Introduction to NIM and CAMAC

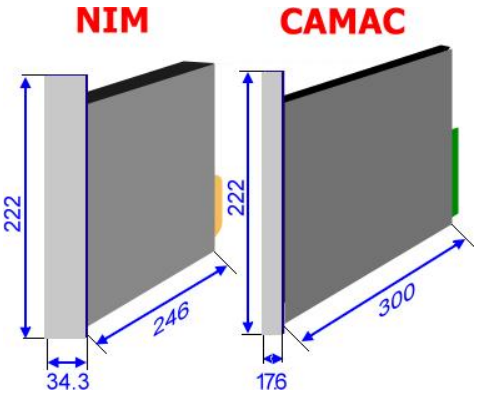
The Nuclear Instrumentation Module (**NIM**) standard defines mechanical and electrical specifications for electronics modules used in experimental particle and nuclear physics. First defined by the U.S. Atomic Energy Commission's report TID-20893 in 1968-1969, NIM was most recently revised in 1990 (DOE/ER-0457T).

The NIM standard provides a common footprint for electronic modules (amplifiers, ADC's, DAC's, discriminators, etc.), which plug into a larger chassis (NIM crate, or NIM bin). The crate must supply ±12V, ±24V DC and 110V AC power to the modules via a backplane; the newer standard also specifies ±6V.

Full size NIM bins for 19" rack mounting have 12 slots and should be equipped with an excellent, low noise linear regulated power supply (150W ... 600W). Due to the low power consumption of NIM modules typically no forced air cooling is required. However, there are NIM modules with high power dissipation and heat production which benefit from a NIM bin with integrated fan tray for cooling.

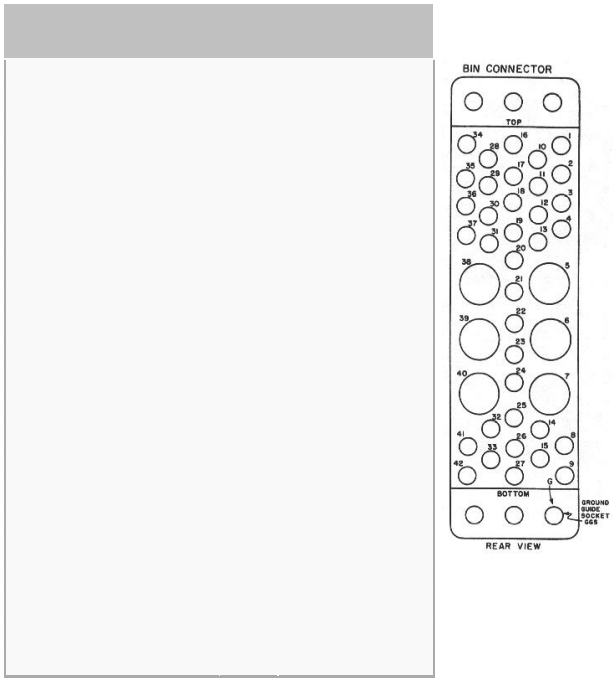
In a step to further improve and standardize NIM crates and power supplies the European High Energy Physics Lab. CERN created in 1977 standards for modular NIM (CERN NIM-120-6U) and CAMAC (CERN CAMAC Note 46-04) crates with interchangeable power supplies and fan trays. Most of the WIENER NIM crates are compliant to the CERN standard.

Standard NIM modules are required to have a height of 222mm (8.75") / depth of 246mm (9.68"), and must have a width which is a multiple of 3.43cm (1.35"). Modules with a width of 3.43cm (1.35"0 are referred to as single width modules and modules with a width of 6.86cm (2.7" are double width modules, etc. On the lower rear side the module has a multi-pin connector, which plugs into mating one on the bin in order to provide the power to the module (see connector schema).



NIM is the perfect standard for small and flexible setups for high resolution measurements with analogue electronics (amplifier, high resolution analog to digital converter), timing modules, noise sensitive electronics as well as for low / high voltage supplies.

Taking advantage of modern high-speed serial interfaces as USB-2 or Ethernet today the NIM standard encounters a renaissance for universal test and measurement applications including high speed digitizers and complex logic and timing functions. Please see the WIENER NIMbox/Nembox series in NIM Modules chapter.



CAMAC - "Computer Aided Measurement And Control" is a joint specification of the U.S. NIM and the European ESONE committees for a modular, high-performance, real-time data acquisition and control system concept. CAMAC was introduced in 1969 by ESONE and fully defined in 1971 with the standards EUR4100 and EUR4600 / IEEE Standard 583-1982 (reaffirmed 1994) "Modular Instrumentation and Digital Interface System (CAMAC)". It represents a complementation of the NIM standard for computer based experiment control and data acquisition. Main field of CAMAC use are computer based control and data acquisition systems in nuclear and high-energy physics experiments but in the past also in industrial applications, aerospace, and defense test systems.

CAMAC modules have half of NIM width but are with 300mm (11.81") deeper and are outfitted with a rear side 86-pin edge card connector. This connector plugs into the CAMAC Dataway which provides module power, address bus, control bus and data bus. including 48 digital data transfer lines (24 read, 24 write), strobe signal lines as well as address and control lines.

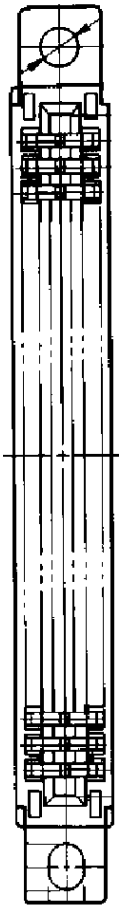
WIENER CAMAC crates are modular designed and compliant to the CERN standard, i.e. the CAMAC crate consist of the bin with the CAMAC bus (Dataway), a fan tray for module ventilation and a low noise power supply which has to provide +/-6V, +/-12V (optional), +/-24VDC and 110V AC (secondary). Power supplies with all 6 DC voltages are exchangeable with NIM bins.

CAMAC crates for 19" rack mounting have 25 slots. Station 25, the rightmost station, is reserved for a CAMAC Crate Controller whereas slots 1 to 24 are "normal stations". Standard CAMAC crate controllers are doublewide and use the two rightmost slots 24 and 25. They are outfitted with an interface to other bus systems ("branch" as per ESONE EUR4600 for type A controller in large CAMAC installations, VME, GPIB, ..) or computers (parallel, USB, Ethernet). Today in most cases CAMAC controllers are connected directly to PC's. WIENER provides controllers with high speed 32bit

parallel and USB-2 interfaces (see CAMAC module section CC32 and CC-USB).

CAMAC Pin assignment (viewed from front)

Controller station		Normal station	
P1	B	P1	B
P2	F16	P2	F16
P3	F8	P3	F8
P4	F4	P4	F4
P5	F2	P5	F2
X	F1	X	F1
I	A8	I	A8
C	A4	C	A4
P6	A2	N	A2
P7	A1	L	A1
S1	Z	S1	Z
S2	Q	S2	Q
L24	N24	W24	W23
L23	N23	W22	W21
L22	N22	W20	W19
L21	N21	W18	W17
L20	N20	W16	W15
L19	N19	W14	W13
L18	N18	W12	W11
L17	N17	W10	W9
L16	N16	W8	W7
L15	N15	W6	W5
L14	N14	W4	W3
L13	N13	W2	W1
L12	N12	R24	R23
L11	N11	R22	R21
L10	N10	R20	R19
L9	N9	R18	R17
L8	N8	R16	R15
L7	N7	R14	R13
L6	N6	R12	R11
L5	N5	R10	R9
L4	N4	R8	R7
L3	N3	R6	R5
L2	N2	R4	R3
L1	N1	R2	R1
-12	-24	-12	-24
NC	-6	NC	-6
NC	NC	NC	NC
Y1	E	Y1	E
12	24	+12	+24
Y2	6	Y2	6
0	0	0	0



In a typical DATAWAY operation, the crate controller issues a CAMAC COMMAND which includes a station number (**N**), a sub-address (**A**), and function code (**F**) to the module in slot N. In response, the module will generate valid command accepted (**X** response) and act on the command. If this command requires data transfer, the (R) or write (W) line will be used (terms Read and Write apply to the controller). The CAMAC cycle for this operation takes about 1.2µs.

All CAMAC bus signals are TTL logic levels as given in the following table:

	Logic 0	Logic 1
Input must accept	+2.0 to 5.5V	0 to +0.8V
Output must accept	+3.5 to 5.5V	0 to +0.5V

STATION NUMBER (N)

Each normal station is addressed by a signal on an individual station number line coming from the control station. The stations are numbered in decimal from the left side as viewed from the front, beginning with slot 1.

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 16 sub-addresses, numbered in decimal from 0 to 15.

FUNCTION (F16, F8, F4, F2, F1)

The function to be performed at the specified sub-address in the selected module or modules is defined by the Function code. CAMAC module function codes have to match the following definitions:

F	FUNCTION	F16	F8	F4	F2	F1	F0
0	Read Group 1 Register	0	0	0	0	0	0
1	Read Group 2 Register	0	0	0	0	1	1
2	Read and Clear Group 1 R.	0	0	0	1	0	2
3	Read Compl. of Group 1 R.	0	0	0	1	1	3
4	Non-standard	0	0	1	0	0	4
5	Reserved	0	0	1	0	1	5
6	Non-standard	0	0	1	1	0	6
7	Reserved	0	0	1	1	1	7
8	Test Look-at-Me	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	Non-standard	0	1	1	0	0	12
13	Reserved	0	1	1	0	1	13
14	Non-standard	0	1	1	1	0	14
15	Reserved	0	1	1	1	1	15
16	Overwrite Group 1 R.	1	0	0	0	0	16
17	Overwrite Group 2 R.	1	0	0	0	1	17
18	Selective Set Group 1 R	1	0	0	1	0	18
19	Selective Set Group 2 R.	1	0	0	1	1	19
20	Non-standard	1	0	1	0	0	20
21	Selective Clear Group 1 R.	1	0	1	0	1	21
22	Non-standard	1	0	1	1	0	22
23	Selective Clear Group 2 R.	1	0	1	1	1	23
24	Disable	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	Non-standard	1	1	1	0	0	28
29	Reserved	1	1	1	0	1	29
30	Non-standard	1	1	1	1	0	30
31	Reserved	1	1	1	1	1	31

STROBE SIGNALS (S1 AND S2)

Two strobe signals S1 and S2 are generated and used for command execution timing. S1 defines the time for the first phase. All units which accept data from the DATAWAY in a Read or Write operation do so in response to S1. S2 initiates actions that may change the state of DATAWAY signals, for example, clearing a register whose output is connected to the DATAWAY.

Data

Up to 24 bits of data may be transferred in parallel between the controller and the selected module. Independent lines (Read and Write) are provided for the two directions of transfer.

THE WRITE LINES (W1-W24)

The controller or other common data source generates data signals on the W bus lines at the beginning of any "Write" operation. The W signals reach a steady state before S1, and are maintained until the end of the operation, unless modified by S2.

THE READ LINES (R1-R24)

Data signals are set up on the R bus lines by the module as soon as a "Read" command is recognized. The R signals reach a steady state before S1, and are maintained for the full duration of the DATAWAY operation, unless the state of the data source is changed by S2. The controller or other data receiver strobes the data from the R bus lines at the time of the Strobe S1.

Status Information

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

Look-At-Me (LAM / L)

The LAM line, is an individual connection from each station to the control station to indicate a service request. When there is no DATAWAY operation in progress (no B present) any unit may generate a signal on its L line to indicate that it requires attention. A LAM request can be reset by Clear LAM, initialize or by the performance of the specific action which generated the request.

DATAWAY BUSY (B)
The Busy signal is used to interlock various aspects of a system which can compete for the use of the DATAWAY. Specifically, it is generated during DATAWAY command or common control operations. Whenever N is present, B is present, and for the duration of B, all L signals are gated off the DATAWAY lines.

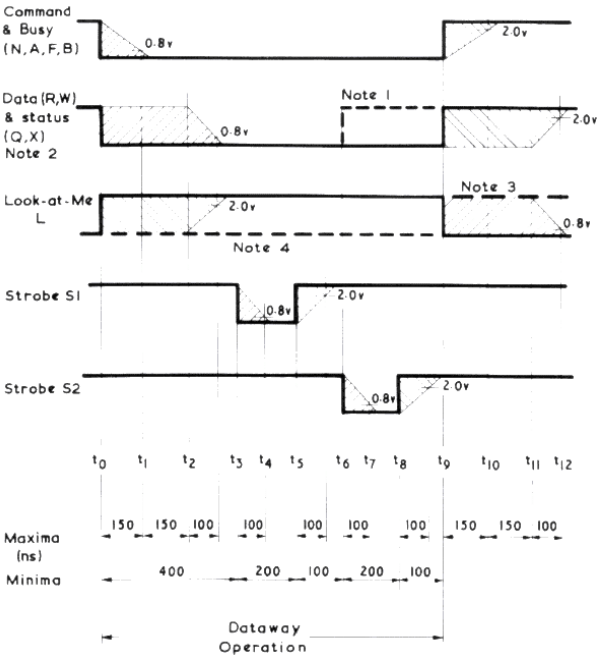
COMMAND ACCEPTED (X)
Whenever an addressed module recognizes a command, it must generate X = 1.

RESPONSE (Q)
The Q bus line is used during a DATAWAY operation to transmit a signal indicating the status of a selected feature of the module. On all Read and Write commands the signal on the Q bus line remains static from the time the command is received until S2. For all other commands the signal on the Q bus line may change at any time.

Common Controls
Common control signals operate on all modules connected to them without the need to be addressed separately by a command. In order to provide protection against spurious signals, the initialize (Z) and Clear (C) signals must be accompanied by Strobe S2.

INITIALIZE (Z)
The initialize signal has absolute priority over all other signals or controls. It sets all units to a defined initial / basic state. It is always accompanied by S2 and B.

INHIBIT (I)
The presence of this signal inhibits any activity (for example, data taking). It must either not change when B is present or have rise and fall times not less than 200 nsec.



CLEAR (C)
This command signal clears all registers or bi-stables connected to it. Units which generate C must also cause S2 and B to be generated. Modules which accept C gate it with S2 as a protection against spurious signals on the C line.

FASTCAMAC is a proposed extension to the CAMAC data acquisition standard, which substantially increases the data transfer rate of CAMAC systems while retaining full compatibility with standard CAMAC. This extension provides an increase in data transfer rate of 2.5 to 20 times that of normal CAMAC (up to 60 Mbytes/s).

These increased speeds are achieved while maintaining full forward and backward compatibility with the existing CAMAC standard. Normal CAMAC modules and the new FASTCAMAC modules will work together in the same crate at their respective speeds. The proposed standard has 3 levels of increasing complexity.

FASTCAMAC level one provides an increase in the maximum data transfer rate to 7.5 Mbytes/s (x2.5 normal CAMAC) by using multiple S1 strobes without increasing dataway speed or replacing driver chips. Currently several commercially available CAMAC modules which include the WIENER CAMAC controllers CC32 and CC-USB support this protocol.

For maximum data transfer speeds of up to 60MB/s FASTCAMAC level 2 and 3 foresee a two edge protocol with multiplexing R and W lines to allow 48bit wide transfers. These changes require significant module re-designs including tri-state bus drivers and are not common practice as of today.

WIENER NIM products:

- powered NIM crates
- NIM modules
- Blank NIM mechanics and NIM parts

WIENER CAMAC products:

- powered CAMAC crates
- CAMAC controllers / interfaces
- CAMAC modules
- Blank CAMAC mechanics
- NIM to CAMAC power adapter