		
		*W*2	*W*1		
Twenty-four Read Bus lines		*R*24	*R*23		
*R*1 = least significant bit		*R*22	*R*21		
*R*24 = most significant bit		*R*20	*R*19		
		*R*18	*R*17		
		*R*16	*R*15		
		*R*14	*R*13		
		*R*12	*R*11		
		*R*10	*R*9		
		*R*8	*R*7		
		*R*6	*R*5		
		*R*4	*R*3		
		*R*2	*R*1		
Power Bus lines	−12 V dc	−12	−24	−24 V dc	
	+200 V dc	+200	−6	−6 V dc	
	117 V ac Live	ACL	ACN	117 V ac Neutral	
	Reserved	*Y*1	E	Clean Earth	
	+12 V dc	+12	+24	+24 V dc	
	Reserved	*Y*2	+6	+6 V dc	
	0 V (Power Return	0	0	0 V (Power Return)	

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Table 3
Contact Allocation at the Control Station
(Viewed From Front of Crate)

Individual patch contact		*P*1	*B*	Busy	Bus line
Individual patch contact		*P*2	*F*16	Function	Bus line
Individual patch contact		*P*3	*F*8	Function	Bus line
Individual patch contact		*P*4	*F*4	Function	Bus line
Individual patch contact		*P*5	*F*2	Function	Bus line
Bus line	Command Accepted	*X*	*F*1	Function	Bus line
Bus line	Inhibit	*I*	*A*8	Subaddress	Bus line
Bus line	Clear	*C*	*A*4	Subaddress	Bus line
Individual patch contact		*P*6	*A*2	Subaddress	Bus line
Individual patch contact		*P*7	*A*1	Subaddress	Bus line
Bus line	Strobe 1	*S*1	*Z*	Initialize	Bus line
Bus line	Strobe 2	*S*2	*Q*	Response	Bus line
Twenty-four individual Look-at Me lines *L*1 from Station 1, etc		*L*24	*N*24	Twenty-four individual Station Number lines *N*1 to Station 1, etc	
		*L*23	*N*23		
		*L*22	*N*22		
		*L*21	*N*21		
		*L*20	*N*20		
		*L*19	*N*19		
		*L*18	*N*18		
		*L*17	*N*17		
		*L*16	*N*16		
		*L*15	*N*15		
		*L*14	*N*14		
		*L*13	*N*13		
		*L*12	*N*12		
		*L*11	*N*11		
		*L*10	*N*10		
		*L*9	*N*9		
		*L*8	*N*8		
		*L*7	*N*7		
		*L*6	*N*6		
		*L*5	*N*5		
		*L*4	*N*4		
		*L*3	*N*3		
		*L*2	*N*2		
		*L*1	*N*1		
Power Bus lines	−12 V dc	−12	−24	−24 V dc	
	+200 V dc	+200	−6	−6 V dc	
	117 V ac Live	ACL	ACN	117 V ac Neutral	
	Reserved	*Y*1	*E*	Clean Earth	
	+12 V dc	+12	+24	+24 V dc	
	Reserved	*Y*2	+6	+6 V dc	
	0 V (Power Return)	0	0	0 V (Power Return)	

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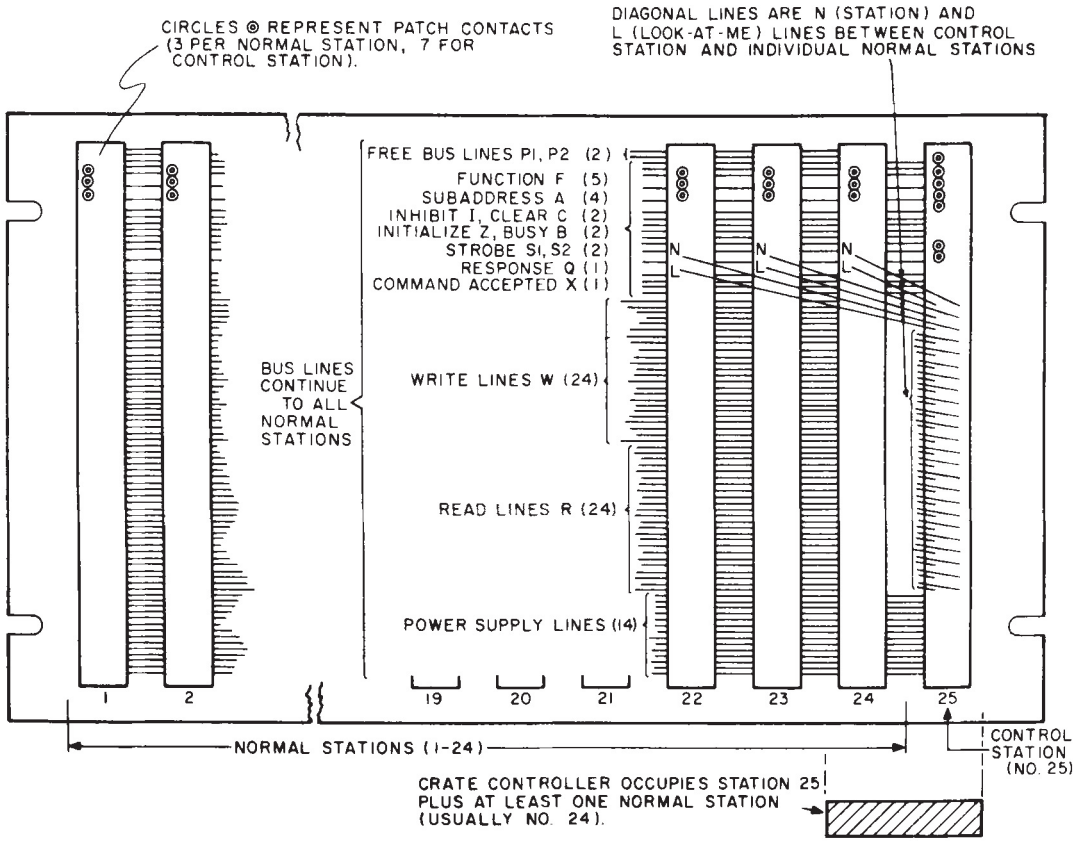


Fig K4.4
Dataway Wiring, Front View of Twenty-Five Station Crate

The power lines link corresponding contacts of the Dataway connector sockets at all stations. The power return line (0 V) links two contacts in parallel at all stations.

The assignment of contacts at the Dataway connector and their connections to bus lines, individual lines, and patch contacts must be as shown in Table 2 for normal stations and Table 3 for the control station. The control station must be to the right of all normal stations.

The method of construction of the Dataway must be consistent with the signal standards for signal lines (see Section 7) and with the maximum current loads specified for the power lines (see Section 8).

Apart from this, the construction of the Dataway is not specified. Appropriate techniques include printed wiring on flexible or rigid substrates (with and without ground planes) and soldered or wrapped wiring. Particular attention should be given to the cross-coupling between signal lines, and to their capacitance to ground. Relatively high voltages may be encountered on three power lines (+200 V dc, 117 V ac live, and 117 V ac neutral). See also Supplementary Information in Section 8 regarding avoidance of use of these high voltages.

SUPPLEMENTARY INFORMATION:

Dataway Wiring. Fig K4.4 shows the Dataway wiring in a crate with twenty-five stations. The twenty-four normal stations (station numbers 1–24) of the crate are wired identically. The wiring of the control station (number 25) is different from that of the normal stations. Since a crate controller must have access to the Read *R* and Write *W* bus lines, it must occupy at least one normal station in addition to the control station.

The Dataway lines (and contacts) fall into the four categories described below:

(1) *All Station Bus Lines* linking corresponding Dataway connector contacts at all stations, including the control station. There are thirty-one such bus lines as follows:

Function lines *F*	5	Busy *B*	1
Subaddress lines *A*	4	Response *Q*	1
Inhibit *I*	1	Strobe *S1*, *S2*	2
Clear *C*	1	Command Accepted *X*	1
Initialize *Z*	1	Power Supply lines	14

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(2) *Normal Station Bus Lines* linking corresponding Dataway connector contacts at all normal stations, but not connected to the control station. There are fifty such bus lines as follows:

Write lines W	24
Read lines R	24
Free bus lines $P1$, $P2$	2

(3) *Individual Lines* between the control station and each normal station. There are two such lines for each normal station, the N line (Station Number line), by which the control station addresses specific normal stations, and the L line (Look-at-Me line), by which specific stations advise the control station that they desire attention. Thus twenty-four N lines and twenty-four L lines connect to the control station.

(4) *Patch Contacts* (for each Dataway station) that are not connected to the Dataway and are thus available for patch connections. There are three patch contacts for each normal station and seven for the control station.

Dataway Patch Contact Terminals. It is mandatory that patch contacts (such as wire-wrap terminals) be provided for $P3$–$P5$ of normal stations and $P1$–$P7$ of the control station. In addition, it is preferred practice to have such contact terminals provided also for I, C, and the 0 V (Power Return) buses and for each N and L line.

5. Use of the Dataway Lines

Each line of the Dataway must be used in accordance with the mandatory requirements detailed in the following sections and summarized in Table 1.

A typical Dataway operation involves at least two plug-in units, one of which acts as a controller and the other as a controlled module. In this standard the terms controller and module have the following specific meanings. Controller refers to a unit occupying the control station and at least one normal station. Module refers to a unit occupying one or more normal stations. Both receive signals from some Dataway lines and generate signals on others in accordance with the definitions given in Appendix A. (In practice there can be special cases of units that combine some properties of a controller with some properties of a module).

There are two types of Dataway operations. During *command operations* the controller generates a command consisting of signals on individual Station Number lines to specify one or more modules, on the Subaddress bus lines to specify a subsection of the module, and on the Function bus lines to specify the operation to be performed. During *unaddressed operations* there is no command, but the controller generates one of the common control signals on the Initialize or Clear bus lines, and this operates on all modules connected to the bus line. During command operations and unaddressed operations the controller generates a signal on the Busy bus line. The Busy signal is available at all stations to indicate that a Dataway operation is in progress. Two timing signals, Strobes $S1$ and $S2$, are generated in sequence on separate bus lines during command operations. Only Strobe $S2$ is mandatory during unaddressed operations, but $S1$ may also be generated.

During a Dataway command operation there may be a read data transfer from a module to the controller, or a write data transfer from the controller to a module, or neither.

In response to a read command the addressed module establishes Read data signals which are available to the controller from the time of Strobe $S1$ onwards. In response to a write command the addressed module accepts Write data signals from the controller at the time of Strobe $S1$.

The addressed module indicates by a signal on the Command Accepted bus line whether it is able to perform the action required by the command. It may also transmit one bit of status information on the Response bus line. The controller accepts the Command Accepted and Response signals at the time of Strobe $S1$.

Any module may generate a signal on its individual Look-at-Me line to indicate that it requires attention.

Three common control signals are available at all stations, without requiring addressing by a command, in order to Initialize all units (typically after switch-on), to Clear data registers, or to Inhibit features such as data taking.

The use of each Dataway line is defined in the following sections. The relationship between signals, in order to generate specific commands, is defined in Section 6, and the electrical signal standards, including timing, are defined in Section 7.

The sequence of events during command operations is described in Section 7.1.3.1 and shown in Fig 9. The sequence during unaddressed operations is described in Section 7.1.3.2 and shown in Fig 10.

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SUPPLEMENTARY INFORMATION: *Block Transfers.* A block transfer may be defined as a specified sequence of CAMAC operations initiated by a single, more powerful command (a block transfer command). It is possible to design a large number of block transfer sequences (modes) which are compatible with this standard. However, a relatively small number of modes can accomplish nearly all block transfers which are usually needed. To enhance compatibility among modules, controllers, and software, it is recommended that only the defined modes be used.

5.1 Commands. The state of the signals on the individual Station Number lines (specifying a module or modules), the four Subaddress lines (specifying a subsection of the module) and the five Function lines (specifying the type of operation) constitute a command.

The command signals are maintained for the full duration of the Dataway operation. They are accompanied by a signal on the Busy bus line, which indicates to all units that a Dataway operation is in progress.

Plug-in units must not rely on the state of signals on the Subaddress and Function lines when no command operation is in progress.

5.1.1 *Station Number N*

Each normal station is addressed by a signal on an individual Station Number line N_i which comes from a separate contact at the control station (see Tables 2 and 3). The stations are numbered in decimal from the left-hand end as viewed from the front, beginning with Station 1 (addressed by $N1$).

There is no restriction on the number of stations that can be addressed simultaneously.

5.1.2 *Subaddress A8, A4, A2, A1*

Different sections of a module are addressed by signals on the four A bus lines. These signals are decoded in the module to select one of up to sixteen subaddresses, numbered in decimal from $A(0)$ to $A(15)$.

The subaddress may be used to select, for example, a register within the module, or a feature that is to control the Response signal Q, or a section of the module that is to be operated on by functions such as Enable, Disable, and Execute. The use made of the subaddress within a module is discussed in relation to the function codes in Section 6.

Each subaddress code used in a module must be fully decoded in the module. Full decoding means that all four Dataway Subaddress signals are used in the decoding process.

The subaddress codes are designated $A(0)$, $A(1)$, $A(2)$, $A(3)$, etc, to distinguish them from the individual Subaddress lines $A1$, $A2$, $A4$, and $A8$. For example, the Subaddress signals $A1 = 1$, $A2 = 1$, $A4 = 0$, and $A8 = 0$ represent the code $A(3)$.

5.1.3 *Function F16, F8, F4, F2, F1*

The function to be performed at the specified subaddress in the selected module or modules is defined by the signals on the five F bus lines. These signals are decoded in the module to select one of up to thirty-two functions, numbered in decimal from $F(0)$ to $F(31)$. The definitions of the thirty-two function codes are summarised in Table 4 and are detailed in Section 6 in relation to the command structure.

In some systems the controller partially decodes the Function signals in order to determine whether a data transfer is required to a module (writing) or from a module (reading). Multiple-station addressing allows operations with the same function code to be performed simultaneously in more than one module. These features depend on some standardization in the assignment of function codes.

The function codes are subdivided into three groups, involving read operations, write operations, and operations with no transfer of data. The standard function codes have defined actions in modules and controllers. There are also reserved codes, for any future additions to the standard codes, and nonstandard codes whose use is not defined in detail.

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Each function code used in a module must be fully decoded in the module. Full decoding means that all five Dataway Function signals are used in the decoding process.

The function codes are designated $F(0)$, $F(1)$, $F(2)$, $F(3)$, etc, to distinguish them from the individual function lines $F1$, $F2$, etc. For example, the Function signals $F1 = 1$, $F2 = 0$, $F4 = 0$, $F8 = 1$, and $F16 = 1$ represent the code $F(25)$.

5.2 Strobe Signals *S*1 and *S*2. During each command operation the controller generates two Strobe signals $S1$ and $S2$ in sequence on separate bus lines. In response to these timing signals plug-in units initiate various actions appropriate to the command that is present on the Dataway.

Both Strobe signals must be generated during each command operation.

Plug-in units must not take irreversible action based on the command or data signals until the time of $S1$. Actions concerned with the acceptance of data and status information from the R, W, Q, and X lines must be initiated at the time of $S1$ (with the possible exception given below). Other actions may also be timed by $S1$, but must not change the state of signals on the R and W lines.

Any actions that can change the state of Dataway Read or Write signals must be initiated by the second strobe $S2$. For example, $S2$ must be used if it is required to clear a register whose output is connected to the Dataway.

Modules normally accept write data in response to $S1$, because the data signals are permitted to change at the time of $S2$. However, modules may accept write data in response to $S2$ under special circumstances, but this is not recommended.

During unaddressed Dataway operations the controller generates Strobe $S2$ to indicate when modules accept the common control signal. Strobe $S1$ may also be generated, but this is not mandatory, and modules cannot rely on it.

Strobe $S2$ must be generated during each unaddressed operation.

5.3 Data. All information carried by the Read and Write lines is conveniently described as data, although it may be information concerned with status or control features in modules. Information that is transferred to or from a control register in a module is thus regarded as data.

Up to 24 b may be transferred in parallel between the controller and the selected module. Independent lines are provided for the read and write directions of transfer.

If the bits of a data word have different numerical significance, line R_n should be used for a higher order bit than R_{n-1}, and W_n for a higher order bit than W_{n-1}.

It is recommended that controllers have 24 b capability. For particular applications assemblies are permitted in which the controller has a word length less than 24 b and the modules have an equal or smaller word length.

Plug-in units must not rely on the state of signals on the Read and Write bus lines when no command operation is in progress.

5.3.1 *Write Lines W1-W24*

The controller generates data signals on the W bus lines during each write operation. The W signals must reach a steady state before $S1$ and must be maintained until the end of the operation, unless modified by $S2$. Strobe $S1$ must be used by the modules to strobe the data unless there are very strong technical reasons for choosing $S2$ (see Section 5.2).

The W lines serve a few data sources (typically only one controller) and many data receivers.

5.3.2 *Read Lines R1-R24*

Data signals are set up on the R bus lines by the module during a read operation. The R signals must reach a steady state before $S1$ and must be maintained for the full duration of the Dataway operation, unless the state of the data source is changed by $S2$. The controller must initiate action concerned with the acceptance of data from the R lines at the time of the Strobe $S1$ and must not take irreversible action before this.

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Table 4
The Function Codes

Code F( )	Function	Use of R and W Lines	Function Signals F16	F8	F4	F2	F1	Code F( )
0	Read Group 1 register	Functions using the R lines	0	0	0	0	0	0
1	Read Group 2 register		0	0	0	0	1	1
2	Read and Clear Group 1 register		0	0	0	1	0	2
3	Read Complement of Group 1 register		0	0	0	1	1	3
4	Nonstandard		0	0	1	0	0	4
5	Reserved		0	0	1	0	1	5
6	Nonstandard		0	0	1	1	0	6
7	Reserved		0	0	1	1	1	7
8	Test Look-at-Me	Functions using the R or W lines	0	1	0	0	0	8
9	Clear Group 1 register		0	1	0	0	1	9
10	Clear Look-at-Me		0	1	0	1	0	10
11	Clear Group 2 register		0	1	0	1	1	11
12	Nonstandard		0	1	1	0	0	12
13	Reserved		0	1	1	0	1	13
14	Nonstandard		0	1	1	1	0	14
15	Reserved		0	1	1	1	1	15
16	Overwrite Group 1 register	Functions using the W lines	1	0	0	0	0	16
17	Overwrite Group 2 register		1	0	0	0	1	17
18	Selective Set Group 1 register		1	0	0	1	0	18
19	Selective Set Group 2 register		1	0	0	1	1	19
20	Nonstandard		1	0	1	0	0	20
21	Selective Clear Group 1 register		1	0	1	0	1	21
22	Nonstandard		1	0	1	1	0	22
23	Selective Clear Group 2 register		1	0	1	1	1	23
24	Disable	Functions not using the R or W lines	1	1	0	0	0	24
25	Execute		1	1	0	0	1	25
26	Enable		1	1	0	1	0	26
27	Test Status		1	1	0	1	1	27
28	Nonstandard		1	1	1	0	0	28
29	Reserved		1	1	1	0	1	29
30	Nonstandard		1	1	1	1	0	30
31	Reserved		1	1	1	1	1	31

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The R lines serve a few data receivers (typically only one controller) and many data sources.

5.4 Status Information. Status information is conveyed by signals on the Look-at-Me L, Busy B, Response Q, and Command Accepted X lines.

5.4.1 *Look-at-Me L*

The Look-at-Me lines, like the N lines, are individual connections from each normal station to separate contacts at the control station ($L1$ from station 1, etc)

Any module may generate a signal on its individual line L_i to indicate that it requires attention. Modules that occupy more than one station may indicate different demands by signals on the appropriate L lines.

The L signal generated by a module may represent demands for attention originating from more than one Look-at-Me source (LAM source) in the module. A LAM structure by which various demands can be selected and grouped to form the L signal is shown in Fig 11 and described below. All modules that generate L have the mandatory features shown in Fig 11 and may incorporate additional features for more complex demand handling.

Individual bits of the LAM status register are set by the corresponding LAM sources, and are cleared by appropriate commands and by the initialize signal. The outputs (LAM status) may be examined collectively by reading the state of all outputs [Read Group 2 at $A(12)$], or individually by the command Test Status with the appropriate subaddress $A(i)$. Each LAM status should be individually enabled and disabled (for example by a LAM mask) to form the corresponding LAM request. The LAM requests are examined collectively by reading the state of all LAM requests [Read Group 2 at $A(14)$], or individually by the command Test LAM with the appropriate subaddress $A(i)$. The internal Look-at-Me signal (L signal), derived from the OR combination of the LAM requests, is tested by the command Test LAM, with subaddress $A(k)$ distinguishing this from tests of individual LAM requests. Finally, the output of this signal as the Dataway L signal is inhibited while the module is addressed by N, possibly in conjunction with certain F and A codes or groups of codes. (See Section 5.4.1.3.)

SUPPLEMENTARY INFORMATION:

(Examples of LAM Logic). Figs K5.4.1A–K5.4.1C are examples of LAM logic in modules. Fig K5.4.1A shows an example of LAM logic for a module with a single source of Look-at-Me. For modules having multiple sources of Look-at-Me, operations on the LAMs may be addressed via subaddresses (as in Fig K5.4.1B) or via bits in the data word associated with the operation (as in Fig K5.4.1C).

5.4.1.1 *Look-at-Me: Clear, Disable, and Test*

Provision must be made for resetting each bit of the LAM status register individually, either by a Clear Look-at-Me operation $F(10)$ (see Section 6.2.2), or by a Selective Clear Group 2 operation $F(23)$ see Sections 5.4.1.2 and 6.3.6). All LAM status bits must be reset collectively by the Initialize signal (see Section 5.5.1).

If the LAM request calls for some specific action (for example, reading the contents of a data register), then the corresponding bit of the LAM status register should also be cleared when the appropriate Dataway operation is performed.

A module that has generated $L = 1$ must not clear the LAM status register until it receives an appropriate command or the Initialize signal.

Each module that generates L should have a means of enabling and disabling the LAM requests. This may be done by loading and clearing a mask register, or by Enable and Disable commands.

All LAM requests that can be disabled by commands must also be disabled by the Initialize signal Z.

A module that generates L must have a means of testing the L signal by a Test Look-at-Me operation [Function code $F(8)$, (see section 6.2.1), with a subaddress distinguishing this from tests of individual LAM requests]. If there are several LAM sources, the corresponding LAM requests must also be capable of being examined either by Test Look-at-Me operations associated with appropriate subaddresses or by reading a LAM request pattern in a read operation.

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