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Technical Information Manual

Revision n. 7
October 08th, 2024

MOD. V 812 series
*16 CH. CONSTANT
FRACTION
DISCRIMINATORS*

NPO:
00101/97:V812x.MUTx/07

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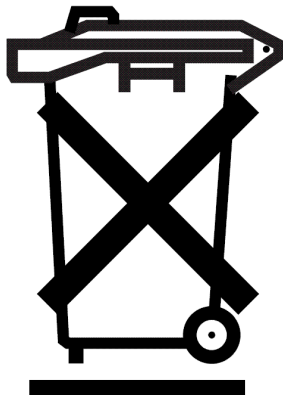
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Change Document Record

Date	Revision	Changes
5 November 2021	Rev. 6	Updated Output width and Dead time values throughout manual

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1. General description

1.1. Functional description

The CAEN Model V812 is a 16 CHANNEL CONSTANT FRACTION DISCRIMINATOR housed in a single width VME module. The module accepts 16 negative inputs and produces 16 differential ECL outputs with a fan-out of two on four front panel flat cable connectors (a functional block diagram is shown in Fig. 1.2). Several version are available, refer to Table 1.1 for details.

Each channel can be turned on or off via VME by using a mask register (Pattern of Inhibit). The pulse forming stage of the discriminator produces an output pulse whose width is adjustable in a range from 12 ns to 206 ns (typical values) via VME. Moreover, in order to protect against multiple pulsing, it is possible to program via VME a Dead Time during which the discriminator is inhibited from retriggering. The maximum time walk is ± 400 ps (for input signals in the range from -50 mV to -5 V with 25 ns rise time). The constant fraction is 20%. The constant fraction delay is defined by a delay line network of 20 ns with 5 taps (see fig. 2.2). The discriminator thresholds are settable via VME in a range from -1 mV to -255 mV (1 mV step) through an 8-bit DAC.

The module can operate also with small (below 10 mV) input signals, though in this case the Constant Fraction operation is not performed, i.e. the walk is higher. VETO and TEST inputs are available on the front panel. The front panel is provided with a Current Sum output that generates a current proportional to the input multiplicity, i. e. to the number of channels over threshold, at a rate of -1.0 mA per hit (-50 mV per hit into a 50 Ohm load) ± 20 %. A "MAJORITY" output provides a NIM signal if the number of input channels over threshold exceeds the MAJORITY programmed value. The logic OR of discriminator outputs is available on a front panel connector. The relevant "OR" LED lights up if at least one of the unmasked channels is over threshold. The module's operations are completely controlled via software for each channel through the VME bus. The most important are:

- setting the discriminator thresholds (8 bit data) from -1 to -255 mV.
- setting pattern of inhibit; each channel can be turned "ON" or "OFF" by using a mask register.
- setting output pulse width
- setting the Majority threshold value.
- selection of the Dead Time value.

Table 1.1: Versions available for the Model V812

Version ¹	Number of channels	PAUX connector ²
V812 ³	16	yes
V812 B	16	no



Fig. 1.1: Model type label (example V812 B)

¹ A label on the printed board soldering side indicates the module's version (see Fig 1.1).

² The version with the PAUX connector requires the V430 backplane.

³ Available exclusively on request

1.2. Block diagram

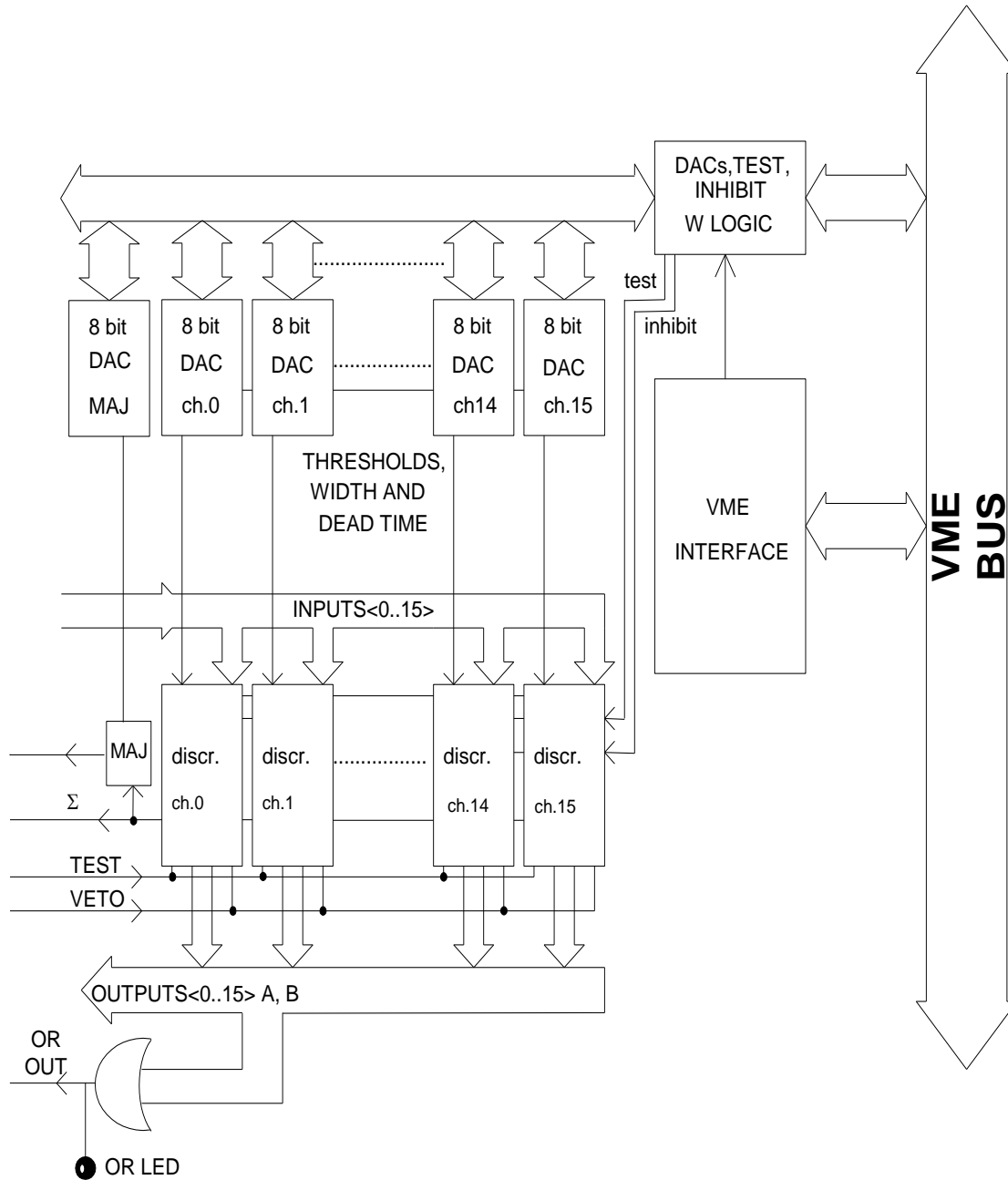


Fig. 1.2: Block Diagram

1.3. Technical specification table

Table 1.2: Technical specification table

Packaging	6U-high, 1U-wide VME unit
Power requirements	Refer to § 2.2
Inputs	16 inputs (negative polarity, 50 Ω impedance)
Max input voltage	-5 V
Min detectable signal	-5 mV
Threshold range	-1 mV to -255 mV (1 mV step)
Constant fraction	20%
Delay	20ns full scale with 4 ns steps (8 ÷ 20 ns operating range) Optional: <ul style="list-style-type: none"> 5ns full scale with 1ns steps (4 ÷ 5 ns operating range) 50ns full scale with 10ns steps (10 ÷ 50 ns operating range) 100ns full scale with 20ns steps (20 ÷ 100 ns operating range)
Outputs	16 outputs with a fan-out of two (ECL, 110 Ω impedance)
Input/output delay	Set delay+4.5±2 ns
Output width	Programmable from 12 ns to 206 ns (typical values)
Dead Time	Programmable from 118 ns to 1625 ns (typical values; dispersion ±10%)
Max outputs time walk	±400 ps for input signals in the range from -50 mV to - 5 V with 25 ns rise time
Autowalk	Automatic adjustment of input offset and low frequency input noise of ±40 mV
Control inputs	NIM logic signals, high impedance: VETO : allows to veto all channels simultaneously TEST : triggers all the enabled channels at once
Control outputs	MAJORITY : standard NIM logic signal, 50 Ω impedance; it indicates if the number of input channels over threshold exceeds the MAJORITY level programmed via VME OR : standard NIM signal, 50 Ω impedance; logic OR of outputs Σ : current proportional to input multiplicity (-1 mA ± 20% per hit), high impedance
Displays	DTACK : green LED; lights up at each VME access OR : green LED; it lights up if at least one output signal is present

2. Technical Specifications

2.1. Packaging

The Mod. V812 is housed in a 6U-high 1U-wide VME unit.

2.2. Power requirements

The power requirements of the Mod. V812 are as follows:

Table 2.1: Power requirements

	V812	V812 B
+ 12 V	100 mA	100 mA
- 12 V	60 mA	60 mA
+ 5 V	1 A	5.5 A
- 5 V	3 A	

2.3. Front Panel

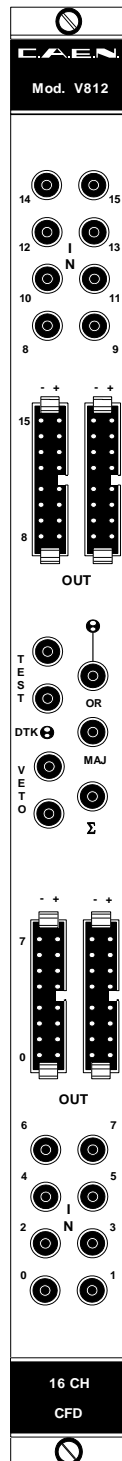


Fig. 2.1: Front Panel

2.4. External connectors

The location of the connectors is shown in Fig. 2.1. Their function and electromechanical specifications are listed in the following subsections.

2.4.1. INPUT connectors

INPUT CHANNELS:Mechanical specifications:

16 LEMO 00 type connectors.

Electrical specifications:

Negative polarity, 50 Ohm impedance.

Max input voltage: -5 V.

Min detectable signal: -5 mV.

VETO INPUT:Mechanical specifications:

1 LEMO 00 type connectors.

Electrical specifications:

Standard NIM logic signal, high impedance, 30 ns minimum FWHM; leading edge of the VETO signal must precede of at least 18 ns the leading edge of the input and overlap completely the input signal.

TEST INPUT:Mechanical specifications:

1 LEMO 00 type connectors.

Electrical specifications:

Standard NIM logic signal, high impedance

8 ns minimum FWHM

Max input frequency: 30 MHz

2.4.2. OUTPUT connectors

OUTPUT CHANNELS:Mechanical specifications:

4 Header 3M 3408-D202 type, 8+8 pin connectors.

Electrical specifications:

Differential ECL level on 110 Ohm impedance; pulse width adjustment from 12 ± 1.5 ns to 206 ± 25 ns (typical values); maximum time walk is ± 400 ps for input signals in the range from -50 mV to -5 V with 25 ns rise time.

Input/Output delay: set delay $\pm 4.5 \pm 2$ ns.

OR OUTPUT:Mechanical specifications:

1 LEMO 00 type connectors.

Electrical specifications:

Standard NIM logic signal, 50 Ω impedance.

Rise/fall time < 4 ns.

Max output frequency: 30 MHz.

 Σ OUTPUT:Mechanical specifications:

1 LEMO 00 type connectors.

Electrical specifications:

current output ($-1 \text{ mA} \pm 20\%$ per hit), high impedance.

Rise/fall time $< 8 \text{ ns}$.

Max output frequency: 30 MHz

MAJORITY OUTPUT:Mechanical specifications:

1 LEMO 00 type connectors.

Electrical specifications:

Standard NIM logic signal, 50Ω impedance.

2.5. Other components

2.5.1. Displays

The front panel hosts the following LEDs:

DTACK

Type: 1 green LED

Function: VME selected; it lights up during a VME access.

OR

Type: 1 green LED

Function: it lights up if at least one output signal is present.

2.5.2. Switches

ROTARY SWITCHES

Function: they allow to select module's VME address; please refer to Fig. 2.2 for their setting.

2.5.3. Jumpers

JP1

Function: it allows to select the Majority logic (Internal, External); please refer to Fig. 2.3 for the jumper location on the V812 board.

JP2...JP17

Function: they allow to set the Delay. The Delay values range up to 20 ns with 4 ns steps (please refer to Fig. 2.3 for the jumpers location on the V812 board).

Factory setting is 20 ns ($8 \div 20 \text{ ns}$ range).

Optionally is also available 5ns full scale with 1ns steps ($4 \div 5 \text{ ns}$ range), 50ns full scale with 10ns steps ($10 \div 50 \text{ ns}$ range) and 100ns full scale with 20ns steps ($20 \div 100 \text{ ns}$ range).

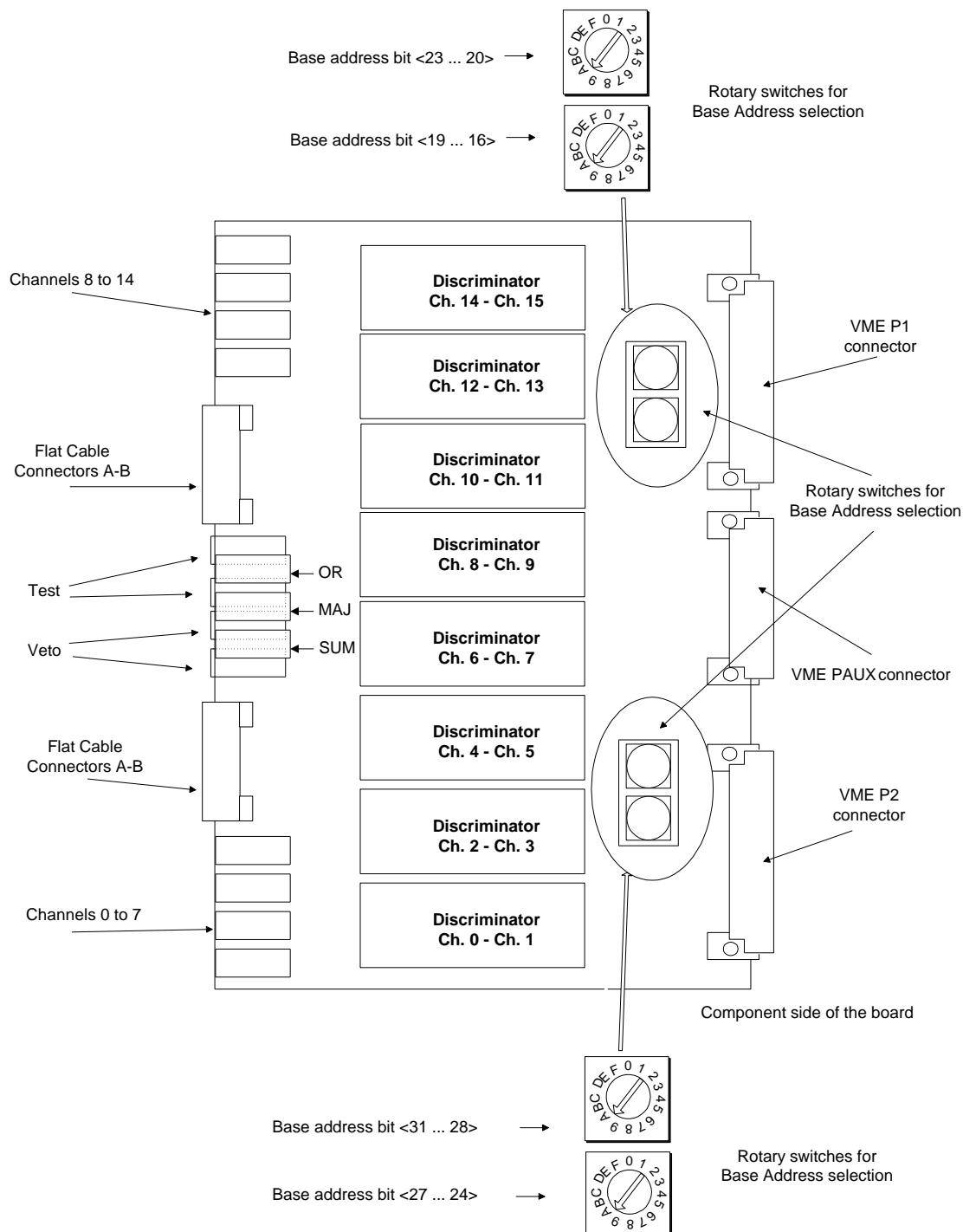


Fig. 2.2: Components location

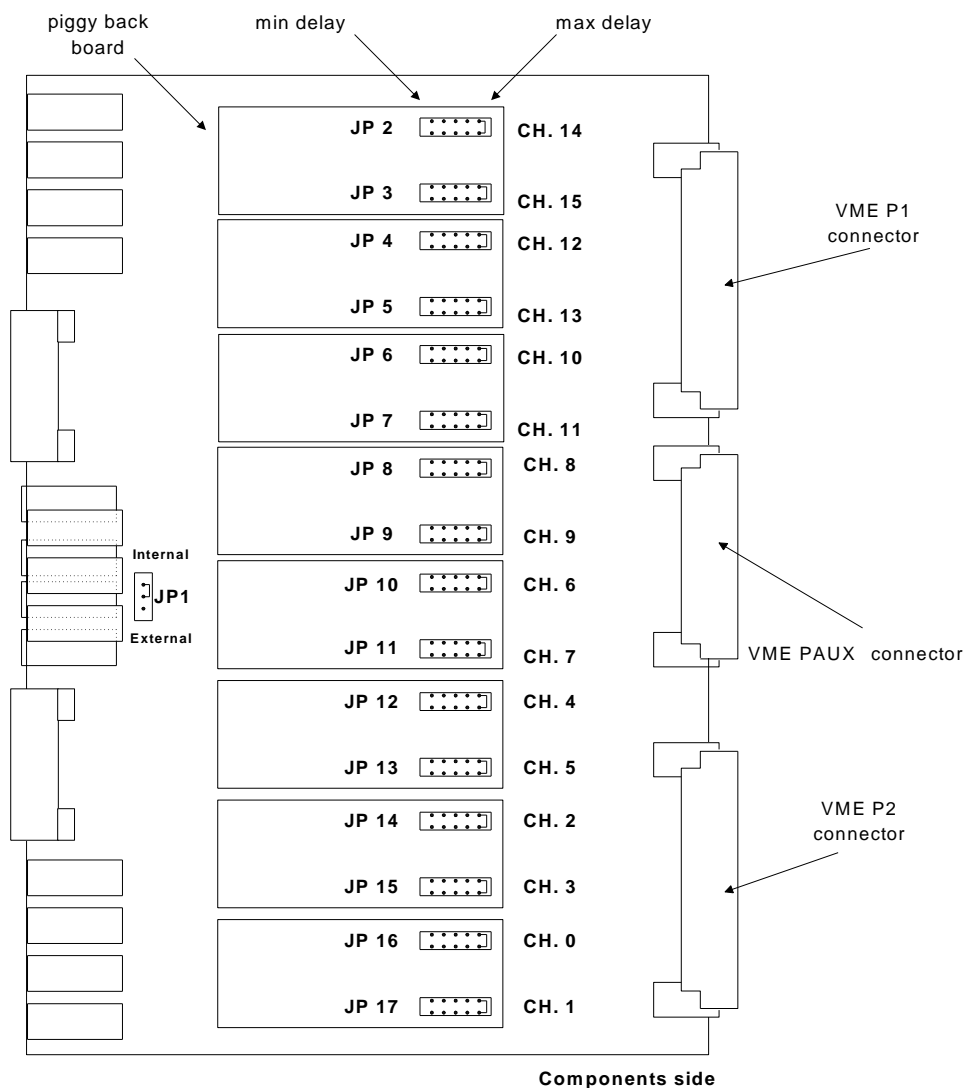


Fig. 2.3: Jumpers location

3.2. *Discriminator thresholds*

(Base address + %00 to %1E write only)

These registers contain the discriminator threshold values on 8 bit words. The threshold values can be programmed in a range from -1 mV to -255 mV with 1 mV steps, writing an integer number between 1 and 255 into the register, although a minimum threshold of -5 mV is required; the channel thresholds are individually settable.

3.3. *Pattern of Inhibit*

(Base address + %4A write only)

This register contains the Pattern of Inhibit, a 16 bit word indicating which channels are either enabled or disabled (bit X=1 \Rightarrow Ch. X enabled...bit X=0 \Rightarrow Ch. X disabled).

3.4. *Output width Ch. 0 to 7 and Ch. 8 to 15*

(Base address + %40 write only; Base address + %42 write only)

These registers contain the output pulse width value of the channels 0 through 7 and channels 8 through 15 respectively, on a 8 bit words. These values can be adjusted in the range from 12 ns to 206 ns (typical values), writing an integer number between 0 and 255 into the registers. The set value corresponds to the width as follows: 255 leads to a 206 ns pulse duration, 0 leads to a 12 ns pulse duration, with a non-linear relation for intermediate values.

3.5. *Dead Time Ch. 0 to 7*

(Base address + %44 write only)

This register is used to select the Dead Time value common to all channels from 0 to 7. This command allows to select on 8 bit (set values: 0 to 255) the Dead Time value between 118 ns and 1625 ns (typical values). The set value corresponds as follows: 255 leads to a 1625 ns value, 0 leads to a 118 ns value.

N.B.: The actual Dead Time is equal to the greater between output width and Dead Time set values

3.6. *Dead Time Ch. 8 to 15*

(Base address + %46 write only)

This register is used to select the Dead Time value common to all Channels from 8 to 15. This command allows to select on 8 bit (set values: 0 to 255) the Dead Time value between 118 ns and 1625 ns (typical values). The set value corresponds as follows: 255 leads to a 1625 ns value, 0 leads to a 118 ns value.

N.B.: the actual Dead Time is equal to the greater between output width and Dead Time set values.

3.7. Majority threshold

(Base address + %48 write only)

This register allows to set the Majority threshold between 1 and 16 for Internal Majority and between 1 and 20 for External Majority by writing a proper value in the Base address + %48 (set values: 1 to 244).

The relation to use is the following:

$$\text{MAJTHR} = \text{NINT}[(\text{MAJLEV} \cdot 50 - 25) / 4]$$

where NINT is the nearest integer function (allowed values for MAJLEV: 1 to 20) e.g., if the User wants to use a majority level of 5, the correct MAJTHR value to use is 56.

3.8. Test pulse

(Base address + %4C write only)

A test pulse on all output channels can be generated by performing a write access at Base address + %4C; the test pulse is generated independently from the number written into this register.

3.9. Module identifier words

(Base address + %F6, + %F8, + %FA, + %FC, + %FE, read only)

Three words located at the Base address , + %F6, + %F8, + %FA, + %FC, + %FE of the page are used to identify the module, as shown in Fig. 3.1:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Version				Module's Serial Number												Add
Manufacturer Number						Module type										Base + %FE
%FA Fixed Code								%F5 Fixed Code								Base + %FC
Long Serial Number MSB																Base + %FA
Long Serial Number LSB																Base + %F6
																Base + %F8

Fig. 3.1: Module Identifier Words

At the address Base + %FA the two particular bytes allow the automatic localization of the module.

For the Mod. V812 the word at the address Base + %FC has the following configuration:

Manufacturer N° = 000010 b

Type of module = 0001010001 b

Bits [12:15] of address BASE + %FE indicates the hardware version. In case of version equal to 0 the serial number is stored in bits [0:11] of the same address.

If the version is 1 or higher, bits [0:11] are set as 0xFFFF and the serial number is indicated address BASE + %F6 (MSB) and BASE + %F8 (LSB).

However, due to hardware limitations, some boards with serial number > 4095 may have BASE + %FE set to 0xFFFF. In such cases, the board's serial number can't be read via software.

4. Principles of operation

4.1. The Constant Fraction Discrimination technique

The Constant Fraction Discrimination technique is based on summing a delayed, full height input signal to an inverted and attenuated signal. The resulting signal is fed into a zero-crossing comparator, thus obtaining a precise timing information that eliminates any walk errors induced by constant rise time and varying amplitude signals.

For correct operation the maximum of the attenuated pulse has to cross the delayed pulse at the selected fraction. This condition leads to the following relation:

$$T_{\text{delay}} = T_{\text{rise}} * (1 - F)$$

where:

T_{delay} = selected delay on the Constant Fraction Discriminator

T_{rise} = rise time of the input signals

F = Constant Fraction value

The Mod. V812 Constant Fraction Discriminator features a factory setting of 20% for the fraction and 20 ns for the full scale delay. The delay can be selected in 4 ns steps up to 20 ns (8 ÷ 20 ns range)

4.2. Power ON / Reset Status

At Power ON the contents of all the module's registers are not determined. A setting of the registers must be performed before any other operation.

4.3. Setting the Delay

For each channel, a 5-positions jumper allows to set the Delay according to the formula expressed in § 4.1. The Delay values range up to 20 ns with a step of 4 ns (8 ÷ 20 ns range); in order to gain access to the jumpers it's necessary to unplug the relevant piggy back board (see for the jumpers location on the V812 board). Factory setting is 20 ns. The fraction is a fixed 20% value.

4.4. Enabling/Disabling the channels

The User can enable or disable each of the 16 channels via VME by performing a VME write access at Base address + %4A. A channel is enabled if the corresponding bit of the Pattern of Inhibit is high (e. g., bin. 1111 1111 1111 0011, or hex FFF3, disables channels 2 and 3 of the discriminator).

4.5. Test, Veto and Or signals

Some operations can be performed by sending two external NIM signals:

- **TEST:** an input signal sent through this connector triggers all the enabled channels at once. This feature allows to test of the module as well as to generate a pattern of pulses suitable to test any following electronics.
- **VETO:** an input signal sent through this connector allows to veto all channels simultaneously. A veto pulse of width T will inhibit the input channels for a period with a T duration. Its leading edge must precede the input signal leading edge by at least 8 ns and overlap completely the input signal.

Note: TEST and VETO are high impedance inputs and each one is provided with two bridged connectors for daisy chaining; the chain has to be terminated on 50 Ohm on the last module; the same is needed also if one module only is used, whose inputs have thus to be properly matched

- An **OR** output connector provides also the logical OR of the output channels. The relevant "OR" LED lights up if at least one of the enabled channels is over threshold.

4.6. Channels test

It is possible to obtain pulses on all channels:

- by sending a NIM pulse through one of the two "TEST" connectors located on the front panel.
- by performing a Write operation at (Base address + %4C).

4.7. Setting the threshold

For each channel of the V812 the discriminator threshold is set up via an 8 bit DAC. The threshold values can be programmed in a range from -1 mV to -255 mV with -1 mV steps (set values: 1 to 255). As in all Constant Fraction Discriminators, these thresholds are to be set above the noise level: they do NOT correspond to the actual level that triggers the discriminator outputs, the latter being a "constant fraction" of the input signals.

In order to write the Threshold for each channel, the User must perform a VME access at (Base address + %00 to %1E).

4.8. Setting the output pulse width

The output pulse width is adjustable on 8 bit from 12 to 206 ns (typical values; set values: 0 to 255) and the chosen value is applied to each group of 8 channels each. It can be set at Base address + %40 for channels 0 to 7 and at Base address + %42 for channels 8 to 15. The set value corresponds to the Width as follows: 255 leads to a 206 ns value, 0 leads to a 12 ns value, with a non-linear interpolation for intermediate values.

4.9. Setting the Dead Time

It is possible via VME to set a Dead Time value in common to a group of 8 channels. This prevents the triggering of the discriminator by unwanted pulses occurring within the Dead Time programmed value. It can be set by a VME access at (Base Address + %44) for channels 0 to 7 and at (Base Address + %46) for channels 8 to 15 (set values: 0 to 255). The set value corresponds to the Dead Time as follows: 255 leads to a 1625 ns value, 0 leads to a 118 ns value (typical values) with a non-linear interpolation for intermediate values.

N.B.: The actual Dead Time is equal to the greater between Output Width and Dead Time set

4.10. Current Sum signal

The front panel also houses the **Current Sum (Σ)** output connector which provides a current proportional to the input signal multiplicity, i.e. to the number of channels over threshold, at a rate of -1.0 mA per hit (-50 mV per hit into a 50 Ohm load) $\pm 20\%$.

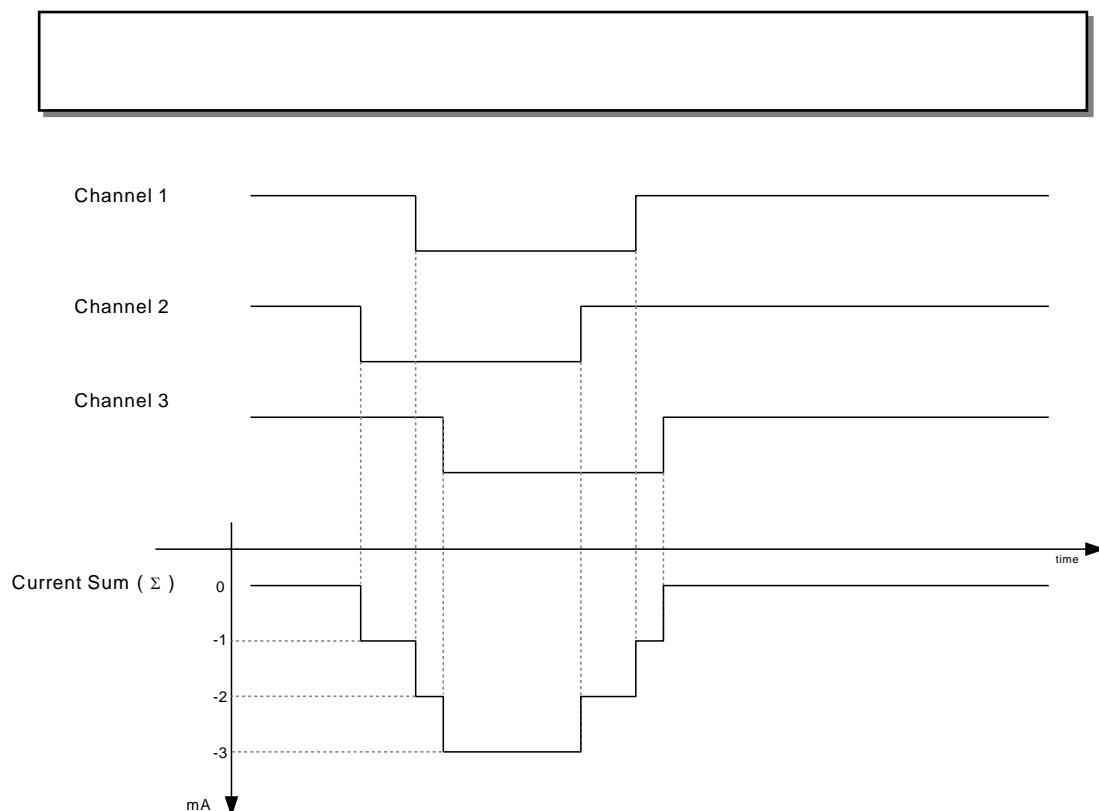


Fig. 4.1: Current Sum signal

4.11. Majority setting

Majority output provides a standard NIM signal if the number of channels over threshold exceeds the programmed majority level (MAJLEV). MAJLEV can be programmed between 1 and 16, writing a proper value (MAJTHR) in the Majority threshold register (see § 0); valid values range between 0 and 255. MAJTHR can be calculated in the following way:

$$\text{MAJTHR} = \text{NINT}[(\text{MAJLEV} \cdot 50 - 25)/4]$$

where NINT is the Nearest Integer.

MAJLEV	MAJTHR	MAJLEV	MAJTHR
1	6	11	131
2	19	12	144
3	31	13	156
4	44	14	169
5	56	15	181
6	69	16	194
7	81	17	206
8	94	18	219
9	106	19	231
10	119	20	244

Table 4.1: Majority Level setting values

The Majority logic can be switched from an "Internal" to an "External" position by means of an internal Jumper (see Fig. 2.3).

- **Internal:** With the jumper on the "Internal" position Majority output provides an active signal if the number of the active channels of the module exceeds the programmed majority level (MAJLEV). In this case valid values of MAJLEV are from 1 to 16

External: Several modules can be connected in daisy chain via the Σ outputs. In this case, by setting the Jumper to the "External" position, the Majority logic will act on the sum of the Σ outputs of the connected modules. The majority signal will be active if the sum of chained modules active channels exceeds or is equal to the programmed MAJLEV. (An example with three chained modules is shown below). The Σ output line must be terminated with 50 Ohm.

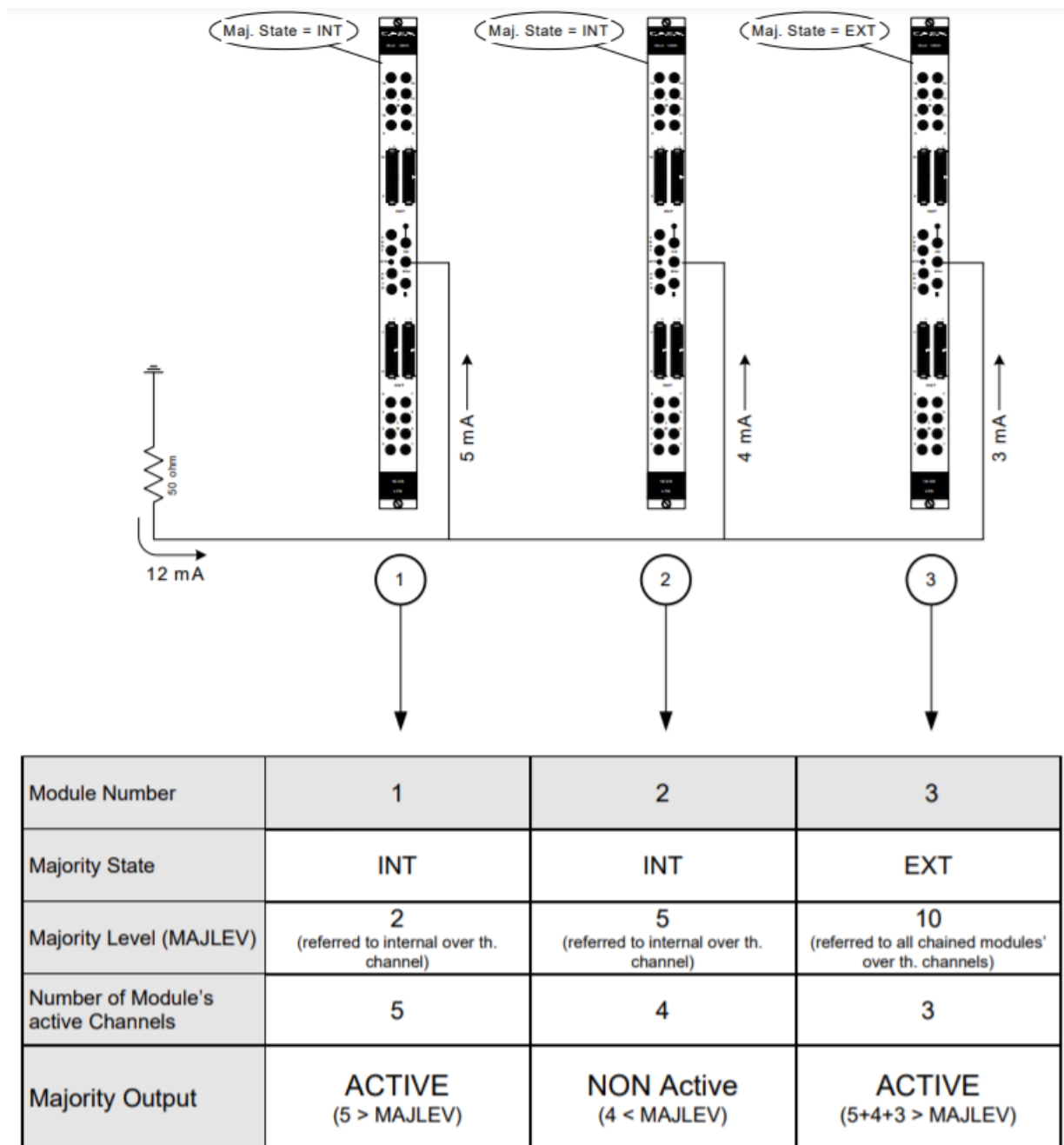
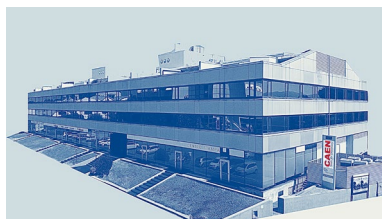


Fig. 4.2: Example of three daisy chained V812

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