A Brief Guide to NIM

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Introduction

NIM modules have long formed a critical element of the HEP data-taking structure, and in recent years have been used most to build highly customizable trigger systems for small experiments. While the modules and standards go back to the seventies and eighties, they are still a key element due to functioning effectively as HEP-lego for setting up triggers. This brief overview will give an idea of the functionality of the main types of modules used for the TP4a Cosmic Ray experiment.

A standard NIM signal is a negative-going signal of arbitrary length with an amplitude of around -800 mV. On many modules, you can find linked outputs (with a line drawn between the output ports). In case only part of a linked output group is used, make sure to terminate the other outputs with a 50Ω terminator. Many modules provide an anti-NIM output as well (labelled as $\overline{\text{NIM}}$), which is the inverse: flat around -800mV and a positive-going signal to 0mV of arbitrary length.

The different modules can be roughly grouped into discriminators, logic & gate, delay, fan-in / out and finally utility. The following sections will give a general description of the function of these groups of modules with some specific behaviours and examples. In case this very brief guide is not sufficient, check the manual of the unit in question. If these steps still do not make things clear, ask your supervisor.

Generally, there is some variation between the modules, most of the NIM signals they return will be 700-800mV or so. Remember that different cables add delay to your signals, around 1ns per 20cm of cable. Each LEMO cable should be labelled with the amount of delay it will give.

Unfortunately, some units are broken and some might break while you are using them. If a unit appears to be broken, try to test it and find out how to replicate the faulty behaviour. Note that cables might also be faulty. In case a unit or channel does not work as expected, please tell your assigned supervisor and label the unit. Note down the unit type, number, and what / how is broken.

1 Discriminators

The discriminator turns the PMT signal into a NIM signal. A PMT will naturally give signals of varying amplitude. Most of the discriminator units allow a threshold to be set, on a per-unit or per-channel basis. When the input signal is bigger than the threshold, it will give a NIM pulse on the output. The threshold can be checked with a voltmeter, with the voltage measured on the NIM unit representing 10× the threshold that is actually set (so if you measure -1 V on the threshold of the NIM module, you have set the discrimination threshold at -100 mV). The width of the output signal can often also be set. The length of the output signal can (and should) be verified with an oscilloscope. Some modules have a switch on the bottom (BURST GUARD / UPDATE ONLY) - set this to UPDATE ONLY.

1.1 Hex Shaper (IPNL module 1009)

This module works a bit differently from a normal discriminator. There are two types of output. The top output has the DLYD / SYNC switch, and gives a short (∼13ns) pulse. The other three outputs (two regular, one anti) give a longer output pulse. The width of the regular output pulse is the maximum of the width of the input pulse (at the discrimination level) and the width setting - whichever is longer. The top output gives its fast pulse on the leading edge of the regular output (SYNC) or on the trailing edge (DLYD).

2 Logic & gate

Logic in terms of NIM signals works the same as it does in regular programming but uses analog signals. Whenever the conditions are met, it will return a signal, the length of which can often be adjusted. The goal of this type of unit is to check that multiple conditions are simultaneously met. For example, you can check that two scintillator plates are simultaneously detecting a signal using a coincidence module requiring two inputs to simultaneously be high (in the case of a NIM signal, "high" or "true" would be -800mV). The logic employed for this, just like in programming, is a combination of requirements, built from a combination of AND and OR statements. The following figure contains a brief overview of the most common ones. Note that the $\overline{\text{NIM}}$ logic outputs of a unit correspond to !A ("not A"), the logic inverse of the regular output.

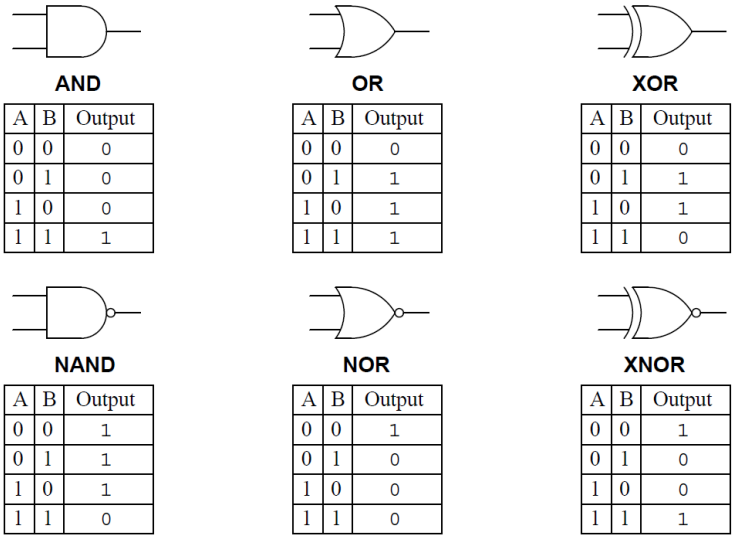

Figure 1: Binary representation of dual-input logic gates (Source)

2.1 Coincidence unit (LeCroy 465/466)

These are the most basic coincidence units, with up to four inputs per channel, allowing the inclusion of each of these in a coincidence, and allowing them to be easily switched on/off. It functionally only provides an AND. This module has two types of output, linear and logic. The linear output is high for as long as the selected inputs are high. The logic output is high for an adjustable time whenever all selected inputs are simultaneously high. The VETO input allows to ignore signals. When the VETO signal is high, and an incoming signal transitions to high, it is ignored.

2.2 Or unit (CERN and SEN N4132, SEN FE270)

This unit provides the other type of logic operator (OR). If any of the inputs are high, the output signal will be high. This unit does not allow to set the output width, it will just be high for as long as any of the inputs are high.

2.3 Coincidence triple (IPNL L80)

This unit expands on the functionality of the basic coincidence unit, but only provides a single channel. For each input, there is a switch adjustable to C/H/AC, standing for "Coincidence", "Hors coincidence", "Anti-coincidence". The setting C puts it in coincidence like for the basic unit, the setting H removes the channel from the coincidence, and the setting AC means that the inverse of the input is considered for creating the output coincidence. Setting input A to "C", input B to "H" and input C to "AC" then gives an output signal when, simultaneously, A is high and C is low (B is not considered since it is out of coincidence).

2.4 4-fold logic unit (LeCroy 365AL / 365ALP)

This unit uses a slightly different kind of logic referred to as "majority logic". Each input channel can be excluded by inserting a pin in the requisite hole A/B/C/D. On the "coincidence" you can select how many channels you want to be simultaneously high, and the module will generate an output signal when any combination of the inputs meets this condition. For example, with three inputs and requiring a coincidence of three, the output signal is effectively A&B&C. However, requiring only two the output signal is effectively (A&B | A&C | B&C). There is a white-labelled patch in the middle which is for pin storage (!!!) - it serves no further function. When you run out of pins, borrow from other modules, if still not enough, bring one pin to the electronics workshop and ask them for a few more.

2.5 Gate modules

Many of the modules have separate inputs labelled as "GATE". These allow for the use of a "gate", a sort of master input for an AND. The inputs are only considered by the logic when the GATE is high. A gate generator (LeCroy 222 / 222N) can be used to generate such a gate, which outputs a NIM signal of adjustable width whenever it receives a leading edge on the START input. There is no difference between a GATE and a regular signal except for how they are used.

3 Fan-in / fan-out

The fan-in / fan-out modules come in two flavours - logic and linear. The linear fan-in (LeCroy 127FL) gives a multi-level output, which will be -400mV when one signal is high and -800mV when two or more inputs are simultaneously high. The logic fan-in (LeCroy 429) is high whenever any input is high (much like the OR modules). The fan-out modules allow for splitting a signal further, when more outputs are required from a module than are available.

4 Delay modules

These modules provide what is effectively a long cable rolled up into a NIM module, and allowing them to be attached to each other. This allows signals to be displaced in time, so that you can overlap signals when they have acquired different delays after having been passed through a set of modules.

5 Utility

There is a number of units available providing generic utility. This section gives some details on how to use these units.

5.1 Multi-scaler (IPNL L1020)

This versatile unit allows to count the number of times a given input transitions to high. It allows for up to three inputs to be counted simultaneously. It supports two counting modes, TIME and COUNT. When selecting TIME, it will count all the inputs for a set amount of time, 0.1 times what is in the numerical display (so if it is set to 1E3, it will count for 100s). When selecting COUNT, it will count until input Pr reaches the number that was set, and indicate how many counts were found on the other input channels. When the START/STOP button is green, it is ready to be used, push to start. When it is blinking, it is done or has a problem, try to reset the module (hold down the SLAVE / DT switches for a few seconds).

6 Things you Should Not Do

Some final warnings! Please follow these instructions while you operate the NIM modules, or you will risk breaking them.

1. Only switch modules in and out with the crate OFF!
2. Always have the fan module below each NIM crate on to prevent the setup from overheating
3. Terminate the output channels you do not use with 50Ω

There are some modules that look potentially interesting. Do not use the Canberra 1454 "Linear gate and stretcher", it has a shaping time of 500ns and is not suitable for this experiment.