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Système modulaire d'instrumentation pour le traitement de l'information; système CAMAC

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

A MODULAR INSTRUMENTATION SYSTEM FOR DATA HANDLING; CAMAC SYSTEM

FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendations and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This publication has been prepared by IEC Technical Committee No. 45, Nuclear Instrumentation.

A first draft was prepared according to document EUR 4100e published in 1972 by ESONE Committee and describing the CAMAC system, a modular system widely used in nuclear laboratories throughout the world for data handling in measurement and control situations.

This draft was discussed at the meeting held in The Hague in 1973, as a result of which the draft, document 45(Central Office)83, was submitted to the National Committees for approval under the Six Months' Rule in February 1974.

The following countries voted explicitly in favour of publication:

Belgium	Poland
Czechoslovakia	Romania
Denmark	South Africa (Republic of)
Finland	Switzerland
France	Turkey
Germany	Union of Soviet Socialist Republics
Israel	United Kingdom
Italy	United States of America
Japan	Yugoslavia
Netherlands	

Other IEC publications quoted in this publication:

Publications Nos. 297: Dimensions of Panels and Racks (for Nuclear Electronic Instruments).
482: Dimensions of Electronic Instrument Modules (for Nuclear Electronic Instruments).

A MODULAR INSTRUMENTATION SYSTEM FOR DATA HANDLING; CAMAC SYSTEM

1. Object

This publication is intended to define a modular instrumentation system 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 CAMAC are summarized as follows:

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

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

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

d) 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.

e) 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.

f) External connections to plug-in units may conform to the digital or analogue signal standards of associated transducers, computers, etc., or to the requirements given in this publication for digital signals.

g) Several CAMAC crates (up to 7) may be interconnected by the CAMAC branch highway.[1)]

In order to claim compatibility with the CAMAC specification, any equipment or system must comply with the mandatory rules (see Sub-clause 3.1).

2. Scope

This standard applies to nuclear instrumentation but may be utilized also for other applications. Further IEC standards may indicate such extensions of this scope. For reactor instrumentation and control systems, other packaging of electronic nuclear instruments may also be used.

2.1 This standard applies to systems consisting of modular electronic instrument units that require input/output transfers for the purpose of digital data processing, normally in association with a form of common controller, computer or other automatic data processor.

2.2 This standard applies to word-serial transfers that involve the parallel transmission of up to, and including, 24-bits as a word between one of many sources and one of many acceptors of data.

2.3 This standard does not concern itself with the features, characteristics or requirements of the system interconnection with the common controller, computer or other automatic data-processor, except in so far as these affect the operating conditions of the interface characteristics of the units.

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1) The CAMAC branch highway is under consideration.

3. Terminology

3.1 *Interpretation of this publication*

Statements that specify mandatory aspects of the system are written in **bold** type and are usually accompanied by the word "shall".

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.

3.2 *Definition of "module" and "controller"*

In this standard, the terms "module" and "controller" refer to plug-in units whose use, if any, of each Dataway line is consistent with the following table. A controller occupies the control station (see Sub-clause 4.4) and at least one normal station. A module occupies one or more normal stations. A plug-in unit may combine some features of a module with some of a controller.

Line	Use by a module	Use by a controller
A	Receives	Generates
B	Receives	Generates
C	Receives	Generates
F	Receives	Generates
L	Generates	Receives
N	Receives	Generates
Q	Generates	Receives
R	Generates	Receives
S	Receives	Generates
W	Receives	Generates
X	Generates	Receives
Z	Receives	Generates

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 86-way connector socket giving access to the "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 may be derived from the definitive dimensions given in Figures 1 to 3, pages 56 to 58, for crates, Figure 4, page 59, for plug-in units, and Figure 5, page 60, 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 non-mandatory Figures 6 to 8, pages 61 to 63, respectively.

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

4.1 *The crate*

The crate mounts in a standard 19-inch rack and has up to 25 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 86-way Dataway connector socket, and a tapped hole for the fixing screw of a plug-in unit.

Normal CAMAC plug-in unit described in Sub-clause 4.2 is the type C module of IEC Publication 482, Dimensions of Electronic Instrument Modules (for Nuclear Electronic Instruments). Furthermore Type N module of this IEC Publication (NIM module) can also be mounted in the crate on their basic pitch of 34.4 mm (see Sub-clause 4.3).

Unless otherwise indicated, all crates shall conform to Figures 1 to 3 and those parts of Figure 5 defining the connector socket.

Sub-clauses 4.1.1 and 4.1.2 are comments on these figures.

4.1.1 *Dimensions*

Figure 1 shows the front view of a basic 25-station crate which occupies the minimum height corresponding to dimension 5U of IEC Publication 297, Dimensions of Panels and Racks (for Nuclear Electronic Instruments).

Crates may have less than 25 stations, which, as indicated by Note 3 on Figure 1, need not be positioned symmetrically.

The lower cross-member of the crate 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 upper 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 Figure 1 by the formulae for dimensions z and w, respectively.

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

Detail B gives dimensions and spacing of mounting holes as specified in IEC Publication 297.

Figure 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 Figure 1 (with height 5U) are mounted above or below other equipment (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 Sub-clause 4.1.3.

Figure 3 is a sectional side view on the offset line *d-d* in Figure 1, passing through the centre 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 mm 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 towards 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 Figures 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 upwards 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 centre lines of the sockets are defined with respect to the left-hand edge of the front aperture by dimension y in Figure 1. The vertical datum of the sockets is shown relative to the vertical datum of the crate in Figures 2 and 3, and the horizontal datum of the sockets relative to the horizontal datum of the crate in Figure 3.

4.1.2 *Dataway connector sockets*

The Dataway connector sockets have two rows of 43 contacts on a pitch of 2.54 mm (0.1 in). Mandatory and recommended dimensions of the sockets are given in Figure 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 Figure 5.5 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 Figure 5.5. The shapes of the straight or curved chamfers that guide the connector plug into the socket are shown in Figures 5.6, 5.7 and 5.8. 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 shall not exceed 60°.

If the front aperture of the crate extends to the inner surface of the right-hand side panel (as in Figures 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 Figure 5.4. 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), as in Figure 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 25 stations. The width of the front aperture is 17.2 $s\,^{+0.3}_{-0.0}$ mm for s stations, and formulae given in Figure 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 Figure 3. A power supply unit is not allowed to extend upwards 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 Figure 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 86-way 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 otherwise indicated, all plug-in units shall conform to Figure 4 and those parts of Figure 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. Figure 4 therefore requires that the upper and lower 11 mm of the rear face of the front panel are free from projections, other than the fixing screws.

Figure 4 shows the dimensions of single-width and double-width plug-in units and gives general formulae 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 insertion and withdrawal forces of the connector socket. The fixing screw of a single-width plug-in unit is located on the centre 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 assistance against the insertion and withdrawal forces of the Dataway connector or connectors (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 may 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 Figures 5.1, 5.2 and 5.3.

The full 86 contacts are always present and extend to the extreme edge of the plug, without a chamfer, 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.

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 mm×1 mm. For at least 13 mm from the edge of the plug, the contacts are straight and plated.

The dimensions of the contacts of the connector plug are shown in Figure 5.3. 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.

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 fixing 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 (see Figures 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 mm×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 Figure 5.5 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 action which may be used to assist 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 may cause difficulty in inserting and withdrawing the plug-in unit and may also result in damage.

Figure 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 jacking 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. Figure 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*

Figure 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 specification.

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 above the maximum height limit of the Dataway assembly.

Coaxial connectors are to be chosen among connectors of the following characteristics: [1]

— miniature,
— impedance 50 Ω,
— snap on.

4.3 *Adaptor for NIM units*

Plug-in units conforming to type N module of IEC Publication 482, Dimensions of Electronic Instrument Modules (for Nuclear Electronic Instruments) (NIM unit) 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 Figure 7.

4.4 *The Dataway*

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

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.

The assignment of contacts at the Dataway connector and their connections to bus-lines, individual lines and patch contacts shall conform to Table II for normal stations and Table III for the control station. The control station shall 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 Clause 7) and with the maximum current loads specified for the power lines (see Clause 8).

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.

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.

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 are encountered on three power lines (+200 V d.c., 117 V a.c. live, and 117 V a.c. neutral).

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[1] An example of a recommended connector is given in document EUR 4100e (1972). 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.