PRELIMINARY

Purpose of this Manual

This User Manual contains the full description of the D75781, Dual/Quad Digital MCA.

Change Document Record

Date	Revision	Changes
03 June 2014	00	Initial release

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] UM2088 – Digital Pulse Height Analyzer User Manual

[RD4] GD2783 – First Installation Guide to Desktop Digitizers & MCA

[RD5] GD2812 – DeskBoot QuickStart Guide

[RD6] GD2827 - How to make coincidences with CAEN digitizers

[RD7] GD2080 - Introduction to Digitizers

[RD8] UM3182 - MC^{2}Analyzer User Manual

All documents can be downloaded at: http://www.caen.it/csite/LibrarySearch.jsp

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Index

List of Figures

List of Tables

CAEN Electronic Instrumentation

1 Introduction

The **DT5781** is a compact desktop system integrating 4 independent 16k channels Digital MCA for Gamma and X-ray spectroscopy. A version with 2 independent 16k channels MCA (**DT5781A**) is also available by ordering option (see **Tab. 1.1**).

The DT5781 is equipped with a **DPP-PHA Firmware**, that is a Digital Pulse Processing algorithm making the DT5781 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 DT5781 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 DT5781 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 720 or 751 series) running specific algorithms for the digital Charge Integration (DPP-CI) or Pulse Shape Discrimination (DPP-PSD). For details, please refer to **[RD7]**.

The module has been designed to operate as a scalable multi-channel 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 DT5781 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).

The following list summarizes what can be done by the DT5781 and the MC^2 Analyzer supported software (see § **8**):

- 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 **[RD6]**);
- 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), compensate for 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, dead time compensation, histogram rebin)

Table of related items:

Board Model	Description	Product Code
DT5781	4 Channel Digital MCA	WDT5781XAAAA
DT5781A	2 Channel Digital MCA	WDT5781AXAAA
DPP Firmware	**Description**	**Product Code**
DPP-PHA*(*)*	Digital Pulse Processing for Pulse Height Analysis	WFWDPPTFAAAA
Accessory	**Description**	**Product Code**
A1422A005F2	1 Ch. Charge Preamplifier, 5mV/MeVgain	WA1422A005F2
A1422B005F2	4 Ch. Charge Preamplifier, 5mV/MeVgain	WA1422B005F2
A1422C005F2	8 Ch. Charge Preamplifier, 5mV/MeVgain	WA1422C005F2
A1422A045F2	1 Ch. Charge Preamplifier, 45mV/MeVgain	WA1422A045F2
A1422B045F2	4 Ch. Charge Preamplifier, 45mV/MeVgain	WA1422B045F2
A1422C045F2	8 Ch. Charge Preamplifier, 45mV/MeVgain	WA1422C045F2
A1422A090F2	1 Ch. Charge Preamplifier, 90mV/MeVgain	WA1422A090F2
A1422B090F2	4 Ch. Charge Preamplifier, 90mV/MeVgain	WA1422B090F2
A1422C090F2	8 Ch. Charge Preamplifier, 90mV/MeVgain	WA1422C090F2
A1422A400F2	1 Ch. Charge Preamplifier, 400mV/MeVgain	WA1422A400F2
A1422B400F2	4 Ch. Charge Preamplifier, 400mV/MeVgain	WA1422B400F2
A1422A005F3	1 Ch. Charge Preamplifier, 5mV/MeVgain	WA1422A005F3
A1422B005F3	4 Ch. Charge Preamplifier, 5mV/MeVgain	WA1422B005F3
A1422C005F3	8 Ch. Charge Preamplifier, 5mV/MeVgain	WA1422C005F3
A1422A045F3	1 Ch. Charge Preamplifier, 45mV/MeVgain	WA1422A045F3
A1422B045F3	4 Ch. Charge Preamplifier, 45mV/MeVgain	WA1422B045F3
A1422C045F3	8 Ch. Charge Preamplifier, 45mV/MeVgain	WA1422C045F3
A1422A090F3	1 Ch. Charge Preamplifier, 90mV/MeVgain	WA1422A090F3
A1422B090F3	4 Ch. Charge Preamplifier, 90mV/MeVgain	WA1422B090F3
A1422C090F3	8 Ch. Charge Preamplifier, 90mV/MeVgain	WA1422C090F3
A1424	Scintillation Preamplifier	WA1424XAAAAA
A2818	PCI Optical Link	WA2818XAAAAA
A3818A	PCIe 1 Optical Link	WA3818AXAAAA
A3818B	PCIe 2 Optical Link	WA3818BXAAAA
A3818C	PCIe 4 Optical Link	WA3818CXAAAA
AI2730	Optical Fibre 30 m simplex	WAI2730XAAAA
AI2720	Optical Fibre 20 m simplex	WAI2720XAAAA
AI2705	Optical Fibre 5 m simplex	WAI2705XAAAA
AI2703	Optical Fibre 30 cm simplex	WAI2703XAAAA
AY2730	Optical Fibre 30 m duplex	WAY2730XAAAA
AY2720	Optical Fibre 20 m duplex	WAY2720XAAAA
AY2705	Optical Fibre 5 m duplex	WAY2705XAAAA

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

(*) The DT5781 is delivered factory equipped with a licensed version of the DPP-PHA firmware.

CAEN Electronic Instrumentation

2 Technical Specifications

MECHANICAL	**Dimensions** 154 W x 50 H x 164 L mm³ (without connectors) 154 W x 50 H x 183 L mm³ (including connectors)		**Weight** 800 g (related to DT5781 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: DT5781 2 inputs: DT5781A
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 rejection and Live Time correction ▪ 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	Power input: +12 VDC, 45 W (by the power supply included in the kit) Operating Supply Voltage: +12 VDC ± 10% Consumptions(@ +12 VDC): 1.75 A (Typ.) for DT5781 (± 10% tolerance) 1.15 A (Typ.) for DT5781A (± 10% tolerance)		

Tab. 2.1: DT5781 Specifications Table

3 Packaging and Compliancy

The unit is a Desktop module housed in an alloy box (weight: 800 g for the 4-channel model) with the following dimension:

154 W x 50 H x 164 L mm³ (connectors encumbrance not included)

154 W x 50 H x 183 L mm³ (including connectors)
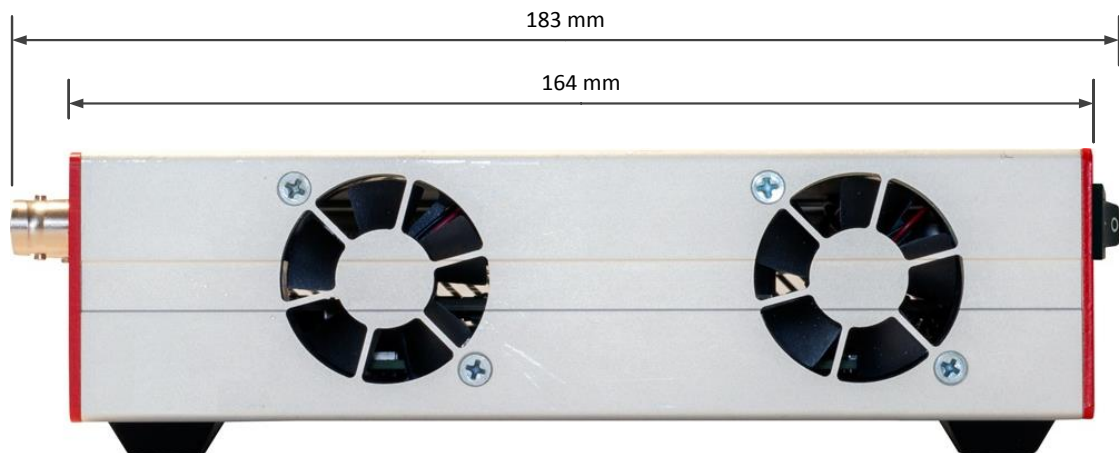

Fig. 3.1: DT5781 front view

Fig. 3.2: DT5781 side view

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

A potential risk exists if the operating instructions are not followed!

CAEN provides the specific document "Precautions for Handling, Storage and Installation", available in the documentation tab of the product's web page, that the user is mandatory to read before to operate with CAEN equipment.

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4 Power Requirements

The module is powered by the external AC/DC stabilized power supply provided with the digitizer and included in the delivered kit (12 VDC, 45 W).

Tab. 4.1 reports the recommended supply voltage operating conditions and the current consumptions for both the available board versions.

	OPERATING SUPPLY VOLTAGE (nominal)	CONSUMPTIONS (@ +12 VDC)
DT5781	+12 VDC ± 10%	1.75 A (Typ.) ± 10%
DT5781A	+12 VDC ± 10%	1.15 A (Typ.) ± 10%

Tab. 4.1: Power requirements table

Note: Using a different power supply source, like battery or linear type, it is recommended the source to provide +12 VDC and, at least 1.75 A (or 1.15 in case of DT5781A) + 10%; the power jack is a 2.1 mm type, a suitable cable is the RS 656-3816 type (or similar).

Fig. 4.1: AC/DC power supply provided with the DT5781 kit
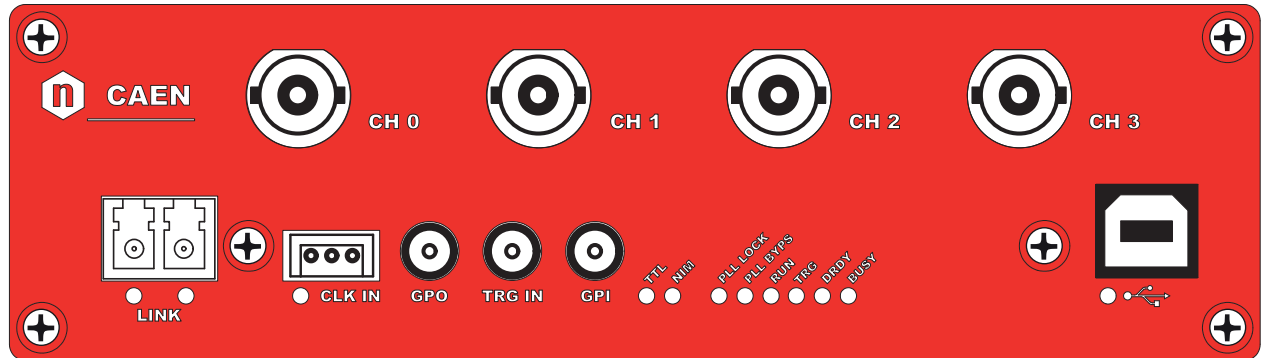
5 Panels Description

Fig. 5.1: DT5781 front panel view

Fig. 5.2: DT5781 rear panel view

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Front Panel

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).
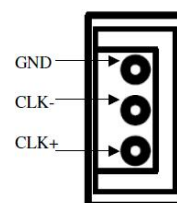
Coupling: AC.

Z_{diff}: 100 Ω.

MECHANICAL SPECS

Series: AMPMODU connectors.

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

Manufacturer: AMP Inc.

PINOUT

GND
CLK-
CLK+

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.
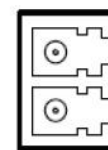
ELECTRICAL SPECS

Transfer rate: up to 80 MB/s.

MECHANICAL SPECS

Series: SFF Transceivers.

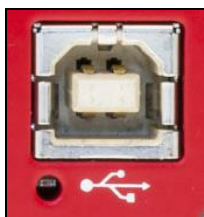Type: FTLF8519F-2KNL (LC connectors).

Manufacturer: FINISAR.

PINOUT

TX (red wrap)

RX (black wrap)

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 **[RD3]**). **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.

Rear Panel

SPARE LINK		
	FUNCTION Auxiliary connector reserved for CAEN usage. **ELECTRICAL SPECS** *Not available.*	**MECHANICAL SPECS** Series: Header connectors. Type: 7610-5002-5+5. Manufacturer: 3M.
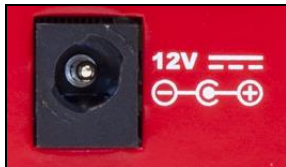
DC INPUT		
	FUNCTION Input power supply (+12 VDC) **ELECTRICAL SPECS** See § **4**	**MECHANICAL SPECS** Series: CC power supply connectors Type: KLDX-0202-A-LT (DC power jack). Manufacturer: KYCON **PINOUT**

ON/OFF SWITCH		
	FUNCTION Panel switch for module power supply ON/OFF: O → power supply OFF. I → power supply ON. **ELECTRICAL SPECS** *Not available.*	**MECHANICAL SPECS** Series: A1 switches. Type: A11331122000 (Single pole two way) Manufacturer: Molveno.

IDENTIFYING LABEL	
	FUNCTION Board's identifying label indicating: – the model; – the serial number (S/N); – the symbol of the CE conformity marking.

6 Notes on operating

The DT5781 operates on the analog signals provided on its 2/4 inputs the same as a DT5780 or a DT5724 module equipped with a DPP-PHA Firmware for the Digital Pulse Height Analysis.
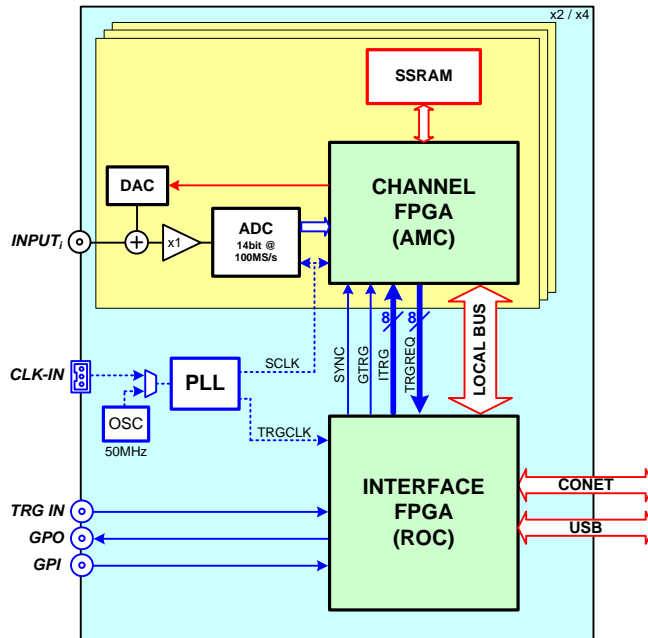

Fig. 6.1: Simplified block diagram of the digitizer block in the DT5781

The DT5781 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.
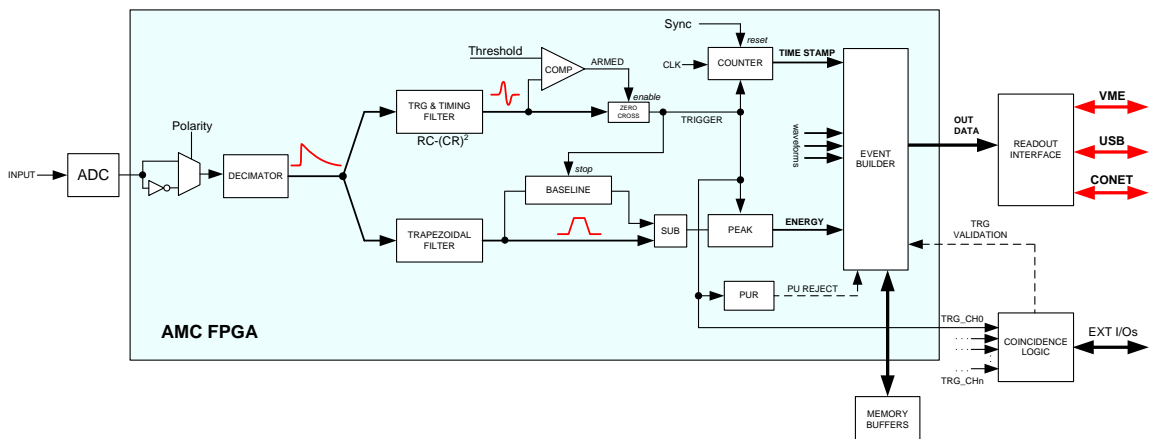
Fig. 6.2: Block Diagram of the processing chain programmed into the digitizer's FPGA

Refer to **[RD3]** for a detailed description of:

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

![CAEN logo] **CAEN** ⬡ **Electronic Instrumentation**

7 Drivers & Libraries

In order to interface with the DT5781, CAEN provides the drivers for all the different types of physical communication channels featured by the DT5781 and compliant with Windows and Linux OS, as well as a set of C libraries.

Drivers

COMM LINKS	OS	OS VERSION
USB / OPT LINK	Windows	XP / Vista / 7 (32 and 64-bit)
	Linux	kernel Rel. 2.4 / 2.6 / 3.6 / 3.10 / 3.11[*]

Tab. 7.1: Drivers info table

[*] Please, refer to the product web page (Board and Bridge) for the specific kernel support

- **Drivers USB 2.0 compliant**. Drivers updates are downloadable on CAEN website (www.caen.it) in the "Software/Firmware" tab at the DT5781 web page (**login required**):

Home / Products / Spectroscopy Solutions / Digital Multi Channel Analyzers / Multi Channel Analyzers / DT5781

| Overview | Tech. Spec. | Software/Firmware | Compare | Related Products | Ordering Option |

Description	Release	Date	OS-Version	Environment	Download
Driver					
DT57xx-N67xx-DT55xx-DT578x Win32 USB Driver[a]	3.4.8	April, 2013	XP, Vista, 7		
Drivers 43.44 KB - Type: .zip					
DT57xx-N67xx-DT55xx-DT578x Win64 USB driver	3.4.3	July, 2013	x64bit XP, x64bit Vista, x64bit 7		
Drivers 37.6 KB - Type: .zip					
DT57xx-N67xx-DT55xx-DT578x-V1718-N957 Linux USB Driver	1.4	January, 2014			
Drivers (Linux kernel 2.6 - 3.6) 7.82 KB - Type: .gz					
Release Notes 3.84 KB - Type: .txt					

Fig. 7.1: Typical view of the drivers download at the DT5781 web page

✎ **Note:** For Microsoft Windows OSs, the USB drivers installation is detailed in **[RD4]**.

- **Drivers Optical Link CONET 2 compliant**. This drivers are managed by the A2818 PCI card or the A3818 PCIe card. Drivers updates are downloadable on CAEN website (www.caen.it) in the "Software/Firmware" tab at the A2818 or A3818 web page (**login required**):

*Home / Products / Modular Pulse Processing Electronics / PCI/PCIe / <Controller>*

| Overview | Tech. Spec. | Documentation | Software/Firmware | Related Products | Accessories | Ordering Option |

Description	Release	Date	OS-Version	Environment	Download
Driver					
A3818 driver	1.5.1	Nov, 2013			
Release Notes 2.65 KB - Type: .txt					
Drivers (Linux kernel 2.6 - 3.11) 23.62 KB - Type: .tgz					
A3818 Win32 Driver(*)	1.2.2	January, 2014	XP, Vista, 7		
Drivers 5.46 MB - Type: .zip					
Release Notes 1.95 KB - Type: .txt					
A3818 Win64 Driver(*)	1.2.2	January, 2014	x64bit XP, x64bit Vista, x64bit 7		
Drivers 6.09 MB - Type: .zip					
Release Notes 1.95 KB - Type: .txt					

Fig. 7.2: Typical view of the drivers download at the A3818 web page.

✎ **Note:** For the installation of the Optical Link drivers, refer to the User Manual of the specific Controller.

Libraries

CAEN provides a set of libraries required by its DPP-PHA software tools, which are also the basis for users who want to develop their own software.

- **CAENVMELib** is a set of ANSI C functions which permit a user program to use and configure the CAEN Bridges and Controllers V1718/VX1718 (VME-USB2.0 Bridge), V2718/VX2718 (VME-PCI/PCIe Optical Link Bridge), A2818/A3818 (PCI/PCIe-CONET Controller).

- **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.

- **CAENDigitizer** is a library of functions designed specifically for the Digitizer family and it supports also the boards running the DPP firmware, as it happens in the DPHA. The CAENDigitizer library is based on the CAENComm which is based on CAENVMELib, as said above.

- **CAENDPP** library The CAENDPP is a high level library of C functions designed to completely control exclusively the digitizers running the DPP-PHA firmware.

As far as the DT5781 is concerned, the supported communication channels are the following:

PC → USB → DT5781

PC → PCI (A2818) → CONET → DT5781

PC → PCIe (A3818) → CONET → DT5781
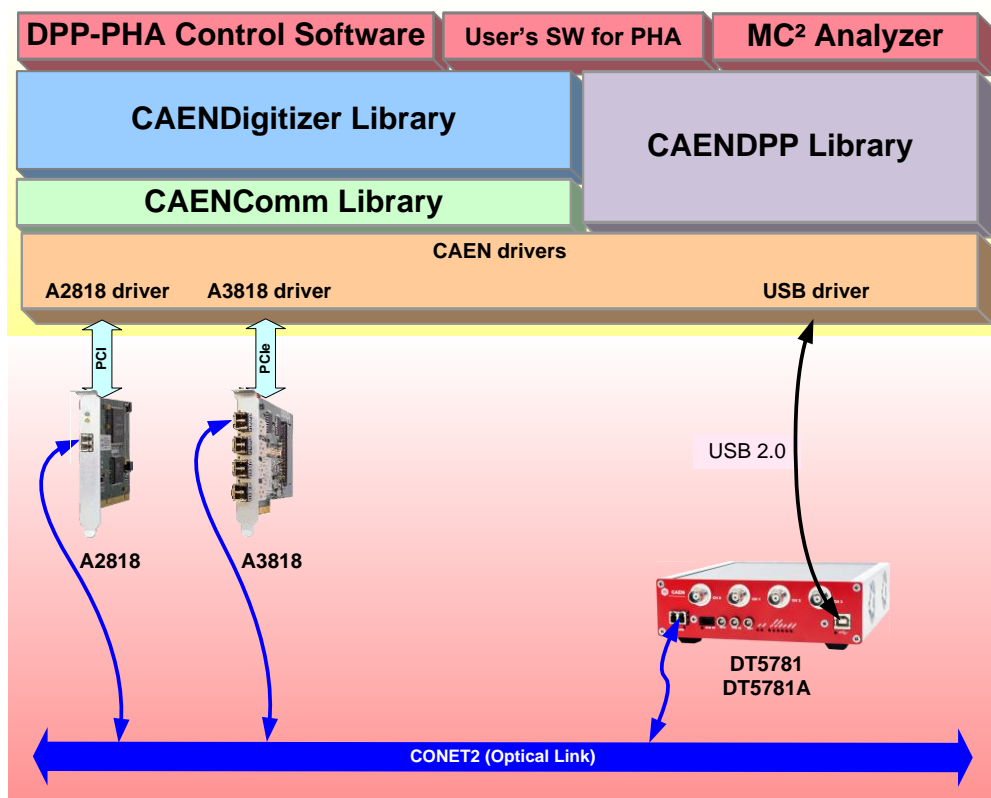
Fig. 7.3: Hardware and software layers scheme

If required to be installed apart by the user (see Chapter **8**), CAEN Libraries are available for download on CAEN web site (www.caen.it) in the "Download" tab at the library web page:

Home / Products / Firmware/Software / Digitizer Software / Software Libraries / <Library>

Install in the order: CAENVMELib → CAENComm library → CAENDigitizer library.

✏️ **Note:** CAENDPP library is stand-alone; no additional software but the drivers are required to be installed.

8 Software Tools

CAEN provides software tools to interface the DT5781, which are available for <u>free download</u> on www.caen.it at:

Home / Products / Firmware/Software / Digitizer Software

MC² Analyzer (MC²A)

MC² Analyzer (MC²A) is a software specifically designed for x780 Dual Digital MCA, x781 Dual/Quad Digital MCA or digitizers running the DPP-PHA (Digital Pulse Processing for the Pulse Height Analysis) firmware like 724 family.

The software is able to completely control and manage a set of boards acquiring data simultaneously, making therefore a multi-board system a "Multichannel - Multichannel Analyzer".

MC²A allows the user to set all the relevant DPP-PHA parameters for each acquisition channel (like trigger threshold, shaping parameters, etc.), handle the communication with the connected boards, run the data acquisition and plot both waveforms for on-line monitoring of the acquisition and histograms. It can also control the HV power supplies provided in the x780.

Moreover, it is able to perform advanced mathematical analysis on both the ongoing histograms and collected spectra: peak search, background subtraction, peak fitting, energy calibration, ROI selection, dead time compensation, histogram rebin and other features available.

Fig. 8.1: MC² Analyzer (MC²A) software tool

MC² Analyzer is currently available only for Windows platforms. The installation package can be downloaded on CAEN web site (www.caen.it) at:

Home / Products / Firmware/Software / Digitizer Software / Readout Software

The reference document for installation instructions and program detailed description is **[RD8]**.

✎ **Note:** Windows version of MC² Analyzer is stand-alone (the required libraries are installed locally with the program; only the communication driver must be installed apart by the user).

CAEN Electronic Instrumentation

DPP-PHA Control Software

The DT5781 is supported through the **DPP-PHA Control Software**, a software interface for configuration, acquisition, data plotting. It allows the user to set the parameters for the acquisition, to configure the DPP parameters and to perform the data readout, the histogram collection and the spectrum or waveform plotting and saving. The program doesn't feature data analysis, but can be easily interfaced to software tools for Spectroscopic analysis.
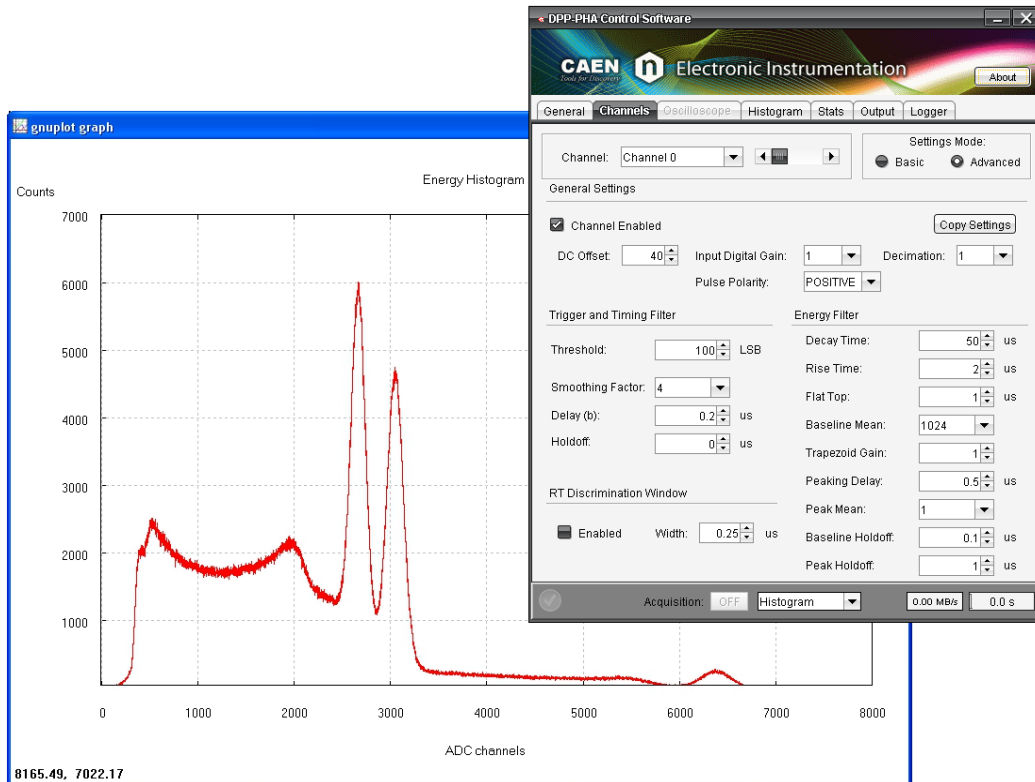
Fig. 8.2: DPP-PHA Control Software tool

DPP-PHA Control Software is available both for Windows and Linux platforms. The installation package can be downloaded on CAEN web site (www.caen.it) at:

Home / Products / Firmware/Software / Digitizer Software / Readout Software

The reference document for installation instructions and program detailed description is **[RD3]**.

Note: Windows version of DPP-PHA Control Software is stand-alone (the required libraries are installed locally with the program; only the communication driver must be installed apart by the user), while the version for Linux needs the required libraries to be already installed apart.

CAEN IS PHASING OUT THIS SOFTWARE, FULLY REPLACED BY THE BRAND NEW "MC² ANALYZER"

CAENUpgrader

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

Specifically for the DT5781, CAENUpgrader allows in few easy steps to:

- • Upload different FPGA firmware versions on the board

- • Read the firmware release of the board and the PCI or PCIe controller eventually used with

- • Upgrade the internal PLL (firmware file that can only be provided on demand by CAEN)

- • Get the Board Info file, useful in case of support

CAENUpgrader can operate with Windows and Linux, 32 and 64-bit operating systems.

The program requires additional software to be installed: CAENComm and CAENVMELib libraries (see § **7**), and the third-party Java SE6 (or later).
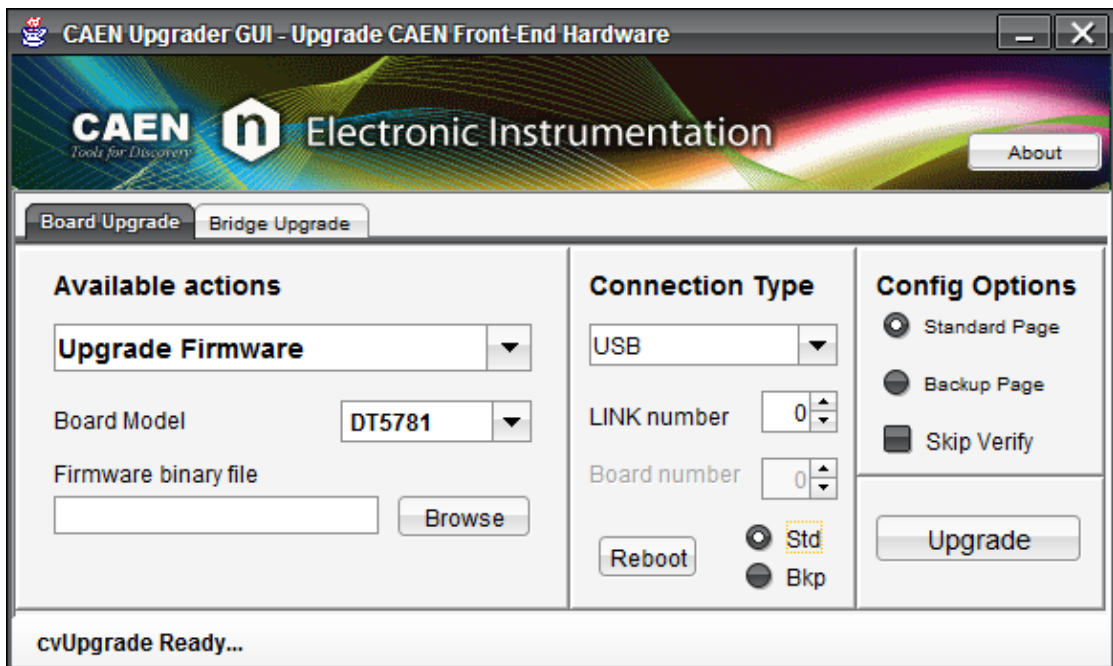
Fig. 8.3: CAENUpgrader Graphical User Interface

CAENUpgrader installation package can be downloaded on CAEN web site (www.caen.it) at:

Home / Products / Firmware/Software / Digitizer Software / Configuration Tools

The reference document for installation instructions and program detailed description is **[RD1]**

Note: Windows version of CAENUpgrader is stand-alone (the required libraries are installed locally with the program), while the version for Linux needs the required libraries to be already installed apart by the user.

Note: DT5781 model is supported by CAENUpgrader software release **1.5** or higher.

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CAENComm Demo

CAENComm Demo is a simple program 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.
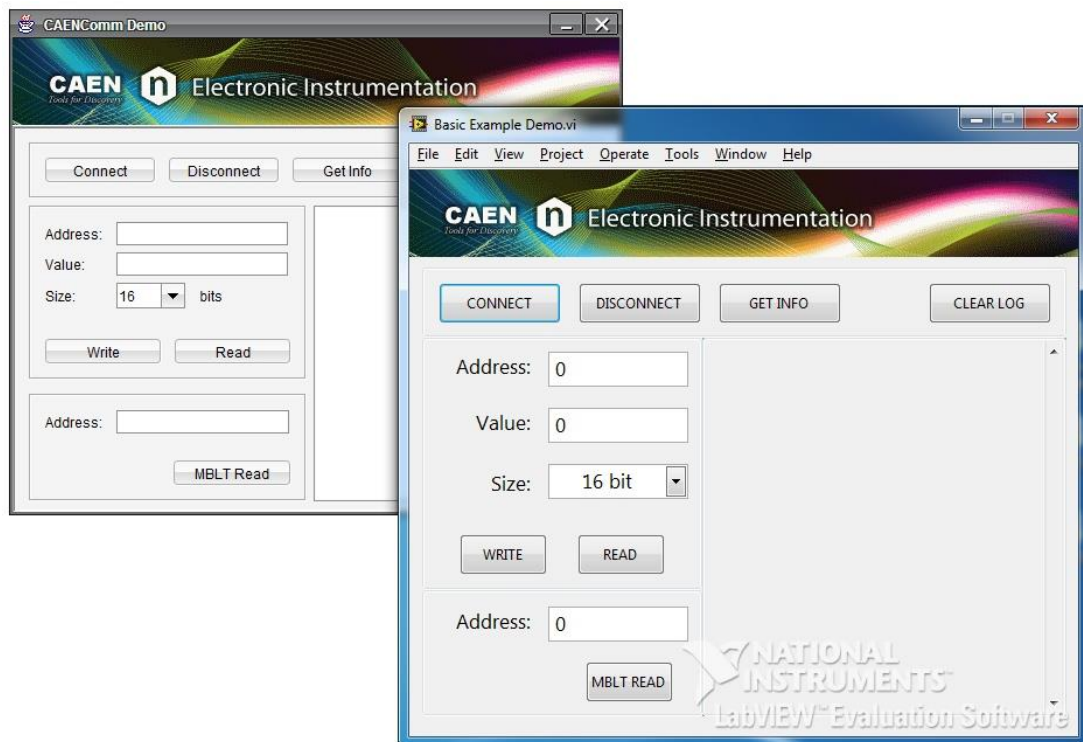
Fig. 8.4: CAENComm Demo Java and LabVIEW graphical interface

CAENComm Demo can operate with Windows OSs, 32 and 64-bit. It requires CAENComm and CAEVMElib libraries as additional software to be installed (see § **7**).

The Demo is included in the CAENComm library installation Windows package, which can be downloaded on CAEN web site (**login required**) at:

Home / Products / Firmware/Software / Digitizer Software / Software Libraries / CAENComm Library

9 HW Installation

Power ON Sequence

To power ON the board, follow this procedure:

1. connect the 12V DC power supply to the DT5781 through the DC input rear connector;
2. power up the DT5781 through the ON/OFF rear switch

See § **5** to identify the relevant components

Power ON Status

At Power-ON, the module is in the following status:

*   the Output Buffer is cleared;
*   registers are set to their default configuration

After the Power-ON, the front panel LEDs status is that only the **NIM** and **PLL LOCK** remain ON (see Fig. **9.1**)

Fig. 9.1: Front panel LEDs status at power ON

CAEN **Electronic Instrumentation**

10 Firmware and Upgrades

The DT5781 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 DT5781.

Firmware updates are available for download on CAEN website (www.caen.it) in the "Software/Firmware" tab at the DT5781 web page **(login required)**:

Home / Products / Spectroscopy Solutions / Digital Multi Channel Analyzers / Multi Channel Analyzers / DT5781

Note: Upgrades of a DPP-PHA firmware file on the DT5781 doesn't have effect on the license validity .

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 § **8**)

IT IS STRONGLY SUGGESTED TO UPGRADE ONLY ONE OF THE STORED FIRMWARE REVISIONS (GENERALLY THE STD ONE): IF BOTH REVISION ARE SIMULTANEOUSLY UPDATED AND A FAILURE OCCURS, IT WILL NOT BE POSSIBLE TO UPLOAD THE FIRMWARE VIA USB OR OPTICAL LINK AGAIN AND THE BOARD MUST BE SENT TO CAEN IN REPAIR!

In case of failures while programming the STD page of the FLASH, which compromise the communication with the DT5781, the user can perform the following recovering procedure as first attempt:

- Run the DeskBoot software application (see § **8**) which forces the board to reboot loading the copy of the firmware stored on the BKP page of the FLASH.

- Without power-cycling the board, use CAENUpgrader to read the firmware revision (in this case the one of the BKP copy). If this succeeds, it is possible now to communicate again with the board.

- Use CAENupgrader to load again the firmware on the STD page, then power-cycle in order the board to get operative again.

The detailed communication recovery procedure based on this program is described in **[RD5]**. In case also this procedure fails, the board needs to be sent back to CAEN in repair (see § **11**).

Firmware File Description

The programming file, that has the extension **.cfa** (CAEN Firmware Archive), is a sort of archive format file aggregating all the DPP firmware files compatible with the same family of digitizers.

The firmware file name follows this general scheme:

x724_x78x_DPP-PHA_rev_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. Note that the major revision number (128) is fixed for the specific DPP algorithm (PHA).

11 Technical Support

CAEN makes available the technical support of its specialists at the e-mail addresses below:

support.nuclear@caen.it
(for questions about the hardware)

support.computing@caen.it
(for questions about software and libraries)

CAEN SpA is acknowledged as the only company in the world providing a complete range of High/Low Voltage Power Supply systems and Front-End/Data Acquisition modules which meet IEEE Standards for Nuclear and Particle Physics. Extensive Research and Development capabilities have allowed CAEN SpA to play an important, long term role in this field. Our activities have always been at the forefront of technology, thanks to years of intensive collaborations with the most important Research Centres of the world. Our products appeal to a wide range of customers including engineers, scientists and technical professionals who all trust them to help achieve their goals faster and more effectively.

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