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Louis Costrell

The standard Nuclear Instrument Module (NIM) system described in AEC Report TID-20893 is widely used in laboratories throughout the world. This report presents a history of the development and reviews the current status of the NIM system.

Key words: Instrumentation, Instruments, Modules, Nuclear, Standards, NIM

1. Introduction

A 1968 report of the National Academy of Sciences National Research Council[1] states that "...the Nuclear Instrument Module (NIM) system has revolutionized the manner in which experiments are now performed in nuclear physics." The world-wide impact of the NIM system makes desirable a presentation of the history of its development and a review and summary of its current status.

2. NIM System

The NIM system (Fig. 1) is a standardized nuclear instrument module system that provides a degree of instrument interchangeability that is unique in the history of instrumentation. The system consists of NIM modules and bins that conform to specifications of the NIM system[2]. The NIM bins are enclosures, based on standard 19-inch panels[3,4], that accommodate a multiplicity of NIM modules and provide power at the proper voltages to the modules that are inserted in the bins. Thus, instrumentation systems consisting of NIM bins and modules have a very high degree of flexibility in that the modules of different manufacturers can be readily interchanged. The systems can be efficiently maintained by rapid replacement of defective modules and can be quickly and economically updated by selective replacement of modules by modules of more advanced design. This obviates the necessity of replacing complex and expensive multi-function instruments. Because of the significant advantages of the NIM system, it is now in wide use in laboratories on every continent.

3. Need for a Standard Module System

Early nuclear instruments were self contained entities as was the case with practically all electronic instruments prior to the advent of the transistor. The vacuum tube circuits were mounted on conventional chassis and had conventional 19-inch front panels that were secured in standard cabinets or racks. The instruments had self-contained dc power supplies that were operated from the ac power lines. There was essentially no difficulty with interchangeability. Each instrument was simply inserted in the rack or cabinet and the line cord connected to the power line. To be sure, there were differences in input requirements and output levels. However, there was no appreciable problem of mechanical compatability and, since each instrument contained its own dc supply, electrical power compatability problems were non-existent. The development of the transistor changed all this.

In 1948 Bardeen and Brattain of the Bell Telephone Laboratories first announced the point contact transistor[5] and this was followed a few years later by the development of the junction transistor. Though transistors are extremely small compared to vacuum tubes and consume far less power, transistorized instruments that emerged in the 1950's were none-the-less constructed in a manner quite similar to that of their vacuum tube predecessors. Thus the instruments utilized 19-inch front panels and contained their own dc power supplies operated from the ac line. It rapidly became apparent that such construction was quite uneconomical and inefficient, that a number of transistorized instruments in modular form could be accommodated in the space occupied by a single 19-inch panel, and that a single dc power supply could provide the necessary power to such a multiplicity of instruments.

Many modular instrumentation systems were produced in laboratories and industries throughout the world and, though the savings in space and power were very great indeed, the interchangeability that existed earlier was sacrificed. Interchange of instruments within an assembly of instruments was severely limited. Modules of a given manufacturer or laboratory required bins from the same manufacturer or laboratory and, even with this restriction, interchange was not always possible. A laboratory was therefore faced with the necessity of (1) obtaining a variety of non-compatible bins, many of which contained far fewer instruments than they could accommodate, or (2) assembling non-optimized systems, restricting the modules used to those of a single manufacturer so as to avoid the expense of many under-utilized bins. Usually the laboratories struck a compromise between these two unsatisfactory alternatives.

The United Kingdom Atomic Energy Research Establishment at Harwell and the European Organization for Nuclear Research (CERN) at Geneva, Switzerland were among the first laboratories to develop comprehensive modular systems[6,7]. These two systems were pioneer systems, immensely far sighted and extremely useful to the originating laboratories. Later the ESONE Committee of EURATOM began work on an additional modular system known as the ESONE standard[8]. There was also a proliferation of commercial module systems with at least eight nuclear instrument manufacturers in the United States alone producing proprietary systems. Exchange of instruments among laboratories was severely restricted since the bins of one laboratory would not, in general, accommodate the modular instruments of another laboratory and commercially produced instruments could not be intermixed with laboratory constructed instruments or instruments of other manufacturers. That was the situation that developed in the early 1960's. The lack of a widely accepted standard modular system made for extreme inflexibility and represented a serious shortcoming of the nuclear instrumentation field.

4. History of Development

In December 1963 the National Bureau of Standards, in a report to the U. S. Atomic Energy Commission, urged:

> ".......that a module be developed by the National Laboratories with the intent that the module will become standard in all of the National Laboratories and will be duplicated by many manufacturers."

Based on this recommendation, the Division of Biology and Medicine of the U. S. Atomic Energy Commission convened a meeting of representatives of the AEC National Laboratories on February 1964 to determine the interest of the laboratories in such a development.* At this meeting it was decided that such a standard module system should be produced and the NIM Committee (AEC Committee on Nuclear Instrument Modules) was established and was assigned responsibility for this task. The Committee included representatives of all of the AEC National Laboratories and other laboratories as listed in Table I with personnel as listed in the appendix. The Committee was enthusiastically supported in this effort by the Atomic Energy Commission.

TABLE I

AEC COMMITTEE ON NUCLEAR INSTRUMENT MODULES (NIM COMMITTEE)

U. S. Atomic Energy Commission
Argonne National Laboratory
Battelle Northwest (Formerly Hanford Laboratories)
Brookhaven National Laboratory
Columbia University
Lawrence Radiation Laboratory (Berkeley)
Lawrence Radiation Laboratory (Livermore)
Los Alamos Scientific Laboratory
National Bureau of Standards
Oak Ridge National Laboratory
U. S. AEC Health and Safety Laboratory
Stanford Linear Accelerator Center (Beginning October 1964)
Princeton-Pennsylvania Accelerator (Beginning January 1965)
National Aeronautics & Space Administration, GSFC
(Beginning January 1965)
Atomic Energy of Canada Limited (Beginning November 1966)
CERN, European Organization for Nuclear Research)
(Beginning November 1966)
Yale University (Beginning February 1968)
National Accelerator Laboratory (Beginning October 1968)

The NIM Committee held its initial meeting on March 17, 1964 and held additional meetings in April and May. Existing module systems were studied so as to take advantage of prior experience. During the development, prototype bins and modules were produced by the Oak Ridge National Laboratory, the Lawrence Radiation Laboratory at Berkeley and the Lawrence

*Organizing Committee: F. S. Goulding, LRL/Berkeley; R. J. Berte, AEC; C. J. Borkowski, ORNL; D. B. Brown, Hanford; M. E. Cassidy, AEC/HASL; L. Costrell, NBS; R. J. Darneal, AEC; R. T. Graveson, AEC/HASL; R. Hiebert, LASL; W. A. Higinbotham, BNL; R. C. Kaifer, LRL/Livermore; N. A. Lindsay, LASL; A. E. Larsh, Jr., LRL/Berkeley; D. A. Mack, LRL/Berkeley; C. Sewell, LRL/Livermore; M. G. Strauss, ANL; H. R. Wasson, AEC.

Radiation Laboratory at Livermore. Later the Berkeley and Livermore laboratories merged their efforts to produce a common design. The prototypes were critically examined at each of the meetings and were important elements in finalizing the specifications. All of the basic decisions were made during the March, April and May meetings. Details remaining to be resolved were cleared up by the NIM Executive Committee (L. Costrell, U. S. National Bureau of Standards, D. A. Mack, Lawrence Radiation Laboratory at Berkeley and G. A. Holt, Oak Ridge National Laboratory. Later T. F. Droege, Princeton-Pennsylvania Accelerator and S. Rankowitz, Brookhaven National Laboratory were added to the Executive Committee.) In July 1964 the specifications for the NIM system were published.[9]

Implementation of the NIM standard was amazingly rapid with many laboratories having NIM systems in operation before the end of 1964. The first commercial NIM instruments were produced in November 1964 and in 1965 a wide variety of NIM instruments was commercially available. By December 1965, a gestation period of less than nine months from the time the NIM Committee first convened, an estimated 30% to 60% of the modular nuclear instruments produced in the United States were NIM instruments as shown in Figure 2. Within an additional year this had climbed to between

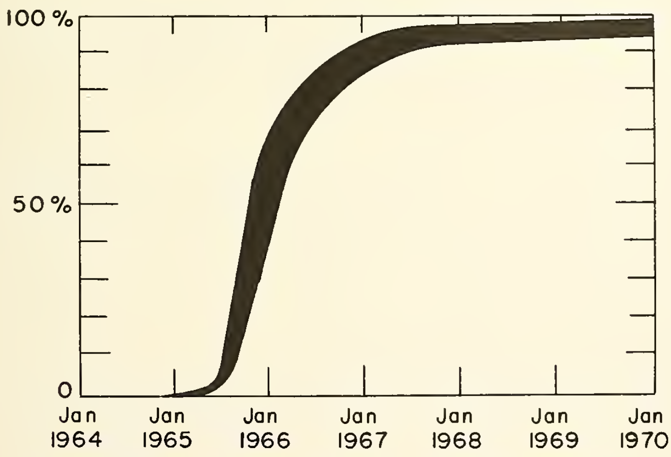

Fig. 2 Estimate of NIM Nuclear Instrument Production in U. S. as a Percentage of Total Modular Nuclear Instrument Production in U. S.

80% and 90%. These instruments became widely used throughout much of the world and European and Asiatic manufacturers began producing instruments in accordance with the NIM specifications. It is estimated that since 1967 in excess of 95% of the modular nuclear instruments produced in the United States have been NIM instruments and such instruments are produced in considerable numbers in Europe and Asia. An incomplete list of countries producing NIM instruments includes the United States, Australia, Belgium, Canada, England, France, Germany, Israel, Italy, Japan, Norway, Scotland, Sweden, and Switzerland. The NIM standard has received international recognition through its wide acceptance and production in many countries of the world.

It is difficult to recall any other instrumentation system in any field that has received even a reasonable fraction of the broad acceptance and utilization received by the NIM system. It is apparent that the system must provide considerable benefits to command such a following.

5. Advantages

The advantages of the NIM system that have accounted for its essentially universal acceptance are many and include the following:

1. Flexibility in interchanging instruments
2. Ready optimization of instrumentation systems
3. Ease of restructuring instrumentation systems
4. Reduction of inventories
5. Increased utilization
6. Ready interchange of instruments between laboratories
7. Deferred obsolescence - update capacity
8. Ease of serviceability
9. Reduction of down time
10. Availability of blank modules
11. Reduction of design effort
12. Availability of numerous commercial NIM instruments from many suppliers.

The advantages listed above derive from the interchangeability of the instruments, the unit function tendency in modular construction, the wide availability of a family of NIM instruments and the wide acceptance of the NIM system. The flexibility in interchanging instruments meeting common mechanical and electrical specifications needs no further comment. Economical optimization of instrumentation systems results from the ability to combine instruments from numerous manufacturers. Such optimization was both expensive and inefficient when the modules of one manufacturer could be used only in bins of the same manufacturer. The NIM system interchangeability has drastically altered this situation. For example, any of the hundreds of laboratories using NIM systems can readily combine in a single bin an amplifier from one supplier with a discriminator from a second supplier, a scaler from a third, a high voltage supply from a fourth, and so on. The user thus defines the optimum to suit his fancy and has no difficulty in assembling an optimized system.

The interchangeability also makes it possible to readily restructure instrumentation systems by interchanging instruments as desired. This permits operation with inventories that are considerably reduced over what would be possible with instruments lacking such interchangeability capabilities. The ease with which the same instruments can be used in different instrumentation set-ups also makes for considerably increased utilization. This also encourages interchange of instruments between different laboratories and between sections of the same laboratories.

The "unit function" or limited function construction that is common with modular instruments permits updating of systems by replacing only the specific modules that become outdated. This is considerably facilitated by the interchangeability features of the NIM system.

A variety of instrumentation systems is readily constructed from an inventory consisting of a limited variety of modules. Defective modules are readily replaced so that serviceability is enhanced and down time is drastically reduced. The maintenance of continuity of operation with minimum interruption is especially important in laboratories with expensive capital facilities where highly skilled scientists are delayed in the conduct of their experiments. This is of even greater importance in process control and control of nuclear reactors and other operations where interruptions must be held to an absolute minimum.

Economical blank modules into which circuits can be installed are available from a variety of sources. The mechanical design effort is thus drastically reduced and the designer is able to devote his efforts to innovative circuit design. This economy of design effort has been an important and significant benefit to both commercial manufacturers and laboratories constructing special in-house circuits.

The availability of numerous commercial NIM instruments from many suppliers enhances the value of NIM and this in turn encourages manufacturers to produce NIM instruments or to expand their lines of NIM instruments. So the regenerative condition is operative wherein availability produces utility which in turn encourages greater availability which in turn makes for increased utility. This cycle has been an important factor in the growth and the contributions of the NIM system.

6. General Description

Compatability of instruments involves three factors:

Mechanical compatability
Electrical compatability from a power supply standpoint
Electrical compatability from a signal standpoint

With regard to NIM, mechanical interchangeability means that any NIM module will fit mechanically into any NIM bin. Electrical interchangeability from a power supply standpoint means that any NIM module when inserted into any NIM bin will connect to the necessary power supply voltages. The objective of the NIM standard was to obtain mechanical and electrical power supply interchangeability and to encourage a considerable degree of electrical signal compatability. This has been achieved to a very great extent.

The NIM specifications are concerned with the mechanical dimensions necessary to assure accommodation of NIM modules by NIM bins, with the connector pair by means of which the module mates with the bin, with the voltages that must be available at the connector and with other items necessary to assure module-bin compatability. Thus the principal concern has been with the mechanical and electrical module-bin interface. In addition, the standard has provided guidance with "typical" power supply specifications, with "preferred" logic levels and with a few other items. The NIM specifications are not concerned with circuit design details, materials or methods of construction.

7. NIM Instruments

Complete families of nuclear instruments in the NIM system are available from many manufacturers. Figure 1 shows a typical NIM bin and a number of NIM modules from a variety of sources. NIM instruments include amplifiers, scalers, coincidence and gating circuits, fanouts, trigger circuits, pile-up gates, pulsers, baseline restorers, pulse stretchers, crossover pickoffs, time pickoffs, ratemeters, current digitizers, analog to digital converters, high voltage supplies, printout controls, particle identifiers and a host of other instruments. In addition, complete pulse height analyzers are available in the NIM system. This permits exchange or expansion of the memories, interchange of the analog to digital converters to provide different functions or different numbers of channels, etc.

Most NIM instrumentation commercially produced is considered nuclear instrumentation and is used primarily in nuclear and high energy physics, nuclear chemistry and other disciplines concerned with radiation measurements. However, many of these instruments, pulse amplifiers, pulse generators, analog to digital converters, pulse height to time converters, high voltage supplies, etc., are also applicable to and used in other areas. Additionally, some NIM instruments are produced for general physics use, for process control and for many other applications. One example of a non-nuclear NIM instrument is a narrow band "lock-in" amplifier used for measurement of extremely low signal intensities in the presence of noise and that finds application in electron resonance, plasma studies, biomedical investigations, laser studies, mass spectrometry, infra red studies, optical pumping, etc. Other non-nuclear NIM instruments include D.C. photometers, photometric preamplifiers, operational amplifiers, light choppers, well logging instruments and a wide variety of other instruments. Numerous control circuits for use with accelerators and accelerator peripherals, as well as many special instruments, are installed in NIM packages in many laboratories.

As mentioned above, a considerable number of instruments intended primarily for the nuclear physics field, such as scalers and analog to digital converters, are finding increased use in a variety of fields, including many branches of physics and chemistry as well as in scientific and engineering measurement and control applications. The NIM design has found its widest use in the nuclear area for historical reasons and because of the close cooperation that exists within the nuclear instrumentation community. The extension of NIM instrumentation into non-nuclear areas has been greatest in those disciplines that have appreciable contact with and familiarity with the nuclear field.

8. Dataway Operations

Instrumentation systems that receive instructions and communicate data primarily through a dataway (digital bus) structure and utilize a minimum of local controls and readouts are coming into increasing use. Though NIM is used in some instances for such purposes, it was not conceived as a dataway system and does not basically make provision for dataway type operations. The NIM Committee has maintained close contact with the ESONE Committee and in March 1970 endorsed the computer oriented CAMAC system[10] as a dataway system complementary to NIM.

9. Conclusions

The NIM system has become dominant for nuclear instrumentation in most of the world and has contributed substantially to experimental nuclear physics. The system has the potential for providing to other fields the same advantages that have accrued to nuclear and radiation physics.

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APPENDIX

REPRESENTATIVES ON AEC COMMITTEE ON NUCLEAR INSTRUMENT MODULES
(NIM COMMITTEE)

Organization	Representatives		
	Initial Committee (March 1964)	Present Committee (August 1970)	Other
National Bureau of Standards	Louis Costrell (Chairman)	Louis Costrell (Chairman)	
U. S. Atomic Energy Commission	H. R. Wasson (AEC Liaison) R. L. Darneal (to 1/68)	H. R. Wasson (AEC Liaison)	
Argonne National Laboratory	S. J. Rudnick M. G. Strauss (to 3/70) T. W. Hoffer (to 7/68)	S. J. Rudnick J. J. Eichholz (from 9/69) R. J. Pecina (from 9/69)	R. D. DeForest (Idaho Falls, 9/65 to 11/66
Atomic Energy of Canada, Ltd.		V. H. Allen (from 11/66)	
Battelle Northwest (Formerly Hanford Laboratories)	W. G. Spear, Jr.	W. G. Spear, Jr. R. E. Connally (from 3/68) Bill E. Dozer (from 9/69)	W. R. Wood (1/66 to 3/68)
Brookhaven National Laboratories	S. Rankowitz L. H. Redmond	S. Rankowitz L. H. Redmond	
CERN		I. Pizer (from 11/66)	
Columbia University	V. Guirogossian J. Hahn	V. Guirogossian J. Hahn	S. Dhawan (2/65 to 3/68, now Yale Rep)
Lawrence Radiation Laboratory, Berkeley	A. E. Larsh, Jr. D. A. Mack	A. E. Larsh, Jr. D. A. Mack F. Kirsten (from 3/70)	
Lawrence Radiation Laboratory, Livermore	C. A. Van DenHeuvel (to 8/65)	R. C. Kaifer (from 7/65) G. L. Strahl (from 9/69)	
Los Alamos Scientific Laboratory	N. A. Lindsay	N. A. Lindsay L. R. Biswell (from 9/69)	B. R. Koch (9/66 to 11/66)
National Accelerator Laboratory		Cordon Kerns (from 2/70)	R. E. Daniels (10/68 to 2/70)
National Aeronautics and Space Administration (GSFC)		J. H. Trainor (from 2/66) D. E. Stillwell(from 9/69)	G. H. Ludwig (to 2/66)
Oak Ridge National Laboratory	S. H. Hanauer (to U.Tenn 4/65) N. W. Hill G. A. Holt	N. W. Hill G. A. Holt J. W. Woody, Jr.(from 2/68)	
Princeton-Pennsylvania Accelerator		(Appointment pending)	T. F. Droege (1/65 to 3/70)
Stanford Linear Accelerator		R. S. Larsen (from 11/66) D. Horelick (from 9/69)	G. Temmes (11/64 to 8/65) V. L. Smith (8/65 to 11/66) W. B. Pierce (8/65 to 11/66)
University of Tennessee			S. H. Hanauer (4/65 to 3/70)
U. S. AEC Health & Safety Laboratory	N. Latner	N. Latner V. C. Negro (from 9/69)	
Yale University		C. E. L.Gingell(from 2/68) S. Dhawan (from 3/68)	

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