Technical Information Manual

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MOD. N1145
*QUAD SCALER
AND PRESET
COUNTER/TIMER*

CAEN will repair or replace any product within the guarantee period if the Guarantor declares that the product is defective due to workmanship or materials and has not been caused by mishandling, negligence on behalf of the User, accident or any abnormal conditions or operations.

CAEN declines all responsibility for damages or injuries caused by an improper use of the Modules due to negligence on behalf of the User. It is strongly recommended to read thoroughly the CAEN User's Manual before any kind of operation.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. General description

1.1. Overview

CAEN Mod. N1145 is a double unit NIM module that includes four independent 8-digit up-counters, plus a fifth 7-digit down-counter that can be used either as a preset counter or as timer.

The counters can perform different operations and can be variously interconnected, thereby making the module a flexible and powerful tool for several applications involving time, frequency and ratio measurements.

All counters can accept either TTL or NIM inputs. All control and output signals are standard NIM. The maximum input frequency is 250 MHz and the minimum pulse width is 2 ns for the up-counters, and respectively 80 MHz and 3 ns for the down-counter.

All input and output connectors as well as all the control switches are located on the front panel. All input and output connectors are LEMO 00 type.

1.2. Front panel
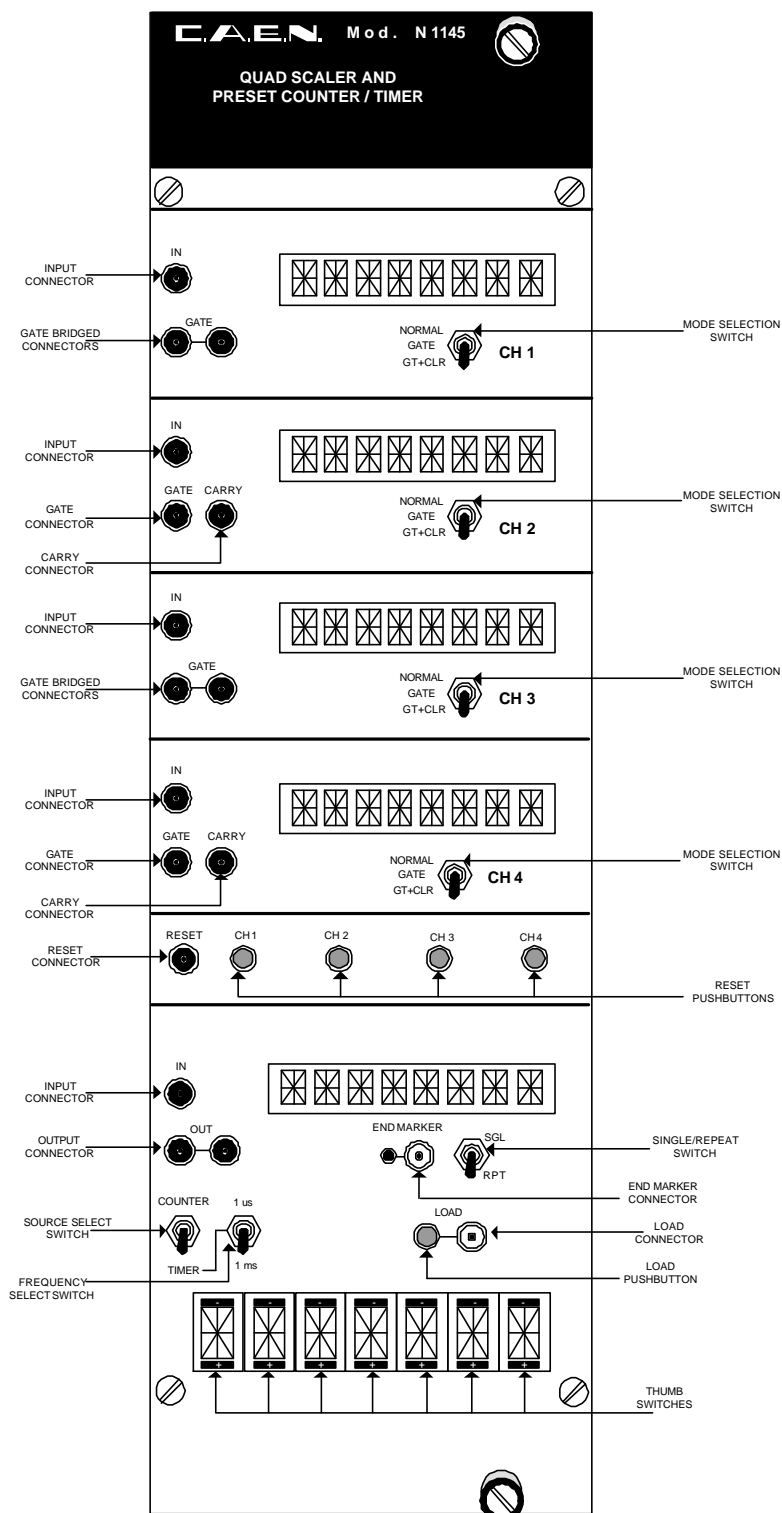
Fig. 1.1 – Mod. N1145 Front Panel

2. Technical specifications

2.1. Packaging

The Model N1145 is housed in a double width NIM module.

2.1. Power requirements

+6 V @ 700 mA; –6 V @ 900 mA

2.2. Front panel I/O connections

SECTIONS 1 AND 3

INPUTS	1, accepts both NIM and TTL signals, 50 Ω impedance.
GATE	2, NIM/TTL bridged input ports, high impedance, internally connected. Free port must be terminated on 50 Ω

SECTIONS 2 AND 4

INPUTS	1, accepts both NIM and TTL signals, 50 Ω impedance.
GATE	one NIM/TTL input, 50 Ω impedance.
CARRY	one NIM output. Generates a pulse when counter has fully cycled (transition 99,999,999 to 0).

SECTIONS 1, 2, 3 and 4

RESET	one NIM/TTL input, 50 Ω impedance, clears *sections 1 to 4*. Same effect is obtained, for each section, with the individual RESET pushbuttons.

SECTION 5

INPUTS	1, accepts both NIM and TTL signals, 50 Ω impedance.
LOAD	one NIM/TTL input, 50 Ω impedance. Loads counter with value preset on the thumb wheel switch digits (same effect with LOAD pushbutton).
OUT	2, NIM outputs, these are true([*])as long as counter contents are different from zero.

([*]) NIM level 1=-800 mV=TRUE

END MARKER one NIM output, a pulse generated when the counter contents become zero. Pulse width is adjusted with trimmer between 50 ns and 1 µs.

All connectors are LEMO 00 type.

2.3. Front panel switches

MODE SELECTION SWITCHES (Section 1 ÷ 4)
Function: they allow to select the operating mode (see § 3.1).

RESET PUSHBUTTONS (Section 1 ÷ 4)
Function: they allow to clear the relevant section (see § 3.1).

SOURCE SELECTION SWITCH (Section 5)
Function: it allows to select the operating mode (see § 3.2).

SINGLE/REPEAT SWITCH (Section 5)
Function: it allows to select the counter cycling (see § 3.2).

FREQUENCY SELECTION SWITCH (Section 5)
Function: it allows to select the internal clock frequency (see § 3.2).

LOAD PUSHBUTTON (Section 5)
Function: it allows to load the thumb switches value (see § 3.2).

THUMB SWITCHES (Section 5)
Function: they allow to set the counter/timer datum (see § 3.2).

2.4. Technical specification table

Table 2.1: Mod. N1145 Technical Features

Packaging		Two units wide NIM module
Inputs		1 NIM/TTL level input per section, 50 Ω impedance; min. FWHM: 2 ns [1] (sections 1 ÷ 4), 3 ns (section 5)
Control inputs	**Comm. Reset**	1 NIM/TTL input, 50 Ω impedance; clears sections from 1 to 4, min. FWHM: 3 ns
	Gate	Section 1 and 3: 2 bridged high-impedance NIM/TTL inputs Section 2 and 4: 50 Ω impedance NIM/TTL input
	Load	1 NIM/TTL input, loads counter with value set on thumb-wheel switches, min. FWHM: 3 ns
Control outputs	**Carry (Section 2 and 4)**	std. NIM level; two sections can be cascaded by feeding first CARRY into the input of the second section, thereby making a 16-digit counter
	End marker	1 NIM output; a pulse is generated when the counter reaches zero. Pulse width can be adjusted by turning the front panel trimmer (50 ns to 1 µs)
	Out	2 NIM outputs; are true as long as counter's value differs from zero
Max. frequency	**Sections 1 to 4**	250 MHz
	Section 5	80 MHz

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[1] FWHM is 2.2 ns when GATE + CLEAR mode (see § 3.1) is used.

3. Principles of operation

3.1. *Sections 1 to 4*

The 8-digit up-counters can operate in three distinct modes, which are:

NORMAL   Free running. The counter is incremented by the input pulses.

GATE   The counter is incremented by input pulses only if the GATE input is true.

GATE + CLEAR   Same as GATE mode, but the leading edge of the GATE input clears the counter.

The modes are manually selectable, for each section, by the relevant switches (see § 2.3) on the front panel. The up-counters are reset to zero, either manually (individually for each section) by acting on the RESET pushbuttons, or electrically (common to all sections) by means of a NIM/TTL pulse on the RESET input.

Sections 1 and 3 have two NIM/TTL high impedance GATE bridged inputs which are internally connected; a NIM/TTL input must be terminated with a 50 Ω impedance at the other port.

Sections 2 and 4 have one 50 Ω GATE NIM/TTL input and one CARRY NIM output. The CARRY output generates a NIM pulse when the counter has fully cycled (transition from max counter value to zero). This can be used to extend the counters' range by cascading sections, as shown later.

3.2. *Section 5*

The fifth counter is a 7-digit counter that can operate as a PRESETTABLE DOWN-COUNTER or as a TIMER. Either mode is selected by the manual SOURCE SELECT switch (labelled COUNTER/TIMER).

In COUNTER mode   the counter is decremented by the external (NIM or TTL) input pulses.

In TIMER mode   the counter is decremented by an internal clock, regardless the input pulses. The frequency is selectable by acting on the TIMER switch and can be set to 1KHz (1 ms) or to 1MHz (1 µs).

In either mode, the counter must be initally preset to the desired value by acting on the Thumb wheel switches and then by loading the datum either manually with the LOAD pushbutton or electrically with the LOAD NIM/TTL pulse[2]. At the trailing edge of the first

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[2] Any value can be loaded except Zero, which is not recognised by the module.

input pulse the OUT ports become true. The counter is then decremented by the input pulses until zero is reached. At the trailing edge of the last input pulse:

the OUT outputs are reset to FALSE (0 V).

the END MARKER output generates a NIM pulse whose length can be adjusted between 50 ns and 1 µs by acting on the trimmer next to the END MARKER connector; this signal is *retriggerable*, thus it can be extended while active by another completed cycle. If the END MARKER is used for retriggering purposes (it is sent to the LOAD connector), a delay larger than the END MARKER duration is required between these connectors.

This arrangement allows direct use of the OUT ports as GATE inputs to the counters of *section 1 to 4.*

CYCLING of Section 5 is controlled by the SINGLE/REPEAT switch, which is labelled SGL/REP.

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In SINGLE mode	the selected function (PRESET COUNTER or TIMER) is performed only once, until zero is reached. In order to restart the counter, a new load operation is required. Actually, when using the LOAD button, the counter can be restarted even BEFORE zero is reached. The LOAD NIM/TTL signal is disabled during counting. After a LOAD via pushbutton, the unit requires 80 ns at least before accepting LOAD pulses, even if the counter is already zero and thus the cycle completed.
In REPEAT mode	a few seconds after zero is reached the counter re-triggers itself automatically, by performing an automatic LOAD, and a new cycle is restarted. The automatic LOAD takes place every 2 seconds after every cycle end. This procedure is repeated indefinitely; anyway, the LOAD button allows to restart the counter at any time. The LOAD NIM/TTL is always useless in REPEAT mode.

Note that by connecting the END MARKER output to the LOAD input the counter is cycled without the time delay of the REPEAT mode.

Important Note: one or more of the following operations may lead the Section 5 to an incorrect operation:
–   The use of an external clock with frequency larger than 80 MHz
–   The use of an external clock with pulse width shorter than 3 ns
–   The variation during the counter operation of the external clock frequency
–   The switching from internal clock to external or vice versa
In any case the counter normal operation is recovered by performing a manual/electrical LOAD.
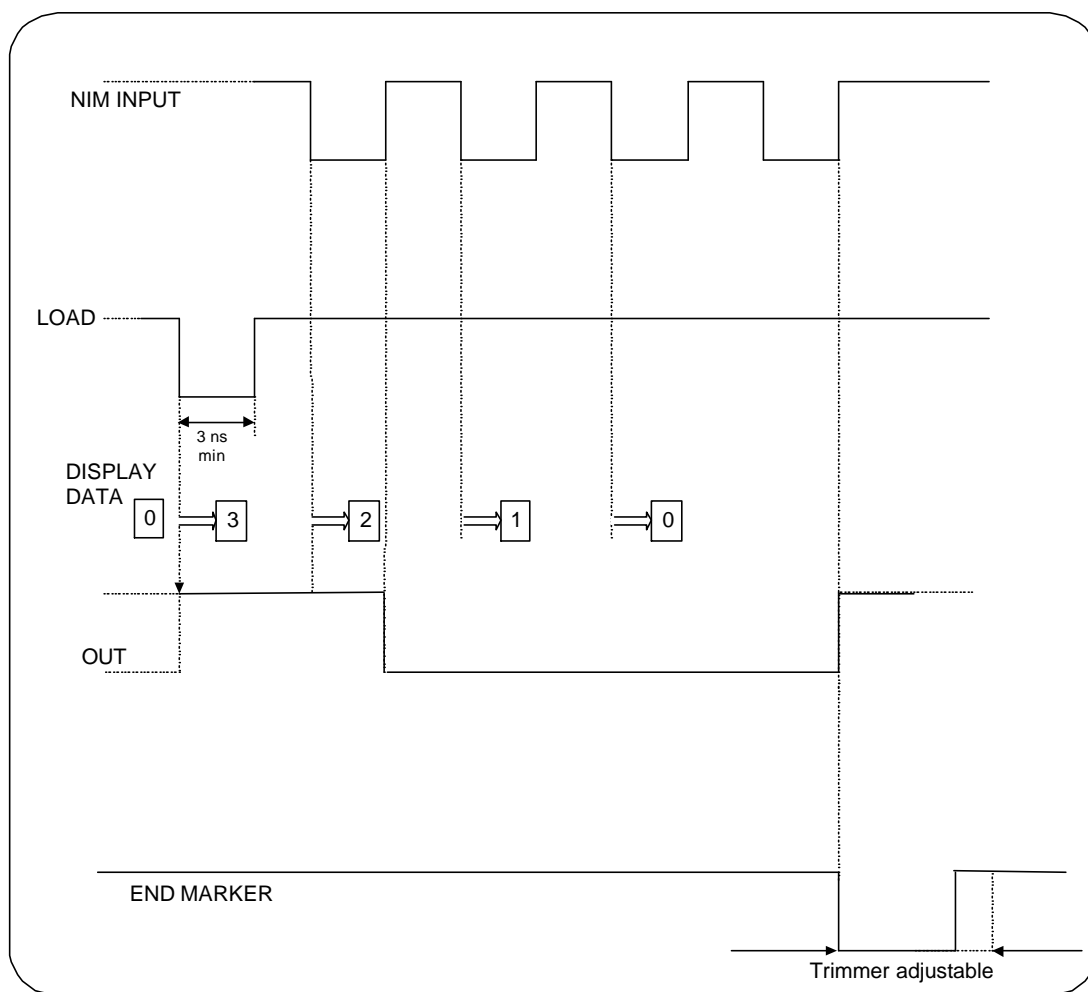
Fig. 3.1 – Section 5 Timing Diagram

4. Operating modes

4.1. Gated up-counting

When in NORMAL MODE, the counters (*sections 1 to 4*) do not require a GATE input. However, when in GATE (or GATE+CLEAR) mode, a NIM/TTL signal must be supplied at the GATE input of each counter used. NOTE: when using NIM input signals, this signal has to be terminated with a 50 Ω impedance at the other GATE bridged input, on *sections 1 or 3*.

A single GATE signal can be sent in parallel, to two channels via cables; if the last *section* is either *2 or 4* then this also provides the correct 50 Ω cable termination. For example*, sections 1 and 2* can share a GATE by feeding the external GATE signal to the GATE input of *section 1* and then connecting a cable between the other GATE output of *section 1* to the GATE input of *section 2*, which has a 50 Ω impedance. It is also possible to connect three *sections* (for instance #1 with #3, and then #3 with #2 or #4) via cables, in order to send them a single external GATE input.

The OUT signal of *section* 5 can be used as the GATE input to the counters. The double OUT connector permits parallel GATE feeding of all four *sections*, as described above.

4.2. 16- or 24- Digit Up-Counting

It is possible to increase the up-counting range to 16 or 24 digits by using the CARRY outputs of *sections 2 and 4*.

For instance, 16-digit up-counting is obtained by connecting the CARRY output of *section 2* to the input of *section 1*. When the counter of *section 2* has fully cycled (transition 99,999,999 to zero) the CARRY output supplies a NIM input pulse to *section 1*, and so on. Thus *section 1* will show the most significant digits, and *section 2* the least significant digits of the counting operation.

Similarly, for 24-digit up-counting, the CARRY output of *section 2* may be connected to the input of *section 4*; the CARRY output of *section 4* may then be fed to the input of *section 1 or 3*.

4.3. Frequency measurements

This is a way of making relative frequency measurements.

By using *section 5* in TIMER MODE, it is possible to make a frequency measurement. For that purpose:

- select the clock rate: $f = 1/\tau$

with the TIMER switch: (τ=1 μs or 1 ms)

- select a value N (for instance a power of 10) with the thumb wheel switches. The measurement time is then: $T_i = N\tau$

- use the OUT signal as the GATE input to the selected *section 1 to 4* Counter(s), operating in GATE+CLEAR mode.

The external input frequency is then given by: $f_i = (M_c)/(N\tau)$

where M_C is the number of pulses received by the Counter while GATE is active.

4.4. Divider

Section 5 can also be used as a divider of an external input sequence. For that purpose:

- connect the END MARKER output to the LOAD input.

- Select the input / output ratio R by setting the thumb wheel switches.

- Connect the external input at the *section 5* input port and pick the NIM output from the OUT ports, which is a pulse generated every R pulses at the input.

4.5. Delay unit

Section 5 can also be used to generate a delayed pulse (at the END MARKER output) or transition (at the OUT ports).

An absolute delay can be obtained with section 5 in TIMER Mode. The duration of the delay is Td=Nτ (actually the time interval between the LOAD signal leading edge and the leading edge of the END MARKER) where N is the preset value on the Thumb wheel switch display, and τ is the internal clock period. The time delay is the elapsed time between the time of the leading edge at the LOAD input and leading edge either at the END MARKER output. See the next section for accuracy. With the counter in COUNTER Mode, a relative delay (in terms of number of pulses) can be obtained between the NIM/TTL input and the END MARKER, after the preset number of input pulses have been counted.

4.6. Measurement accuracy

For the previous applications, it is important to remember that with any measurement made with a counter on a periodic waveform there is always an intrinsic uncertainty of one pulse. This is due to the fact that, depending on the position of the start of the measurement window with respect to the period of the waveform, one pulse may or may not be totally included, and thus counted for. This also applies to the uncertainty of the selection of the reference time window.

The uncertainty of the measurement of an absolute time delay is therefore equal to the clock period.

For frequency measurements it is:

$$\Delta f_i = f_{max} - f_{min} = (M_C)/(N_\tau) - (M_C-1)/(N_\tau) = 1/(N_\tau)$$

where Δf_i is the absolute frequency uncertainty. The relative frequency uncertainty is then:

$$\Delta f_i = 1 - (M_C)$$

and since for a given (constant) frequency $M_C (=N f_\tau)$ is proportional to N, the percent accuracy is increased by increasing N.