Rev. 2 - 03 Nov 2023

N6781

Dual/Quad Digital Multi Channel Analyzer - NIM

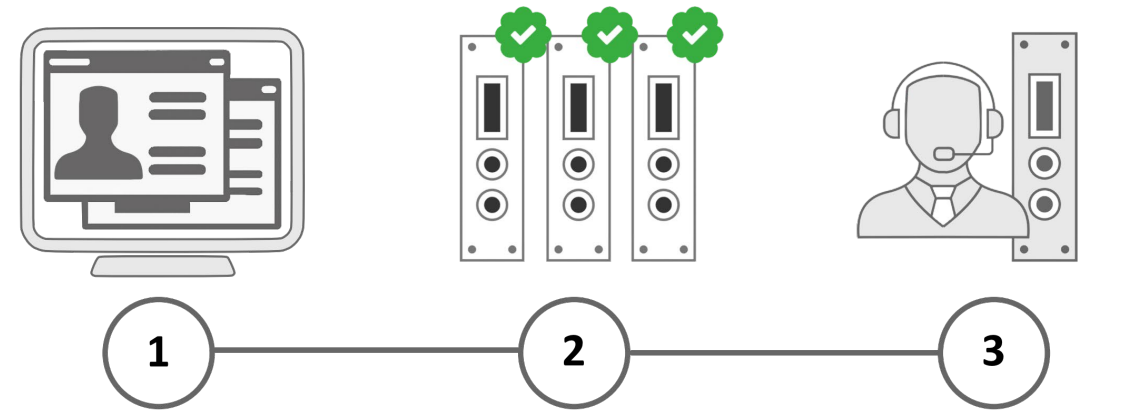
CAEN
Tools for Discovery

User Manual
UM3189

Register your device

Register your device to your **MyCAEN+** account and get access to our customer services, such as notification for new firmware or software upgrade, tracking service procedures or open a ticket for assistance. **MyCAEN+** accounts have a dedicated support service for their registered products. A set of basic information can be shared with the operator, speeding up the troubleshooting process and improving the efficiency of the support interactions.

MyCAEN+ dashboard is designed to offer you a direct access to all our after sales services. Registration is totally free, to create an account go to https://www.caen.it/become-mycaenplus-user and fill the registration form with your data.



https://www.caen.it/become-mycaenplus-user/

Purpose of this Manual

This document contains the full hardware description of the N6781 Dual/Quad Digital MCA.

Change Document Record

Date	Revision	Changes
08 July 2014	00	Initial release.
03 February 2015	01	Added power consumptions at +12V rail for N6781. Updated Chap.11.
03 November	02	Reviewed the document format. Added N6781A power requirements in Chap. **2** and Chap. **5**. Updated **Tab. 1.1**. Added new Chap.**4**. Updated Chap. **8**, Chap. **11**, and Chap. **12**.

Symbols, Abbreviated Terms, and Notation

ADC	Analog to Digital Converter
CSP	Charge Sensitive Preamplifier
DPP	Digital Pulse Processing
DPP-CI	DPP for Charge Integration
DPP-PHA	DPP for Pulse Height Analysis
DPP-PSD	DPP for Pulse Shape Discrimination
MCA	Multi-Channel Analyzer
PMT	Photo Multiplier Tube

Reference Documents

[RD1] GD2512 – CAENUpgrader QuickStart Guide

[RD2] AN2086 – Synchronization of a multi-board acquisition system with CAEN digitizers

[RD3] GD2783 – First Installation Guide to Desktop Digitizers & MCA

[RD4] GD2812 – DeskBoot QuickStart Guide

[RD5] GD2827 - How to make coincidences with CAEN digitizers

[RD6] GD2080 - Introduction to Digitizers

[RD7] UM5960 - CoMPASS User Manual

[RD8] UM4413 - A2818 Technical Information Manual

[RD9] UM3121 - A3818 Technical Information Manual

[RD10] DS7799 - A4818 USB-3.0 to Optical Link Adapter Datasheet

[RD11] UM1934 - CAENComm User & Reference Manual

https://www.caen.it/support-services/documentation-area/

Manufacturer Contacts

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Limitation of Responsibility

If the warnings contained in this manual are not followed, CAEN will not be responsible for damage caused by improper use of the device. The manufacturer declines all responsibility for damage resulting from failure to comply with the instructions for use of the product. The equipment must be used as described in the user manual, with particular regard to the intended use, using only accessories as specified by the manufacturer. No modification or repair can be performed.

Disclaimer

The information contained herein has been carefully checked and is believed to be accurate; however, no responsibility is assumed for inaccuracies. CAEN spa reserves the right to modify its products specifications without giving any notice; for up to date information please visit www.caen.it.

Made in Italy

We remark that all our boards have been designed and assembled in Italy. In a challenging environment where a competitive edge is often obtained at the cost of lower wages and declining working conditions, we proudly acknowledge that all those who participated in the production and distribution process of our devices were reasonably paid and worked in a safe environment (this is true for the boards marked "MADE IN ITALY", while we cannot guarantee for third-party manufactures).

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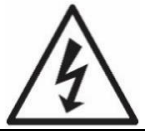
Safety Notices

N.B. Read carefully the "Precautions for Handling, Storage and Installation" document provided with the product before starting any operation.

The following HAZARD SYMBOLS may be reported on the unit:

	Caution, refer to the product manual
	Caution, risk of electrical shock
	Protective conductor terminal
	Earth (Ground) Terminal
	Alternating Current
	Three-Phase Alternating Current

The following symbol may be reported in the present manual:

	General warning statement

The symbol could be followed by the following terms:

- **DANGER**: Indicates a hazardous situation that, if not avoided, will result in serious injury or death.
- **WARNING**: Indicates a hazardous situation that, if not avoided, could result in death or serious injury.

CAUTION: Indicates a situation or condition that, if not avoided, could cause physical injury, or damage the product and/or its environment.

GENERAL NOTICES:

CAUTION: Avoid potential hazards.

USE THE PRODUCT ONLY AS SPECIFIED.

ONLY QUALIFIED PERSONNEL SHOULD PERFORM SERVICE PROCEDURES

CAUTION: Avoid Electric Overload.

TO AVOID ELECTRIC SHOCK OR FIRE HAZARD, DO NOT POWER A LOAD OUTSIDE OF ITS SPECIFIED RANGE

CAUTION: Avoid Electric Shock.

TO AVOID INJURY OR LOSS OF LIFE, DO NOT CONNECT OR DISCONNECT CABLES WHILE THEY ARE CONNECTED TO A VOLTAGE SOURCE

CAUTION: Do Not Operate in Wet/Damp Conditions.

TO AVOID ELECTRIC SHOCK, DO NOT OPERATE THIS PRODUCT IN WET OR DAMP CONDITIONS

CAUTION: Do Not Operate in an Explosive Atmosphere.

TO AVOID INJURY OR FIRE HAZARD, DO NOT OPERATE THIS

PRODUCT IN AN EXPLOSIVE ATMOSPHERE

THIS DEVICE SHOULD BE INSTALLED AND USED BY A SKILLED TECHNICIAN ONLY OR UNDER HIS SUPERVISION

DO NOT OPERATE WITH SUSPECTED FAILURES.
IF YOU SUSPECT THIS PRODUCT TO BE DAMAGED, PLEASE CONTACT THE TECHNICAL SUPPORT

NIM NOTICES:

CAUTION: This product needs proper cooling.

USE ONLY CRATES WITH FORCED COOLING AIR FLOW SINCE OVERHEATING MAY DEGRADE THE MODULE PERFORMANCES!

CAUTION: This product needs proper handling.

THIS DIGITIZER DOES NOT SUPPORT LIVE INSERTION (HOT-SWAP)! REMOVE OR INSERT THE BOARD WHEN THE CRATE IS POWERED OFF!

ALL CABLES MUST BE REMOVED FROM THE FRONT PANEL BEFORE EXTRACTING THE BOARD FROM THE CRATE!

1 Introduction

The **N6781** is a NIM system integrating 4 Independent 16k channels Digital MCA for Gamma and X-ray spectroscopy. A version with 2 independent 16k channels MCA (**N6781A**) is also available by ordering option (see **Tab. 1.1**).

The N6781 is equipped with a **DPP-PHA Firmware**, that is a Digital Pulse Processing algorithm making the N6781 a spectroscopy acquisition system providing energy (i.e. pulse height) and timing information as well as portions of the waveform for debugging, monitoring and pulse shape analysis. It is ideally suited for high energy resolution detectors, such as **HPGe**, connected to the output of a Charge Sensitive Preamplifier (CSP), but it can also properly work with PMT-based detectors (**NaI**, **CsI**) and other types of crystal, provided that the pulse shape is exponential, and the decay time is long enough (typ. > 200 ns). The N6781 operates as a traditional spectroscopy acquisition chain made of Shaping Amplifier plus Peak Sensing ADC, thus representing a digital replacement of that modules. In some cases, it can also replace Discriminators, TDCs, Scalers and Coincidence Units. It is possible to apply the digital algorithm used in the N6781 also to signals that are not coming from CSP (for instance the output of a PMT), but for this type of detector CAEN recommends solutions based on its faster digitizers (such as the 730 or 751 series) running specific algorithms for the digital Charge Integration and Pulse Shape Discrimination (**DPP-PSD**). For details, please refer to **[RD6]**.

The module has been designed to operate as a scalable multi-input acquisition system. Thanks to its four or two inputs of simultaneous acquisition (depending on the model version), it is able to manage coincidences and anticoincidences between multiple detectors, allowing the user, for example, to easily take advantage of background rejection or anti-Compton techniques. The module is designed with synchronization capabilities, so that multi-board systems can easily be built by the customer (see **[RD2]**).

The N6781 houses USB-2.0 and Optical Link interfaces. USB-2.0 allows data transfers up to 30 MB/s. The Optical Link supports transfer rate of 80 MB/s and offers Daisy-chain capability. Therefore, it is possible to connect up to 8/32 MCA modules to a single Optical Link Controller (Mod. A2818/A3818). Optical link can also be used with the A4818 adapter from USB-3.0 to CONET2.

The following list summarizes what can be done by the N6781 and the CoMPASS supported software (see Chap **9**):

- receive the signals coming from a charge sensitive preamplifier (CSP) and adapt to the dynamic range (by the programmable DC offset and Gain);
- detect input pulses and generate a local trigger on them;
- calculate the time of arrival of the trigger and the pulse height by means of digital shaping filters (trapezoidal filters);
- build an event made of a configurable combination of Trigger Time Stamp, Pulse Height (energy) and raw waveforms (i.e. series of ADC samples belonging to a programmable size acquisition window);
- detect pile-up conditions and manage the count loss (dead-time);
- implement coincidences and anticoincidences between channels within the board as well as across different boards (refer to **[RD5]**);
- save events (list) into a memory buffer and manage the readout through the Optical Link or USB;

Lists can be read by the software, which allows to:

- accumulate, plot and save the histograms (energy spectra over up to 16k channels), calculate the dead-time and plot the spectra acquired from each channel;
- generate output files (lists, histograms or waveforms) in a binary or ASCII format.
- run the signal inspector that plots the waveforms of the input signals as well as of the internal filters in order to adjust the parameters of the acquisition;
- set manually or automatically parameter configurations.
- perform advanced mathematical analysis on both the ongoing histograms and collected spectra (e.g. peak search, background subtraction, peak fitting, energy calibration, ROI selection, histogram rebin)

Table of related items:

Board Model	Description
N6781	4 Channel Digital MCA
N6781A	2 Channel Digital MCA
DPP Firmware	**Description**
DPP-PHA*(*)*	Digital Pulse Processing for Pulse Height Analysis
Related Products	**Description**
A1422A005F2	1 Ch. Charge Preamplifier, 5mV/MeVgain
A1422B005F2	4 Ch. Charge Preamplifier, 5mV/MeVgain
A1422C005F2	8 Ch. Charge Preamplifier, 5mV/MeVgain
A1422A045F2	1 Ch. Charge Preamplifier, 45mV/MeVgain
A1422B045F2	4 Ch. Charge Preamplifier, 45mV/MeVgain
A1422C045F2	8 Ch. Charge Preamplifier, 45mV/MeVgain
A1422A090F2	1 Ch. Charge Preamplifier, 90mV/MeVgain
A1422B090F2	4 Ch. Charge Preamplifier, 90mV/MeVgain
A1422C090F2	8 Ch. Charge Preamplifier, 90mV/MeVgain
A1422A400F2	1 Ch. Charge Preamplifier, 400mV/MeVgain
A1422B400F2	4 Ch. Charge Preamplifier, 400mV/MeVgain
A1422A005F3	1 Ch. Charge Preamplifier, 5mV/MeVgain
A1422B005F3	4 Ch. Charge Preamplifier, 5mV/MeVgain
A1422C005F3	8 Ch. Charge Preamplifier, 5mV/MeVgain
A1422A045F3	1 Ch. Charge Preamplifier, 45mV/MeVgain
A1422B045F3	4 Ch. Charge Preamplifier, 45mV/MeVgain
A1422C045F3	8 Ch. Charge Preamplifier, 45mV/MeVgain
A1422A090F3	1 Ch. Charge Preamplifier, 90mV/MeVgain
A1422B090F3	4 Ch. Charge Preamplifier, 90mV/MeVgain
A1422C090F3	8 Ch. Charge Preamplifier, 90mV/MeVgain
A1424	Scintillation Preamplifier
A2818	PCI Optical Link
A3818A	PCIe 1 Optical Link
A3818B	PCIe 2 Optical Link
A3818C	PCIe 4 Optical Link
A4818	A4818 – USB-3.0 to Optical Link
Accessories	**Description**
DT4700	Clock Generator and Fan Out Unit
A318	Adapter for Clock signal FISCHER S101A004 male to 3-pin AMPMODU IV female - 10 cm
A654	Cable assembly LEMO 00 male to MCX male - 1 m
A654 KIT4	4 Cable assembly LEMO 00 male to MCX male - 1 m
A654 KIT8	8 Cable assembly LEMO 00 male to MCX male - 1 m
A659	Cable assembly BNC male to MCX male - 1 m
A659 KIT4	4 MCX to BNC Cable Adapter
A659 KIT8	8 MCX to BNC Cable Adapter
AI2730	Optical Fibre 30 m simplex
AI2720	Optical Fibre 20 m simplex
AI2705	Optical Fibre 5 m simplex
AI2703	Optical Fibre 30 cm simplex
AY2730	Optical Fibre 30 m duplex
AY2720	Optical Fibre 20 m duplex
AY2705	Optical Fibre 5 m duplex

Tab. 1.1: Compliance table of supported CAEN boards, accessories and DPP firmware

(*) The N6781 is delivered factory equipped with a licensed version of the DPP-PHA firmware.

2 Technical Specifications

MECHANICAL	**Dimensions** 1-unit wide NIM		**Weight** 1000 g (related to N6781 version)	
ENVIRONMENTAL	**Operational Conditions** 0 – 50°C Temperature Range - EMC compliant			
ANALOG INPUT	**Input Features** ▪ BNC connector ▪ Single ended, DC coupled ▪ Impedance: 1 kΩ ▪ Positive and negative signals accepted ▪ Programmable 4-step analog coarse gain corresponding to 0.3Vpp-1Vpp-3Vpp-10Vpp ranges ▪ Bandwidth: DC to 5 MHz ▪ Programmable DC offset adjustment on each input in the full scale range		**Number of Inputs** 4 inputs: N67781 2 inputs: N6781A	
ADC	**Resolution** 14 bits		**Sampling Rate** 100 MS/s(simultaneously on each input)	
DIGITAL SIGNAL PROCESSING	▪ Trapezoidal filter for the energy calculation with adjustable rise time in the range 0 - 10µs and flat top in the range 0 – 5µs ▪ Manual and automated trigger threshold adjustment ▪ Manual and automated Pole-Zero cancellation; decay time up to 6.5 ms ▪ Digital decimation in steps of 2-4-8 allows to extend the time parameters range ▪ Digital fine gain ▪ Pile-up detection and Dead Time calculation ▪ Baseline restorer with programmable averaging ▪ Trigger and Timing filter based on integrative-derivative component ▪ Time Stamp: 10 ns resolution, 31 bit and rollover tracking event ▪ Adjustable moving average low pass filter to reduce the high frequency noise			
OPERATING MODES	▪ Pulse Height Analysis (PHA): pulse height histogram (1k-2k-4k-8k-16k) built at software level ▪ List mode: pulse height and time stamp for each event ▪ Oscilloscope mode: input and internal filters waveforms			
TRIGGER MODES	▪ Uncorrelated: each channel operates independently (based on channel self-trigger) ▪ Correlated: coincidence/anticoincidence among channels and/or an external trigger (TRG-IN) ▪ External: channels are triggered by external trigger only (TRG-IN)			
FRONT PANEL DIGITAL I/O	**CLK-IN (AMP Modu II)** AC coupled differential Input Clock: LVDS, ECL, PECL, LVPECL, CML (single ended NIM/TTL available by orderable cable); Jitter<100ppm requested; Can be used as external clock reference for single board or to synchronize the clocks of multiple boards, provided through a Fan In **TRG-IN (LEMO)** External Trigger Input: NIM/TTL, Z_{in} = 50 Ω Can be used to force the event acquisition from all the channels of the board, to gate/veto the individual channel triggers, or to propagate the common trigger in multi-board synchronization (in combination with GPO)		**GPO (LEMO)** General Purpose Output: NIM/ TTL, Z_{in} = 50 Ω Can be used to propagate the global trigger in multi-board synchronization (in combination with TRG-IN), as output register or Run ON/OFF status **GPI (LEMO)** General Purpose Input: NIM/TTL, Z_{in} = 50 Ω Can be used as SYNC/START in multi-board synchronization or Run ON/OFF Control	
COMMUNICATION INTERFACE	**Optical Link** CAEN CONET proprietary protocol Up to 80 MB/s transfer rate Daisy chain capability: it is possible to connect up to 8 or 32 ADC modules to a single Optical Link Controller (A2818 or A3818 respectively)		**USB** USB 2.0 compliant Up to 30 MB/s transfer rate	
FIRMWARE	Firmware can be upgraded via USB/Optical Link			
SOFTWARE	Fully controlled by DPP-PHA Control Software and the MC² Analyzer spectroscopy Software For developers: general purpose C libraries with demo samples available			
POWER REQUIREMENTS	Operating Supply Voltages: (± 10% tolerance)	**@ +6 VDC (Typ.)**	**@ -6 VDC (Typ.)**	**@+12 VDC (Typ.)**
	N6781	3.3 A	100 mA	280 mA
	N6781A	2.5 A	80 mA	120 mA

Tab. 2.1: N6781 Specifications Table

3 Packaging and Compliancy

The N6730 and N6725 are NIM module housed in a single-width unit (weight 880 g).

The device is inspected by CAEN before the shipment, and it is guaranteed to leave the factory free of mechanical or electrical defects.

The content of the delivered package standardly consists of the part list shown in the table below (**Tab. 3.1**).

	Part	Description	Qt
	N6781	MCA device	x1
	Documentation	UM3189 – N6781 Dual/Quad Digital MCA User Manual	x1

Tab. 3.1: Delivered kit content

CAUTION: to manage the product, consult the operating instructions provided.

When receiving the unit, the user is strictly recommended to:

- Inspect containers for damage during shipment. Report any damage to the freight carrier for possible insurance claims.
- Check that all the components received match those listed on the enclosed packing list as in **Tab. 3.1**. (CAEN cannot accept responsibility for missing items unless we are notified promptly of any discrepancies.)
- Open shipping containers; be careful not to damage contents.
- Inspect contents and report any damage. The inspection should confirm that there is no exterior damage to the unit such as broken knobs or connectors and that the front panel and display face are not scratched or cracked. Keep all packing material until the inspection has been completed.
- If damage is detected, file a claim with the carrier immediately and notify CAEN service.
- If equipment must be returned for any reason, carefully repack equipment in the original shipping container with original packing materials if possible. Please, contact CAEN service (Chap. **12**).

If equipment is to be installed later, place equipment in the original shipping container and store it in a safe place until ready to install.

DO NOT SUBJECT THE ITEM TO UNDUE SHOCK OF VIBRATIONS

DO NOT BUMP, DROP OR SLIDE SHIPPING CONTAINERS

DO NOT LEAVE ITEMS OR SHIPPING CONTAINERS UNSUPERVISED IN AREAS WHERE UNTRAINED PERSONNEL MAY MISHANDLE THE ITEMS

USE ONLY ACCESSORIES WHICH MEET THE MANUFACTURER'S SPECIFICATIONS

Official documentation, firmware updates, software tools, and accessories are available on the CAEN website *www.caen.it* in the product web page (**login required**).

The module is housed in a single-width NIM unit.

4 PID (Product Identifier)

PID is the CAEN product identifier, an incremental number greater than 10000 that is unique for each product. The PID is on a label affixed to the product (**Fig. 4.1**) and readable by software using the Get Information function of CAENUpgrader tool (see Sec. **CAENUpgrader**).

Fig. 4.1: PID location on the NIM device (the number and digitizer model in the picture are purely indicative)

5 Power Requirements

Tab. 5.1 reports the supply voltage operating conditions and the current consumptions for both the available board versions.

	OPERATING SUPPLY VOLTAGE (nominal)	POWER CONSUMPTIONS (Typical)
N6781	+6 V	3.3 A
	-6 V	100 mA
	+12 V	280 mA
N6781A	+6 V	2.5 A
	-6 V	80 mA
	+12 V	120 mA

Tab. 5.1: Power requirements table

6 Panel Description

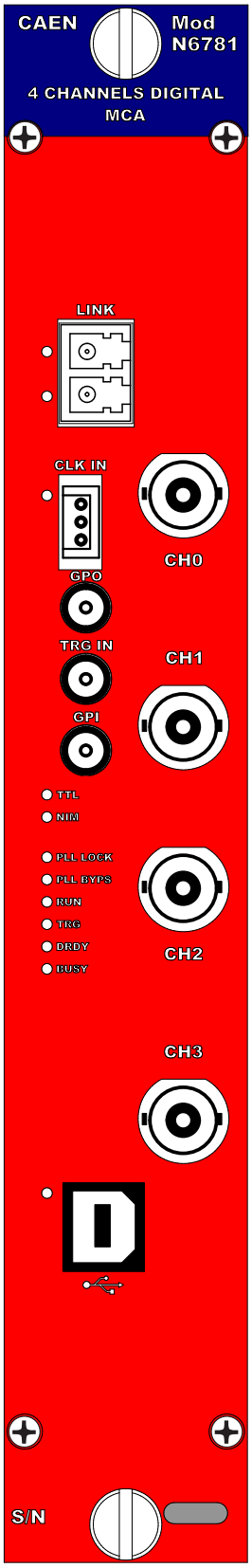


Fig. 6.1: N6781 rear panel view

ANALOG INPUT

FUNCTION

Input connectors receiving the analog signals from the detector.

ELECTRICAL SPECS

Input dynamics: 0.3 V; 1.0 V; 3.0 V; 10 V (software selectable).

Input impedance (Z_{in}): 1 kΩ.

MECHANICAL SPECS

Series: BNC connectors.

Type: R 141 557 000W.

Manufacturer: RADIALL.

EXTERNAL CLOCK IN

FUNCTION

Input for the external clock.

ELECTRICAL SPECS

Sign. type: differential (LVDS, ECL, PECL, LVPECL, CML).

Coupling: AC.

Z_{diff}: 100 Ω.

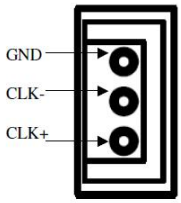
MECHANICAL SPECS

Series: AMPMODU connectors.

Type: 3-102203-4 (3-pin).

Manufacturer: AMP Inc.

PINOUT



CLK IN LED (GREEN): indicates the external clock is enabled.

GENERAL PURPOSE OUTPUT

FUNCTION

General purpose digital output. Can be used to propagate the trigger as well as the GPI signal to other boards connected in Daisy chain.

ELECTRICAL SPECS

Signal level: NIM or TTL.

Requires 50 Ω termination.

MECHANICAL SPECS

Series: 101 A 004 connectors.

Type: DLP 101 A 004-28.

Manufacturer: FISCHER.

Alternatively:

Type: EPL 00 250 NTN.

Manufacturer: LEMO.

EXTERNAL TRIGGER INPUT

FUNCTION

Input for the external trigger.

ELECTRICAL SPECS

Signal level: NIM or TTL.

Input impedance (Z_{in}): 50 Ω.

MECHANICAL SPECS

Series: 101 A 004 connectors.

Type: DLP 101 A 004-28.

Manufacturer: FISCHER.

Alternatively:

Type: EPL 00 250 NTN.

Manufacturer: LEMO.

GENERAL PURPOSE INPUT

FUNCTION

General purpose digital input. Can be used to reset the time stamp or to start/stop the acquisition.

ELECTRICAL SPECS

Signal level: NIM or TTL.

Input impedance (Z_{in}): 50 Ω.

MECHANICAL SPECS

Series: 101 A 004 connectors.

Type: DLP 101 A 004-28.

Manufacturer: FISCHER.

Alternatively:

Type: EPL 00 250 NTN.

Manufacturer: LEMO.

OPTICAL LINK PORT

FUNCTION

Optical LINK connector for data readout and flow control. Daisy chainable. Compliant to Multimode 62.5/125µm cable featuring LC connectors on both sides.

ELECTRICAL SPECS

Transfer rate: up to 80 MB/s.

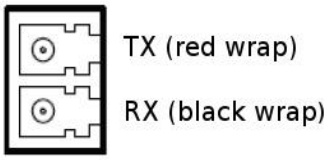
MECHANICAL SPECS

Series: SFF Transceivers.

Type: FTLF8519F-2KNL (LC connectors).

Manufacturer: FINISAR.

PINOUT



LINK LEDs (GREEN/YELOW): right LED (GREEN) indicates the network presence, while left LED (YELLOW) signals the data transfer activity.

USB PORT

FUNCTION

USB connector for data readout and flow control.

ELECTRICAL SPECS

Standard: compliant to USB 2.0 and USB 1.0.

Transfer rate: up to 30 MB/s.

MECHANICAL SPECS

Series: USB connectors.

Type: 787780-2 (B-Type).

Manufacturer: AMP Inc.

USB LINK LED (GREEN): indicates the USB communication is active.

DIAGNOSTICS LEDs

TTL (GREEN): indicates GPO, TRG IN, and GPI signals are TTL;

NIM (GREEN): indicates GPO, TRG IN, and GPI signals are NIM;

PLL LOCK (GREEN): indicates PLL is locked to the reference clock;

PLL BYPS (GREEN): indicates the PLL drives directly the ADCs. PLL circuit is switched off and PLL LOCK LED is turned off;

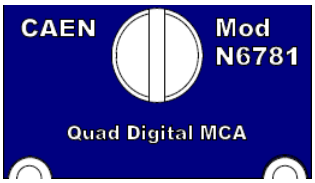
RUN (GREEN): indicates the acquisition is running (data taking). Please, refer to the ACQUISITION_STATUS register description, Chapter 8 of Errore. L'origine riferimento non è stata trovata.).

TRG (GREEN): indicates the trigger is accepted.

DRDY (GREEN): indicates the event/data is present in the Output Buffer.

BUSY (RED): indicates all the buffers are full for at least one channel.

LABELS



Top:

- Model name.
- Short functional description

Bottom:

- SN: 4-digit serial number (old boards)
- PID: 10-digit product identifier (recent boards)

7 Notes on operating

The N6781 operates on the analog signals provided on its 2/4 inputs the same as a N6780 or a N6724 module equipped with a DPP-PHA Firmware for the Digital Pulse Height Analysis.

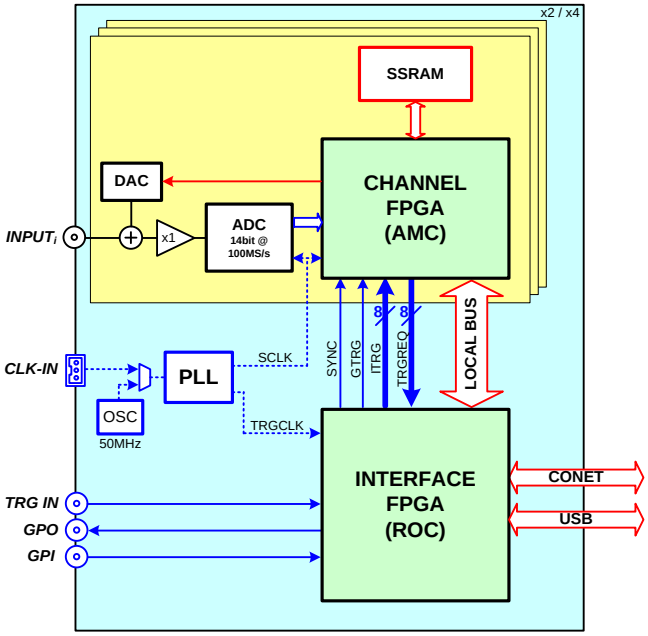


Fig. 7.1: Simplified block diagram of the digitizer block in the N6781

The N6781 is an acquisition system that receives the analog signal and performs a continuous A/D conversion (@100 MS/s, 14 bit) at the input of the module, just after an analog input stage whose purpose is to adapt the signal voltage swing to the dynamic range of the ADC. After the A/D conversion, the stream of samples is managed by an FPGA programmed to perform on-line Digital Pulse Processing in order to implement the MCA based on the Pulse Height Analysis (**DPP-PHA**); the algorithms implemented in the DPP-PHA firmware are based on the trapezoidal filter (Moving Window Deconvolution) for the calculation of the pulse height.

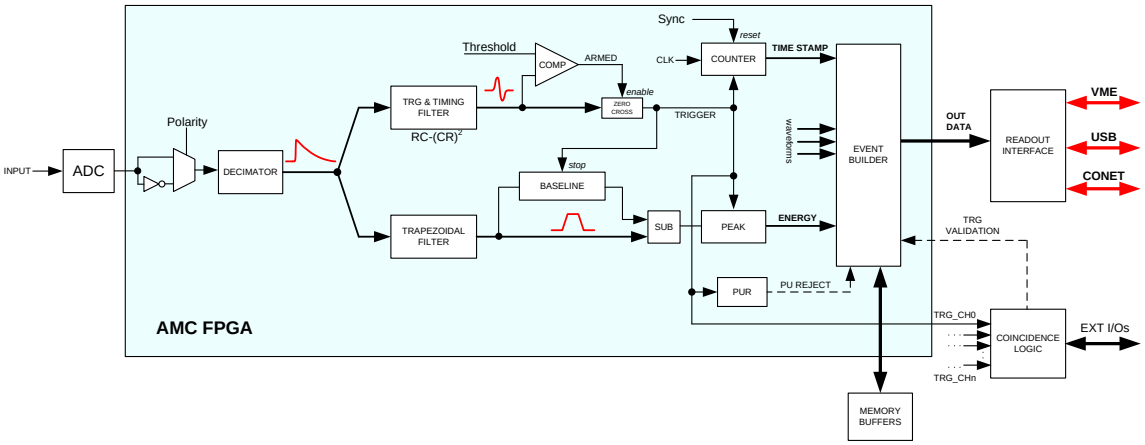


Fig. 7.2: Block Diagram of the processing chain programmed into the digitizer's FPGA

Refer to **[RD7]**for a detailed description of:

- Principle of operation of the DPP-PHA Firmware.
- Acquisition modes supported at firmware level.
- Memory organization

8 Drivers & Libraries

Drivers

To interface with the board, CAEN provides Windows® and Linux® drivers for the different types of the supported physical communication links:

- **CONET Optical Link,** managed by the A2818 (PCI) A3818 (PCIe) cards. The driver installation packages are downloadable for free on CAEN website at the A2818 or A3818 page respectively (**login required**).

Note: For the installation of the Optical Link driver, refer to the User Manual of the specific card **[RD8][RD9]**.

- **USB2.0 Link.** The driver installation packages are downloadable for free on CAEN website at the digitizer page (**login required**).

Note: to install the USB Link driver on Windows OS, refer to the dedicated Guide **[RD3]**. Linux users can follow the installation instructions of the ReadMe file included in the packet.

- **USB-3.0 Link**, managed by the A4818 (USB3-to-CONET) Adapter. The driver installation package is downloadable for free on the CAEN website at the adapter page **(login required).** Find the installation instructions in the adapter data sheet **[RD10]**.

Libraries

CAEN libraries are a set of middleware software required by CAEN software tools for a correct functioning. These libraries, including also demo and example programs, represent a powerful base for users who want to develop customized applications for the digitizer control (communication, configuration, readout, etc.):

- **CAENDPP (DPP-PHA firmware only)** is a high-level library of C functions designed to completely control exclusively CAEN digitizers running DPP-PHA firmware and Digital MCAs. The library manages all the relevant board settings, DPP parameters configuration, data acquisition storage. Configuration of synchronized start/stop acquisition is supported in multi-board hardware setup, as well as the single board can be configured for coincidences or anticoincidences among channels. Histograms are built at the library level and managed through specific library functions; other advanced histogram functionalities are provided (e.g. histogram recovery). Lists of data can be automatically saved to output files. HV management is also handled by the library, if supported by the target board.
- **CAENDigitizer** is a library of C functions designed specifically for the Digitizer family and it supports also the boards running the DPP firmware. The CAENDigitizer library is based on the CAENComm which is based on CAENVMELib, as said above. For this reason, **the CAENVMELib and CAENComm libraries must be already installed on the host PC before installing the CAENDigitizer**.
- **CAENComm** library manages the communication at low level (read and write access). The purpose of the CAENComm is to implement a common interface to the higher software layers, masking the details of the physical channel and its protocol, thus making the libraries and applications that rely on the CAENComm independent from the physical layer. Moreover, the CAENComm is based in turn on CAENVMELib and it requires the CAENVMELib library (access to the VME bus) even in the cases where the VME is not used. This is the reason why **CAENVMELib must be already installed on your PC before installing the CAENComm**.

Find the libraries installation packages for free download on CAEN web site (www.caen.it) at the relevant library product page (**login required**).

WHEN TO INSTALL CAEN LIBRARIES:

WINDOWS® compliant CAEN software = NOT*. CAEN software for Windows® are stand-alone, which means the program locally installs the DLL files of the required libraries.*

LINUX® compliant CAEN software = YES*. CAEN software for Linux® is not stand-alone. The user must install the required libraries apart to run the software.*

WINDOWS® and LINUX® compliant customized software = YES*. The user must install the required libraries apart in case of custom software development.*

Supported communication links:

PC → USB2 → N6781

PC → PCI (A2818) → CONET2 → N6781

PC → PCIe (A3818) → CONET2 → N6781

PC → USB3 → A4818 → CONET2 →N6781

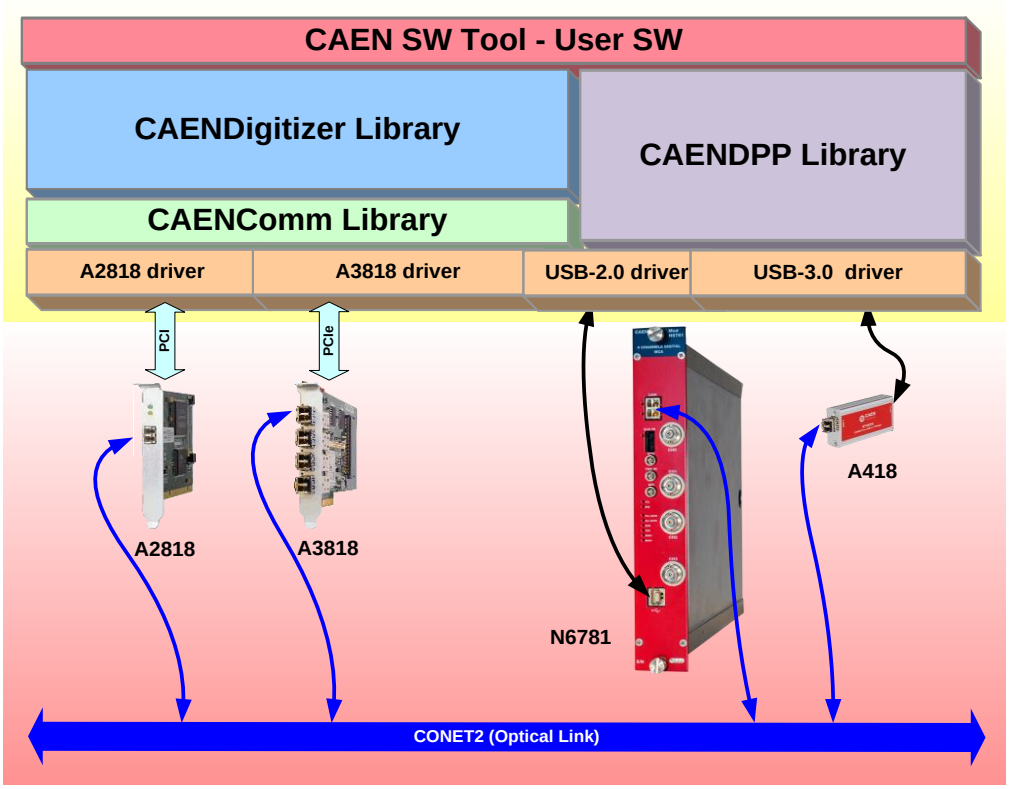


Fig. 8.1: Hardware and software layers scheme

9 Software Tools

CAEN provides software tools to interface the 730 and 725 digitizer families, which are available for free download on CAEN web site (www.caen.it) in the relevant software and firmware product pages (**login required**).

CAENUpgrader

CAENUpgrader is a software composed of command line tools together with a Java Graphical User Interface.

With N6781, CAENUpgrader allows in few easy steps to:

- Upload different FPGA firmware versions on the digitizer
- Read the firmware release of the digitizer and the Controller (when included in the communication chain)
- Upgrade the internal PLL
- Get the Board Info file, useful in case of support
- Manage the reboot of the FPGA firmware from the Backup or the Standard FLASH page.

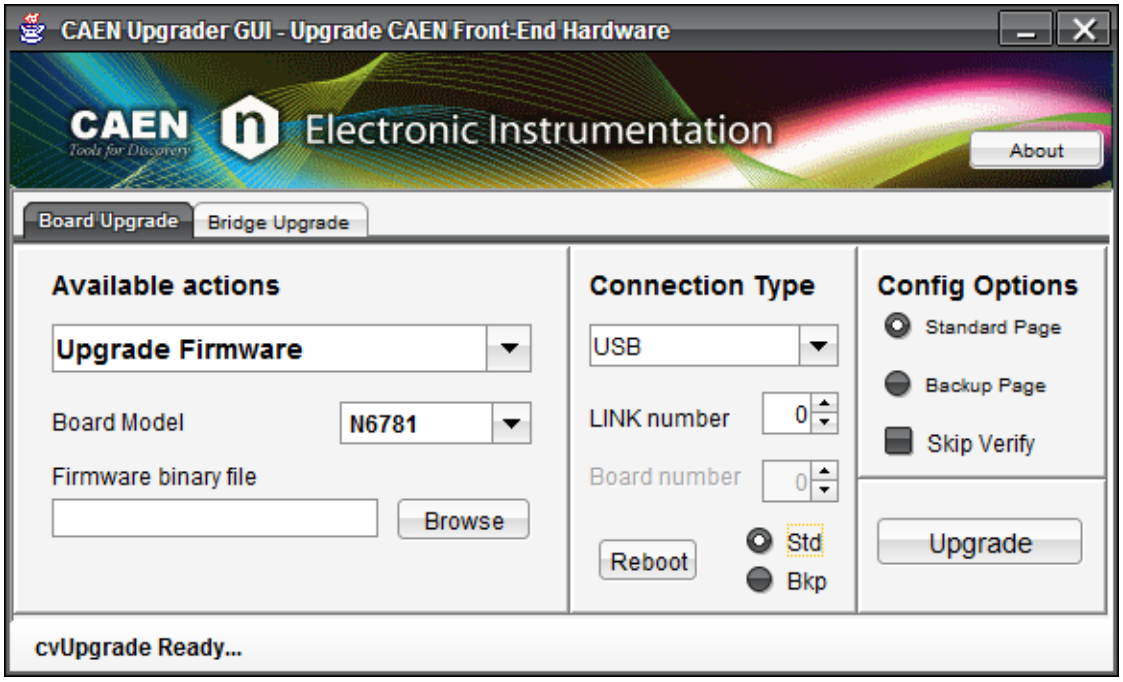


Fig. 9.1: CAENUpgrader Graphical User Interface

CAENUpgrader runs on Windows® and Linux® platforms, 32 and 64-bit operating systems. User must also install the required third-party Oracle Java RE 8 u40 or higher.

The software relies on the CAENComm library (see Chap. Errore. L'origine riferimento non è stata trovata.).

CAENUpgrader for Windows® is stand-alone, the user needs to install only the driver for the communication link, while the software locally installs the DLLs of the required libraries.
The Linux® version of the software needs the required CAENVME and CAENCOMM libraries to be installed apart by the user.

Refer to the CAENUpgrader documentation for installation instructions and a detailed description **[RD1]**.

CAENComm Demo

CAENComm Demo is a simple software developed in C/C++ source code and provided both with Java™ and LabVIEW™ GUI interface. The demo mainly allows for a full board configuration at low level by direct read/write access to the registers and may be used as a debug instrument.

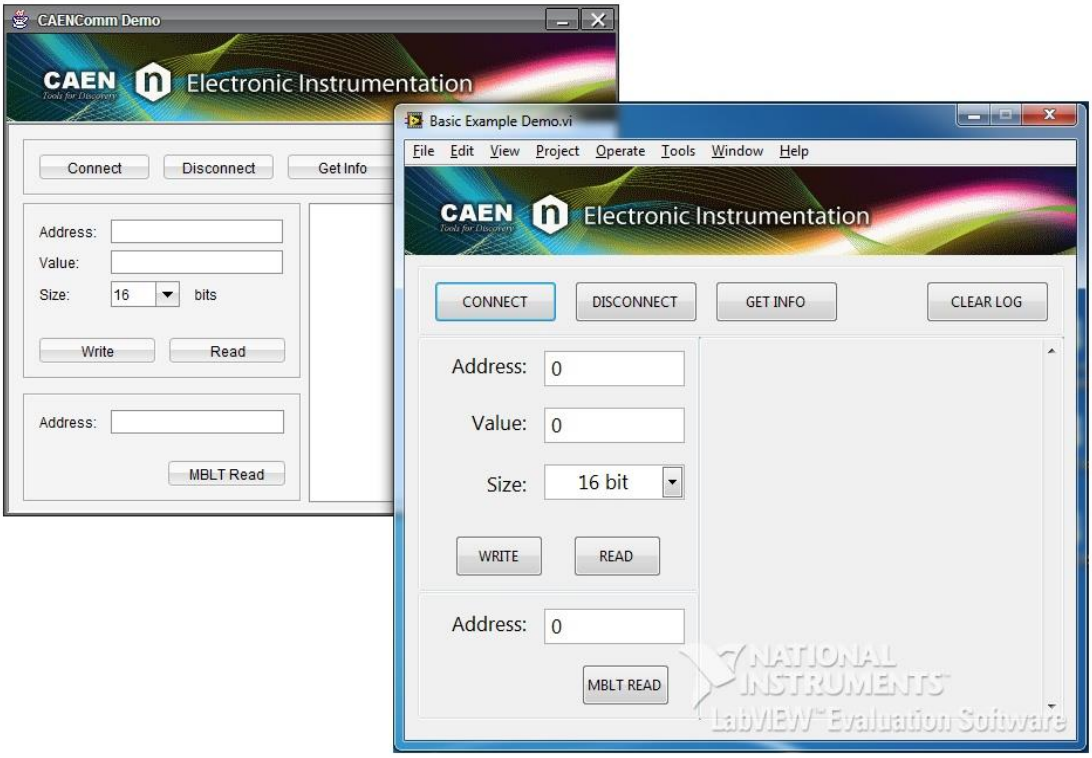


Fig. 9.2: CAENComm Demo Java and LabVIEW graphical interface

The Demo is currently provided only with the CAENComm library Windows® installation package.

Refer to the CAENComm documentation for installation instructions and a detailed description **[RD11]**.

CoMPASS

THIS SOFTWARE DOES NOT WORK WITH WAVEFORM RECORDING FIRMWARE

CoMPASS (CAEN Muti-PArameter Spectroscopy Software) is the new software from CAEN able to implement a Multi-parametric DAQ for Physics Applications, where the detectors can be connected directly to the digitizer inputs and the software acquires energy, timing, and PSD spectra. Both Linux® and Windows® OS are supported.

CoMPASS software has been designed as a user-friendly interface to manage the acquisition with all the CAEN DPP algorithms. CoMPASS can manage multiple boards, even in synchronized mode, and the event correlation between different channels (hardware and/or software), apply energy and PSD cuts, calculate and show the statistics (trigger rates, data throughput, etc...), save the output data files (raw data, lists, waveforms, spectra) and use the saved files to run off-line with different processing parameters.

CoMPASS Software supports CAEN 720, 724, 725, 730, 740D, 751 digitizer families running the DPP-PSD, DPP-PHA and DPP-QDC firmware, and the 781 MCA family.

Fig. 9.3: CoMPASS software tool

Refer to CoMPASS documentation for installation instructions and a detailed description **[RD7].**

10 HW Installation

Before installing the hardware, please pay attention to the here listed warnings.

ONLY QUALIFIED PERSONNEL SHOULD PERFORM INSTALLATION OPERATIONS

DO NOT INSTALL THE EQUIPMENT SO THAT IT IS DIFFICULT TO ACCESS THE BACK PANEL FOR DISCONNECTING THE DEVICE

IT IS RECOMMENDED THAT THE SWITCH OR CIRCUIT-BREAKER IS NEAR THE EQUIPMENT

THE SAFETY OF ANY SYSTEM THAT INCORPORATES THE DEVICE IS UNDER THE RESPONSIBILITY OF THE ASSEMBLER OF THE SYSTEM

Then:

- Insert the Digitizer into a compliant crate:
- Power up the crate

Power ON Status

Power-on takes a few seconds during which the front panel LEDs may flash.

After power-on, the module is in the following status:

- The Output Buffer is cleared.
- Registers are set to their default configuration.
- Only NIM and PLL LOCK LEDs must stay on (see **Fig. 10.1**)

Fig. 10.1: Front panel LEDs status at power ON

11 Firmware and Upgrades

The N6781 is delivered running a licensed version (i.e. not time limited) of the DPP-PHA Firmware. This means that no license needs to be bought apart by the user when purchasing a N6781.

Note: after loading a DPP-PHA firmware update on the N6781, the stored license remains valid.

The board hosts one FPGA on the mainboard and two FPGAs on the mezzanine (i.e. each FPGA serves 2 channels). The channel FPGAs firmware is identical. A unique file is provided that will updated all the FPGAs at the same time.

ROC FPGA MAINBOARD FPGA (Readout Controller + VME interface):

FPGA Altera Cyclone EP1C20.

AMC FPGA CHANNEL FPGA (ADC readout/Memory Controller):

FPGA Altera Cyclone EP1C20

The firmware is stored onto on-board FLASH memory. Two copies of the firmware are stored in two different pages of the FLASH, called Standard (STD) and Backup (BKP); at power on, a microcontroller reads the FLASH memory and programs the module with the firmware version that is the STD one by default.

It is possible to upgrade the board firmware via USB or Optical Link by writing the FLASH with the CAENUpgrader software (see Chap. **9**)

IT IS STRONGLY SUGGESTED TO OPERATE THE DIGITIZER UPON THE STD COPY OF THE FIRMWARE. UPGRADES ARE SO RECOMMENDED ONLY ON THE STD PAGE OF THE FLASH. THE BKP COPY IS TO BE INTENDED ONLY FOR RECOVERY USAGE. IF BOTH PAGES RESULT CORRUPTED, THE USER WILL NO LONGER BE ABLE TO UPLOAD THE FIRMWARE VIA USB OR OPTICAL LINK AGAIN AND THE BOARD NEEDS TO BE SENT TO CAEN IN REPAIR!

Firmware Upgrade

Firmware updates are available for download on CAEN website (www.caen.it) at the MCA page **(login required)**.

The updates are uniquely DPP-PHA firmware.

Firmware File Description

The programming file is a CFA file (CAEN Firmware Archive). It is an archiving file format that aggregates all the programming files of the same firmware kind which are compatible with one or more digitizer families.

The name of the CFA file follows a general convention:

The firmware file for the M6781 is named as:

x724_x780_x781_V1782_DPP_PHA_X.Y_128.Z.cfa

where:

- x724_x78x are all the boards the file is compliant to.
- DPP-PHA is the specific digital algorithm implemented into the firmware.
- X.Y is the major/minor revision number of the mainboard FPGA.
- 128.Z is the major/minor revision number of the channel FPGA. The 128 value is fixed and identifies the DPP-PHA algorithm.

Troubleshooting

In case of upgrade failure (e.g. STD FLASH page is corrupted), the user can try to reboot the board: after a power cycle, the system programs the board automatically from the alternative FLASH page (e.g. BKP FLASH page), if this is not corrupted as well (check the LED status as in Sec. **Power ON Status**). The user can so perform a further upgrade attempt on the STD page to restore the firmware copy.

The reboot from the FLASH pages is managed by CAENUpgrader only though the USB link (**Fig. 11.1**).

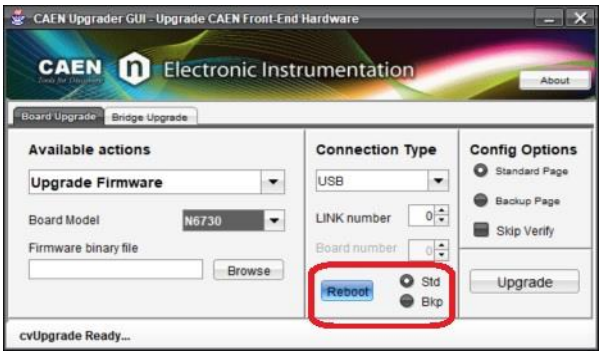


Fig. 11.1: Reboot section of CAENUpgrader

Note: old versions of the digitizer motherboard have a slightly different FLASH management. Use CAENUpgrader 1.6.0 or later to get the BoardInfoFile (using the "Get Information" function) and check that the FLASH_TYPE=0. Alternatively, use a software utility like CAENComm Demo to read at register address 0xF050 and check that bit[7]=0. In this case, at power-on, the micro-controller loads exactly the firmware copy from the STD page of the FLASH.

When a failure occurs during the upgrade of the STD page of the FLASH, which compromises the communication with the N6781, the user can perform the following recovering procedure as first attempt:

- force the board to reboot loading the copy of the firmware stored on the BKP page of the FLASH. For this purpose, make sure to connect by USB link and use the "Reboot" function in CAENUpgrader software by checking "Bkp" option;
- use CAENUpgrader to read the firmware revision (in this case the one of the BKP copy). If this succeds, it is so possible to communicate again with the board;
- use CAENUpgrader to load the proper firmware file on the STD page, then power-cycle in order the board to get operative again.

If neither of the procedures here described succeeds, it is recommended to send the board back to CAEN in repair (see Chap. **12**).

12 Instructions for Cleaning

The equipment may be cleaned with isopropyl alcohol or deionized water and air-dried. Clean the exterior of the product only.

Do not apply cleaner directly to the items or allow liquids to enter or spill on the product.

Cleaning the Touchscreen

To clean the touchscreen (if present), wipe the screen with a towelette designed for cleaning monitors or with a clean cloth moistened with water.
Do not use sprays or aerosols directly on the screen; the liquid may seep into the housing and damage a component. Never use solvents or flammable liquids on the screen.

Cleaning the air vents

It is recommended to occasionally clean the air vents (if present) on all vented sides of the board. Lint, dust, and other foreign matter can block the vents and limit the airflow. Be sure to unplug the board before cleaning the air vents and follow the general cleaning safety precautions.

General cleaning safety precautions

CAEN recommends cleaning the device using the following precautions:

1) Never use solvents or flammable solutions to clean the board.
2) Never immerse any parts in water or cleaning solutions; apply any liquids to a clean cloth and then use the cloth on the component.
3) Always unplug the board when cleaning with liquids or damp cloths.
4) Always unplug the board before cleaning the air vents.
5) Wear safety glasses equipped with side shields when cleaning the board

13 Device decommissioning

After its intended service, it is recommended to perform the following actions:

- Detach all the signal/input/output cable
- Wrap the device in its protective packaging
- Insert the device in its packaging (if present)

THE DEVICE SHALL BE STORED ONLY AT THE ENVIRONMENT CONDITION SPECIFIED IN THE MANUAL, OTHERWISE, IT WILL NOT BE GUARANTEED PERFORMANCE AND SAFETY

14 Disposal

The disposal of the equipment must be managed in accordance with Directive 2012/19 / EU on waste electrical and electronic equipment (WEEE).

The crossed bin symbol indicates that the device shall not be disposed with regular residual waste.

15 Technical Support

To contact CAEN specialists for requests on the software, hardware, and board return and repair, it is necessary a MyCAEN+ account on www.caen.it:

https://www.caen.it/support-services/getting-started-with-mycaen-portal/

All the instructions for use the Support platform are in the document:

A paper copy of the document is delivered with CAEN boards.

The document is downloadable for free in PDF digital format at:

https://www.caen.it/wp-content/uploads/2022/11/Safety_information_Product_support_W.pdf

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