Rev. 0 - 18/01/2023

Sci-Compiler SMART

Evaluation and learning kit for SCI-Compiler

CAEN
Tools for Discovery

User Guide
GD8712

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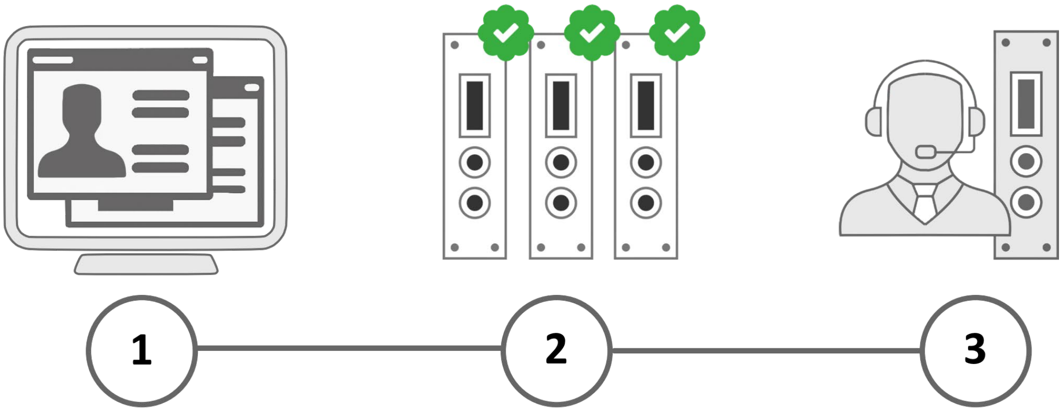

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Purpose of this User Guide

This User Guide contains a full description of the Sci-Compiler SMART Kit, including a DT1260 2ch, 12-bit 65MS/s Digitizer with open FPGA and a Lite License for Sci-Compiler software.

Change Document Record

Date	Revision	Changes
February 18th, 2022	00	Initial release

Symbols, abbreviated terms and notation

ADC	Analog to Digital Converter
FPGA	Field Programmable Gate Array
OS	Operating system

Reference Document

[RD1] GD6520 - SCI-Compiler Quick Start Guide

[RD2] UM6519 - SCI-Compiler User Manual

[RD3] https://www.xilinx.com/products/design-tools/vivado.html

[RD4] https://www.xilinx.com/content/dam/xilinx/support/documentation/sw_manuals/xilinx2020_2/ug973-vivado-release-notes-install-license.pdf#namedDest=InstallingTheVivadoDesignSuiteTools

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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.

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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1 Introduction

The SCI-Compiler SMART is a hardware + software kit for non-expert users who are approaching the FPGA programming. We introduce them to an innovative method to simplify the firmware development. This method is based on **SCI-Compiler** software, a block-diagram-based programming interface consisting of a prebuilt set of functions (for example oscilloscope, TDC, MCA, charge integration, etc.) specifically developed for physics/engineering applications. Placing and interconnecting the available blocks on a diagram, SCI-Compiler is able to automatically generate a VHDL piece of code that implements the required function and deploy it to the FPGA (refer to **[RD1]** for more details). In this way, even a non-expert user can write his own firmware code without having any knowledge of the VHDL/Verilog programming language.

The SCI-Compiler SMART kit is composed of a SCI-Compiler license and a basic hardware (DT1260 unit), designed for the exact purpose of evaluating the software and learning how to design custom firmware using the block-diagram method. It includes:

- **1x DT1260** , 2 Channel, 65 MS/s, 12 bit ADC unit with Open FPGA – *also named **SciDK** board*
- **1x SCI-Compiler Lite** license working with the DT1260 unit only

The SCI-Compiler software, in combination with DT1260, allows to develop both **FPGA firmware** for *custom digital pulse processing* and **software application** for data readout, using the generated libraries. It is thus possible to access registers of the DT1260 and transfer data to the PC in list, waveform or user-customizable format.

A basic, ready-to-use default firmware and readout software is provided for free and open source. The default firmware manages the basic waveform digitization and Pulse Height Analysis (trapezoidal filter). The user can take advantages of examples firmware diagram available in the SCI-Compiler, in order to start learning how to program the FPGA and take confidence with the software.

Available ordering option are listed below:

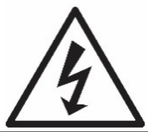
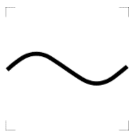
Item	Description	Product Code
SCI-Compiler SMART	SCI-Compiler SMART kit	WKSCISMARTXA

Table 1.1: table of models.

2 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 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 which, if not avoided, will result in serious injury or death.
- **WARNING**: indicates a hazardous situation which, 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.

To avoid potential hazards, use the product only as specified. Only qualified personnel should perform service procedures.
Avoid Electric Overload. To avoid electric shock or fire hazard, do not power a load outside of its specified range.
Avoid Electric Shock. To avoid injury or loss of life, do not connect or disconnect cables while they are connected to a voltage source.

Do Not Operate without Covers. To avoid electric shock or fire hazard, do not operate this product with covers or panels removed.
Do Not Operate in Wet/Damp Conditions. To avoid electric shock, do not operate this product in wet or damp conditions.
Do Not Operate in an Explosive Atmosphere. To avoid injury or fire hazard, do not operate this product in an explosive atmosphere.
Do Not Operate with Suspected Failures. If you suspect this product to be damaged, please contact Technical Support.

The following operating limits must be respected for the DT1260:

Net class	Connector	Unit	Min	Max
Power	/	Voltage	4.5 V	5.5 V
Input Analog Channels	LEMO	Voltage	-2.15 V	2.15 V
Digital I/Os	LEMO	Voltage	-0.3 V	4.5 V

Table 2.1: operating limits for DT1260 connectors.

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

3 What is SCI-Compiler?

The increasing use of programmable logic devices in trigger and data acquisition systems makes clear that having a general-purpose platform and technicians dedicated to the firmware development is becoming more and more important. The advantage of employing programmable logic devices with respect to standard logic modules (like NIM logic modules) is remarkable: a single programmable logic device includes the potentiality of hundreds of thousands of standard logic modules. However, the use of specific programming languages like VHDL or Verilog for the firmware development could represent a limitation in the spread of these powerful devices.

We introduce an innovative software for easy FPGA programming, called **SCI(entific)-Compiler**, a diagram-based compiler to simplify the firmware development. The software exploits a method which is based on a **graphical programming interface** consisting of blocks specifically developed for physics applications. It uses a prebuilt library set, containing macroblocks with complex functions (MCA, Oscilloscope, TDC ,…) that can be connected with each other to draw a diagram describing the firmware structure. For instance, any trigger logic could be implemented by connecting specific blocks in the graphical interface, as easily as physically connecting NIM modules in a rack.

SCI-Compiler, starting from a graphical block diagram, automatically generates a VHDL peace of code that implements the required functions. Moreover, it is able to generate C/C++/C#/Phyton libraries, drivers and example codes to be used in Windows, Linux and MacOS for custom software development based on the compiled firmware.

AVOID FPGA LABYRINTH!

SCI-Compiler allows to develop purely digital applications, exploiting blocks like scaler, counter, pattern matching, logic analyser and state machine, or analog processing algorithms, such as custom multichannel analyser using charge integration, trapezoidal filter, spectrum and oscilloscope blocks. In addition, SCI-Compiler provides the blocks needed to read and test WeeROC(*) ASICs, enabling the user to develop a full operating system using those ASICs.

Thanks to its structure, SCI-Compiler focuses the attention only on the functional blocks of the application to be implemented and does not require a deep knowledge of the device in use or of the FPGA programming language, enabling the employment of programmable devices also to users who do not have expertise in firmware development.

Refer to **[RD1]** and **[RD2]**for more details.

The flow

SCI-Compiler is an automatic code generator software that starts ***from a graphical block diagram to generate a VHDL piece of code*** that implements the required functionalities. SCI-Compiler uses a prebuilt library set containing macroblocks with complex functionalities. Each macroblock could be imagined as a modular instrument (MCA, Oscilloscope, Digitizer, TDC) that the user could connect with other macroblocks.

Programming with SCI-Compiler is much more similar to implement an experimental setup than developing a firmware:

1. The user places the macro-functional blocks and connects them together;

2. SCI-Compiler generated the VHDL code starting from the user design;
3. SCI-Compiler executes Xilinx Vivado or Intel Quartus in background, in order to compiler the firmware and generate the bitstream;

Note: SCI-Compiler is a VHDL/Verilog code generator, not an FPGA compiler. For this reason, Xilinx Vivado is automatically executed to compile the code into a working configuration file. Vivado HLx can be installed for free on the local PC.

4. SCI-Compiler converts the bitstream in the proper configuration file compatible with one of the supported platforms (V2740, V2495, DT5550, R5560, …);
5. SCI-Compiler downloads the bitstream on the target hardware platform;
6. SCI-Compiler generates C/C++/C#/Python libraries and a correspondent example application code in order to test the communication bus.

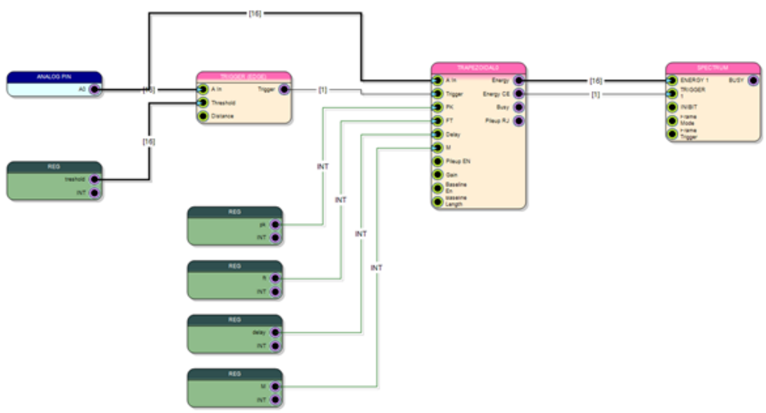
SCI-Compiler produces in output:

- A configuration file for the target hardware
- An FPGA firmware project in VHDL
- Libraries based on the compiled project, for different programming languages
- Code examples exploiting libraries features, in order to test the communication interface USB/VME/Ethernet bus.

An example

For the user, SCI-Compiler is a **fully integrated IDE**: pressing a button the software generates files and projects, executes the FPGA compiling tool, gets the output file, programs the connected target and generates communication libraries.

For example, to implement an MCA that generates in output a 1024 channels spectrum, the user should implement a graphical design like the one below:



SCI-Compiler generates in output the corresponding VHDL code, FPGA bitstream, C/C++/C#/Phyton libraries and an example code, that can be compiled in Windows (Visual Studio), Linux (gcc) and MacOS (Xcode), to test the communication bus. This code can be the starting point for a custom application development.

The library generated for the previous circuit would export the following functions:

```
SCILIB int REG_threshold_SET(uint32_t val, int32_t handle);
SCILIB int REG_pk_SET(uint32_t val, int32_t handle);
SCILIB int REG_ft_SET(uint32_t val, int32_t handle);
SCILIB int REG_M_SET(uint32_t val, int32_t handle);
SCILIB int REG_delay_SET(uint32_t val, int32_t handle);


SCILIB int MMC_spectrum_SP0_INTEGRAL_GET(uint32_t *val, int32_t handle);
SCILIB int MMC_spectrum_SP0_PARTIAL_GET(uint32_t *val, int32_t handle);
```

The first five functions configure the trigger threshold, the trapezoidal peaking time, flat top, deconvolution parameter and sampling delay. The last two instructions return the accumulated spectrum and the partial (from last readout) spectrum. The library functions can be used for further software implementation.

4 Technical Specifications

TECHNICAL			
POWER CONSUMPTION	0.3 A @ 5 V (Typ.), power over USB		
ANALOG INPUT	**Channels** 2 single-ended input **Input impedance** 1 kΩ / 50 Ω jumper selectable **Noise Level** 1 LSB rms, 3 LSB p-p	**Connector** 2x LEMO **Full Scale Range** 4 V_{pp}	**Bandwidth (-3 dB)** Max. dynamic range : 25 MHz Small amplitude (200 mV): 30 MHz **Offset** Programmable [0:4096] LSB Non-linearity < 0.15% Minimum offset 0 corresponds to values in the range [50:100] LSB
DIGITAL I/Os	**Channels** 2 general purpose programmable digital I/Os Single-ended **Input impedance** 1 kΩ / 50 Ω jumper selectable	**Connector** 2 x LEMO **Maximum rate** 25MHz IN, 32 MHz out	**Signal Type** TTL
DIGITAL CONVERSION	**Resolution** 12 bits **Non-Linearity** < 0.15%	**Sampling Rate** 65 MS/s Simultaneously on each channel	
MEMORY	**FPGA onchip memory** 200 Kbytes of fast FPGA memory. Memory can be arbitrary partitioned for specific task using SciCompiler. Example: 2 channel, 12 bit resolution waveform digitizer → 32 ksamples per channel memory depth use about the 65 % of available memory	**FPGA onchip memory user available** > 95% of total onchip memory	
TRIGGER	**Trigger Source** *Internal (default firmware)*: managed by the default firmware, using a fast trapezoidal filter *External: from LEMO, edge sensitive* *Software triggered acquisition* *Complex trigger logic*: implementable by the user on the open FPGA.	**Trigger timestamp** 32 bit counter, 16.6 ns resolution with default trigger Possibility to increase the resolution using the Digital Costant Fraction Discrimitation algorithm present in SciCompiler. Resolution depends on input signal characteristics	
FPGA	**Open FPGA** Xilinx Spartan7-LX25		
SYNCRONIZATION	**Custom sync** User multi-board synchronization can be achieved with custom SciCompiler firmware using the two LEMO connectors as clock/t0/trigger source		
COMMUNICATION INTERFACE	**USB 2.0** Micro-USB	**Firmware upgrade** Via USB using Open Hardware stand alone software or directly from SciCompiler **JTAG** Jtag connector available for firmware debugging using Vivado Logic Analyser. (to access to JTAG connector the box must be removed) **LED** 2 user programmable green LED + 1 blu led power/bootloader indicator **GPIO (for OEM integration)** 8 GPIO, 3.3V directly connected to FPGA PIN. (to access to GPIO connector the box must be removed)	

		GPIO can be used to implement also serial (UART/I2C) interfaces using SciCompiler/Vivado
FIRMWARE	**Default** Waveform recording Pulse Height Analysis with trapezoidal filter Default firmware distributed open source as SciCompiler projects	**Custom** Use SCI-Compiler to develop your own firmware! LICENSE INCLUDED Several firmware examples included in SciCompiler
SOFTWARE	- **SCI-55X0 Readout Software** to manage the default firmware - **SCI-Compiler** for custom firmware development	
MECHANICAL		
FORM FACTOR	Desktop module	
DIMENSIONS (H/W/L)	72x22x84 mm^3 (WxHxD)	
ENVIRONMENTAL		
ENVIRONMENTAL	Indoor use	
OPERATING TEMPERATURE	Operating Temperature -20 °C ÷ 50 °C	
OPERATING HUMIDITY	25% ÷ 95% RH non condensing	
STORAGE TEMPERATURE	-30 °C ÷ +80 °C	
STORAGE HUMIDITY	5% ÷ 90% RH non condensing	
ALTITUDE	≤2000 m	
POLLUTION DEGREE	2	
OVERVOLTAGE CATEGORY	II	
EMC ENVIRONMENT	Commercial and light industrial	
IP DEGREE	IPX0 enclosure, not for wet location	
REGULATORY		
COMPLIANCE	• EMC: CE 2014/30/EU Electromagnetic compatibility Directive • Safety: CE 2014/35/EU Low Voltage Directive	

Table 4.1: technical specifications for the SCI-Compiler SMART kit.

5 Packaging and compliancy

The SCI-Compiler SMART kit includes a DT1260 module and a SCI-Compiler license USB Dongle. The DT1260 is available as Desktop module housed in a 72x22x84 mm^3 (WxHxD) Aluminium case.

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

When receiving the unit, the user is strictly recommended to inspect for any damage which may have occurred during transportation. Particularly, inspect for exterior damages like broken connectors and check that the panel is not scratched or cracked.

All packing material should be held on until the inspection has been completed. If damage is detected, the user must file a claim with the carrier immediately and notify CAEN.

Before installing the unit, make sure to read thoroughly the safety rules and installation requirements (see Sec. **Safety Notices** and **Installing the device**), then place the package content onto your bench.

The content of the delivered package standardly consists of the part list shown in the table below (**Table 5.1**). All the official documentation, firmware updates, software tools, and accessories are available on *www.caen.it* at the product web page.

	Part	Description	Qty
	D1260	2 channels 12-bit 65 MS/s Open FPGA Desktop Digitizer	x1
	USB 2.0 cable	USB 2.0 type A-Micro B - I/O cable	X1
	SCI-Compiler	USB Dongle for SCI-Compiler software, working exclusively for DT1260 target board	x1
	User guide	UM7970 – SCI-Compiler SMART User Manual	x1

Table 5.1: delivered kit.

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

It is 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. (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 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.
- If equipment is to be installed later, place equipment in original shipping container and store 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 WICH MEET THE MANUFACTURER SPECIFICATIONS

SCI-Compiler License

The Sci-Compiler SMART kit includes a full working *Lite* license for SCI-Compiler. A physical USB Dongle (delivered with the SMART kit) needs to be plugged in the PC during software usage.

Note: The SCI-Compiler *Lite* license unlocks all the features of SCI-Compiler compatible with the DT1260 and can be used for SCI-Compiler SMART kit only. In order to upgrade your license to use SCI-Compiler on other boards too, contact CAEN at info@caen.it

SCI-Compiler installation setup is accessible after activation of the **software license** on CAEN website using the SERIAL NUMBER and an ACTIVATION key provided in the delivered kit. Refer to Par. **SCI-Compiler License Activation** for more details.

Figure 5.1: SCI-Compiler USB Dongle and keys for license activation.

Note: user is not allowed to use the code generated by the SCI-Compiler on boards different from DT1260. Even using a small part of the code generate by the SCI-Compiler on a custom design board or other products is an explicit violation of the license terms and it is an offense against CAEN S.p.A and Nuclear Instruments S.R.L.

6 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. 6.1**) and it is even stored in an on-board non-volatile memory readable via Readout Software (see Chap**. SCI-55X0 Readout Software**).

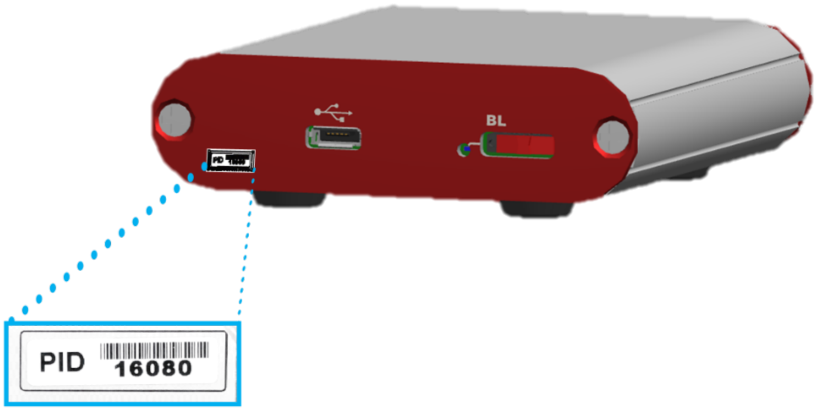


Fig. 6.1: PID location taking a CAEN desktop unit as an example. The PID can be found on the rear panel.

7 Power Requirements

The DT1260 is a power-over-USB module, rated at 5V. The proper USB cable is included in the delivered kit.

8 Installing the device

- Connect the DT1260 USB connector on the rear panel to a USB port on the PC, using the micro-USB cable provided within the delivered kit.

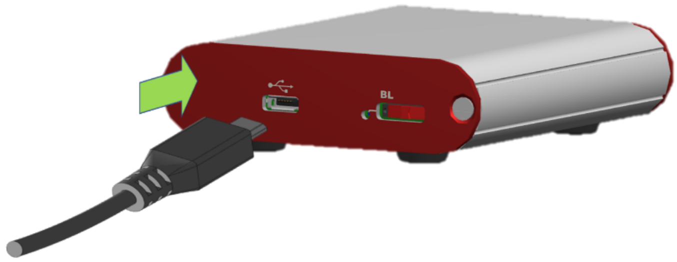


Fig. 8.1: installing the DT1260.

ONLY QUALIFIED PERSONNEL SHOULD PERFORM INSTALLATION, OPERATIONS

DO NOT INSTALL THE EQUIPMENT SO THAT IT IS DIFFICULT TO OPERATE THE ON/OFF SWITCH ONBOARD

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

Do not use the device and contact technical support if one of these situations is verified:
- Enclosure integrity is compromised
- Insulation of HV chord is damaged (if present)
- The indication led or display is not performing as required (e.g. led not working, display with incorrect graphic)
- Fans are not working (if present)

9 Panels Description

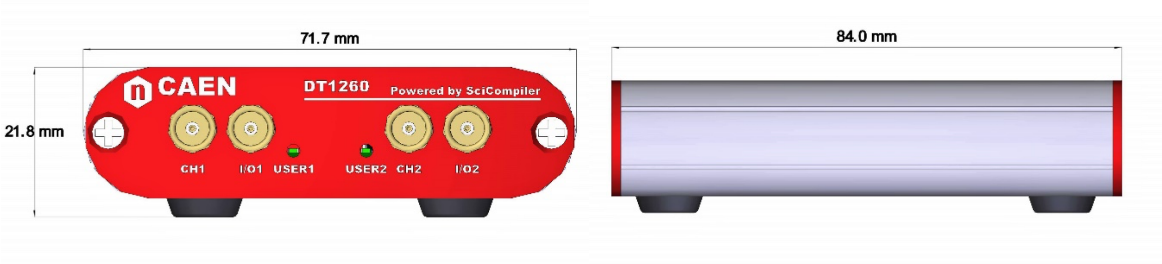


Figure 9.1: front and side view of the DT1260 with dimensions.

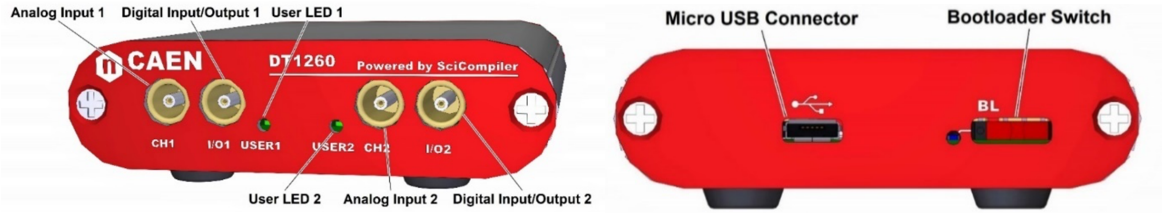
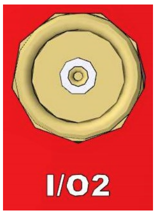
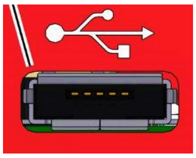
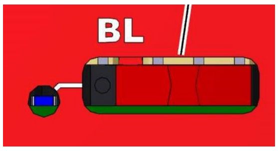


Figure 9.2: Front and rear panel view with description of the main parts

Front Panel

ANALOG INPUT		
	**FUNCTION** Input connectors CH1 and CH2 receive the input analog signals. **ELECTRICAL SPECS** Input dynamics: 2 V_{pp} Input impedance: 50Ω / 1kΩ	**MECHANICAL SPECS** Series: LEMO
DIGITAL I/O		
	**FUNCTION** I/O1 and I/O2 connectors can be programmed to receive or output logic signals **ELECTRICAL SPECS** TTL digital signals	**MECHANICAL SPECS** Series: LEMO
USER LEDs		
	**FUNCTION** USER1 and USER2 LEDs can be programmed to be ON/OFF according to the user's specific needs **ELECTRICAL SPECS** *Not available*	**MECHANICAL SPECS** *Not available*

Rear Panel

Micro-USB		
	**FUNCTION** USB 2.0 connector for data readout **ELECTRICAL SPECS** Standard: compliant with USB 2.0	**MECHANICAL SPECS** Series micro-USB
Bootloader switch		
	**FUNCTION** Switch to accesso bootloader mode in order to upload firmware permanently on the flash memory of the board. **ELECTRICAL SPECS** *Not available*	**MECHANICAL SPECS** *Not available*

10 Hardware Description

The DT1260 is a dual channel, open FPGA Flash ADC unit. The core of the system is a programmable Spartan 7 LX25 FPGA, compatible with SCI-Compiler software tool.

Its main features are:

- 2x Analog input channels on LEMO connectors
- 65 MS/s, 12-bit ADC
- Spartan7-LX25 Open FPGA
- Single-ended analog front-end with configurable analog offset
- 1k/50 Ω selectable analog impedance
- 2x Programmable Digital I/Os
- USB2 High Speed Communication Interface
- Power on USB
- 2x Programmable User LEDs
- Factory-programmed fast bootloader
- Low Power Consumption < 2W

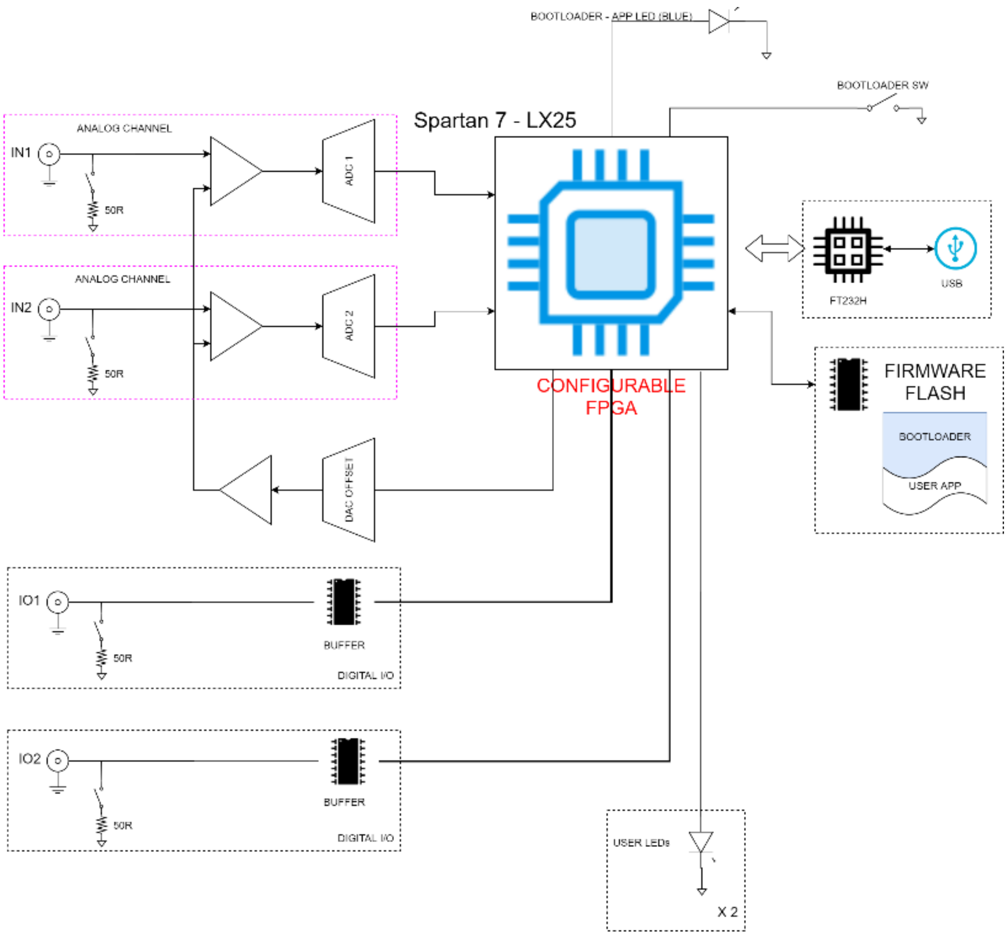


Figure 10.1: block diagram of the DT1260 unit.

The memory hosted onboard is sufficient to implement even complex algorithm, for example a trapezoidal filter for energy reconstruction. There is no extenal RAM on the board, therefore the maximum wavelength is limited by the amount of RAM available in the device. In any case, at least 500us per channel buffer can be allocated.

The analog input is directly connected to the input front-end, i.e. a buffer with offset regulation connected on the inverting input. The analog input is by default connected to ground with a 1kΩ resistor. A 50Ω termination can be set by opening the box and inserting the jumpers as shown in the instructions given in **Table 10.1**.

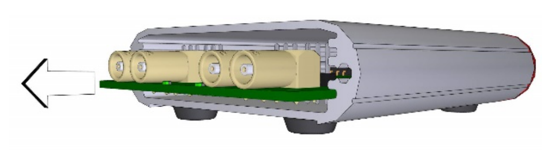
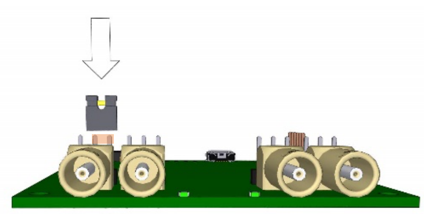
	Unscrew the two fixing screws on the front panel
	Remove the front panel
	Pull out gently the board PCB from the case, as much as needed to reach the pins mounted on the rear of LEMO connectors.
	Insert a jumper in the 50R position indicated on the serigraphy. Here CH1 is taken as example, same procedure stands for CH2.

Table 10.1: how to set 50 Ω input impedance on analog inputs, for instance CH1.

The analog input offset can be regulated via the integrated 12-bit DAC. SCI- Compiler exports by default an ANALOG_OFFSET DAC register. The 12-bit value written in the register is directly transfered to the DAC. As a result, the offset value is calibrated to move the ADC baseline to the value written in the register. For example if you write 2048, you will have the baseline at about 2150 level (over a total of 4096).

The input dynamic of the device is 4 V_{pp}: a 0 V signal will appear nearly at 2078 levels, 2078 to 4095 are for positive signals while from 2078 down to minimum offset are for negative signals. If the input signal is positive only, it is possible to cover the entire input dynamic using the minimum offset; while, if the input signal is bipolar, the offset should be set to 2048 nearly in order to have simmetrical dynamic.

Two 65 MS/s 12-bit ADCs convert the analog signal in digital data provided by the firmware in the FPGA. Two programmable digital I/Os are avaialable. Their direction (input or output) is programmable within the firmware block diagram in SCI-Compiler.

The firmware is stored in a 128 Mbit Flash. The first part of the Flash is pre-programmed with a bootloader which is not accessible to the user. The rest of the flash can be programmed by SCI- Compiler to store the user firmware.

There are two user LEDs for general purpose usage. The LEDs can be driven as defined by the user in the firmware deisgned in SCI-Compiler.

11 Getting Started with SCI-Compiler

In this Chapter we present a step-by-step procedure to be taken as example to program the DT1260 (also named SciDK) unit using SCI-Compiler. More examples are given as diagrams in the Example Project folder of SCI-Compiler. It is possible to use them to move the first steps with the software and modify them to create custom design. More details about SCI-Compiler can be found in the online help and **[RD1][RD2]** documentation available on CAEN website.

System Requirements

The SCI-Compiler is compliant with Windows 10 OS - 64 bit. The software requires Microsoft .NET 4.0 or higher. If the framework is not available on your PC, it can be downloaded from Microsoft© website.

The DT1260 is based on a Xilinx FPGA and require the free Vivado HLx System Edition (refer to **[RD3]**) to compile the firmware generated with the SCI-Compiler, create the bitstream and program the FPGA. The minimum version of Vivado for which the compatibility is guaranteed is the 2017.4. The Vivado tool can be installed by following the procedure described in **[RD4]**.

OS	Windows Framework required	Third-party software required
Windows 10 – 64 bit	Microsoft .NET Framework 4.0 or higher	Xilinx VIVADO 2017.4

Table 11.1: system requirements to properly run SCI-Compiler for DT1260.

Drivers installation

The DT1260 unit uses the standard FTDI drivers for USB 2.0 connection, that should be automatically recognized by Windows OS (see **Figure 11.1**). We decided not to customize the device driver in order to preserve the portability of the driver on Windows/Linux/MacOS/Android OS. Drivers for these operating systems can be also downloaded from FTDI web page:

https://ftdichip.com/drivers/d2xx-drivers/

Follow the FTDI driver installation guide to install the device driver.

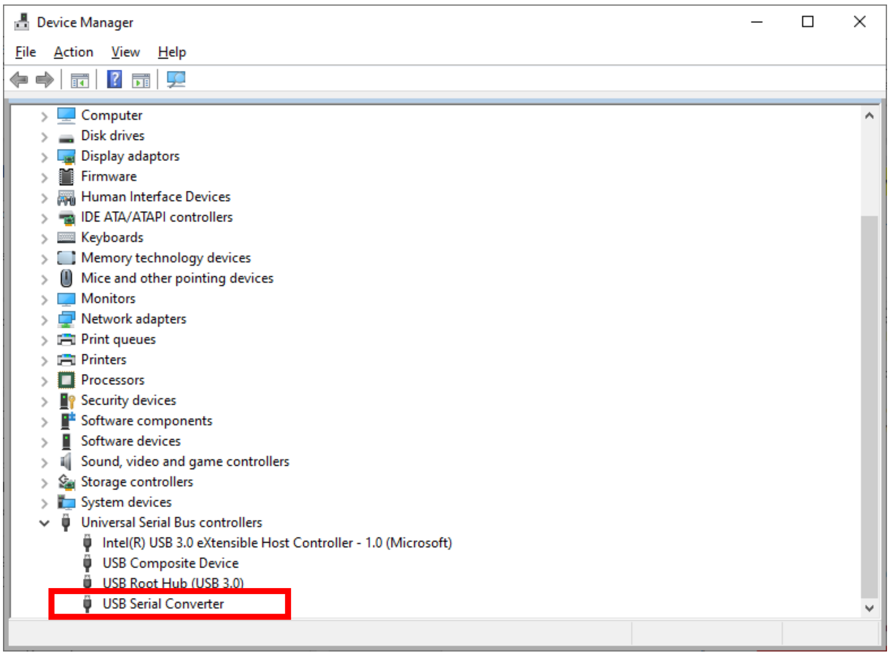


Figure 11.1: the Windows Device Manager showing up the DT1260 as USB Serial Converter Device.

SCI-Compiler License Activation

SCI-Compiler can be downloaded after activation of the **software license** on CAEN website using the SERIAL NUMBER and an ACTIVATION key provided together with the USB Dongle. The USB Dongle must be plugged into the PC to run SCI-Compiler full version. The generated firmware can be uploaded on DT1260 board only. Refer to **[RD1]** and **[RD2]** for more details.

Figure 11.2: SCI-Compiler USB Dongle and keys for license activation.

Note: user is not allowed to use the code generated by the SCI-Compiler on boards different from DT1260. Even using a small part of the code generate by the SCI-Compiler on a custom design board or other products is an explicit violation of the license terms and it is an offense against CAEN S.p.A and Nuclear Instruments S.R.L.

The user needs to create an account at www.scicompiler.cloud and add the serial number and activation key in the "MySciCompiler" area, in order to unlock the license and access the download area.

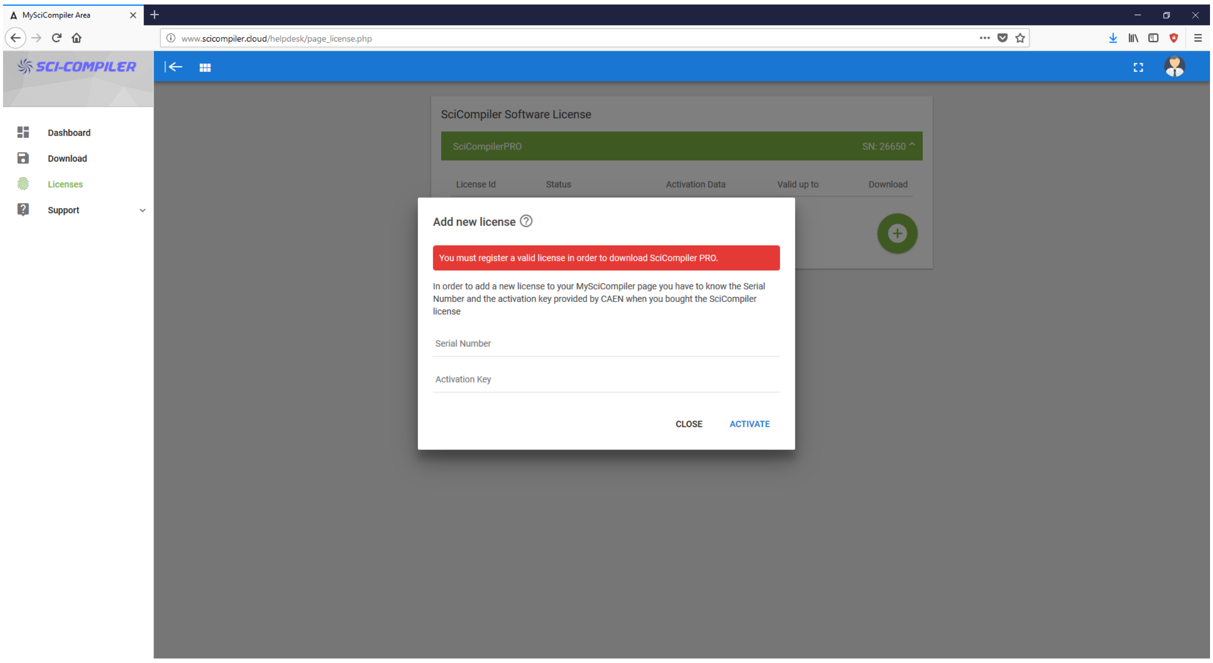


Figure 11.3: "MySciCompiler" area at www.scicompiler.cloud to add the license, download the SCI-Compiler installation setup and create a support request.

SCI-Compiler Installation

Before installing SCI-Compiler, please check if the target hardware is properly installed and make sure you have installed the needed driver to exploit USB communication.

Note: It is possible to download the latest available full installation package for SCI-Compiler at www.scicompiler.cloud, in the "MySciCompiler" area, after having registered your license. Also, the past software releases are available for download, up to the latest upgrade included in your license.

After activating your license**, download the installation package** from www.scicompiler.cloud, in the "MySciCompiler" area (**login required)** and **run the setup file.** A setup Wizard will guide you through the software installation.

At first software start-up, a Welcome Wizard to configure SCI-Compiler is launched, reporting all the needed actions to set properly the external Xilinx Vivado as well as the access to "MySciCompiler" personal area.

SCI-Compiler Quick Start

In the following we show how to create, load and test a firmware implementing waveform recording on both analog channels of the DT1260 with adjustable signal offset. Follow this procedure only after all preliminary operations described in the previous paragraphs have been fulfilled.

- Launch SCI-Compiler software
- Click **NewProject** and select SciDK-DT1260 as a target for the project itself. Choose a name and folder for the project and press *Create.* A blank diagram page will open.

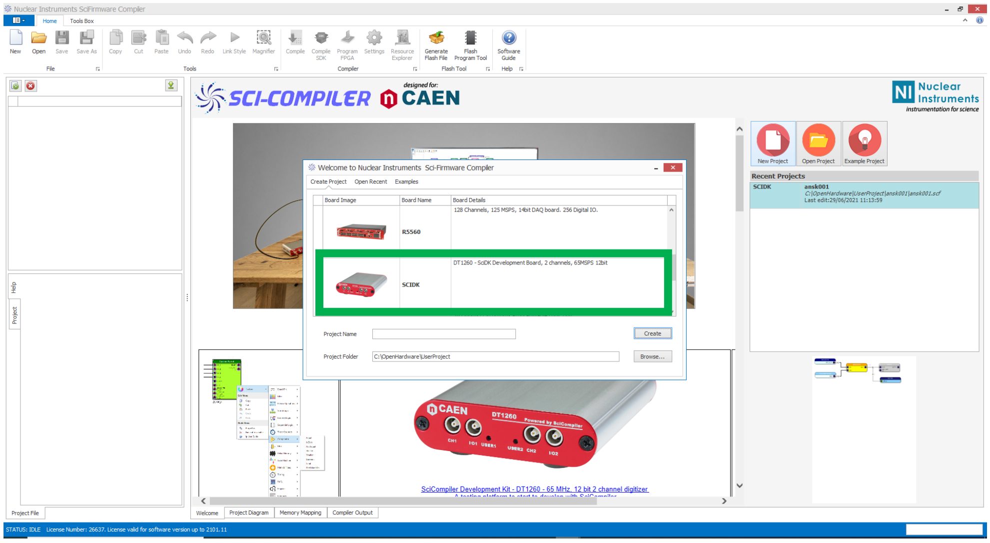
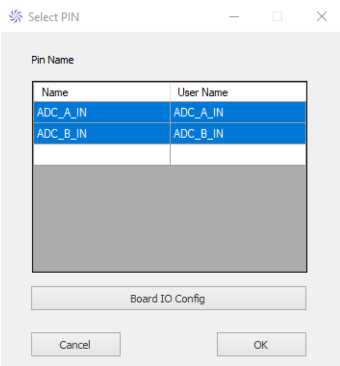
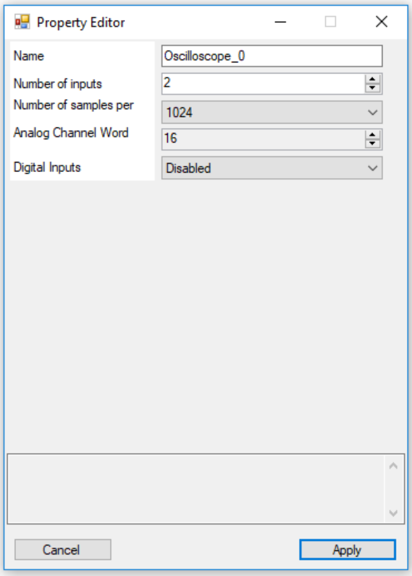


Figure 11.4: create a new project for DT1260 unit in SCI-Compiler

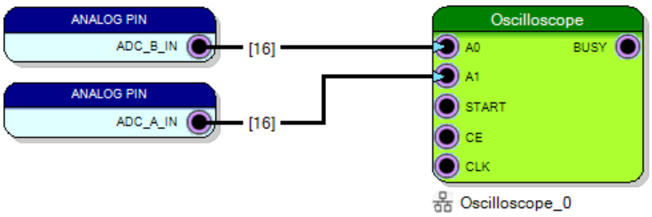
- From the top toolbar, pick Board Pin → Analog In block. The following window will open. Select both rows, corresponding to the two analog input channels of the DT1260 and Press *Ok.* You will see the two created blocks placed in the blank sheet.



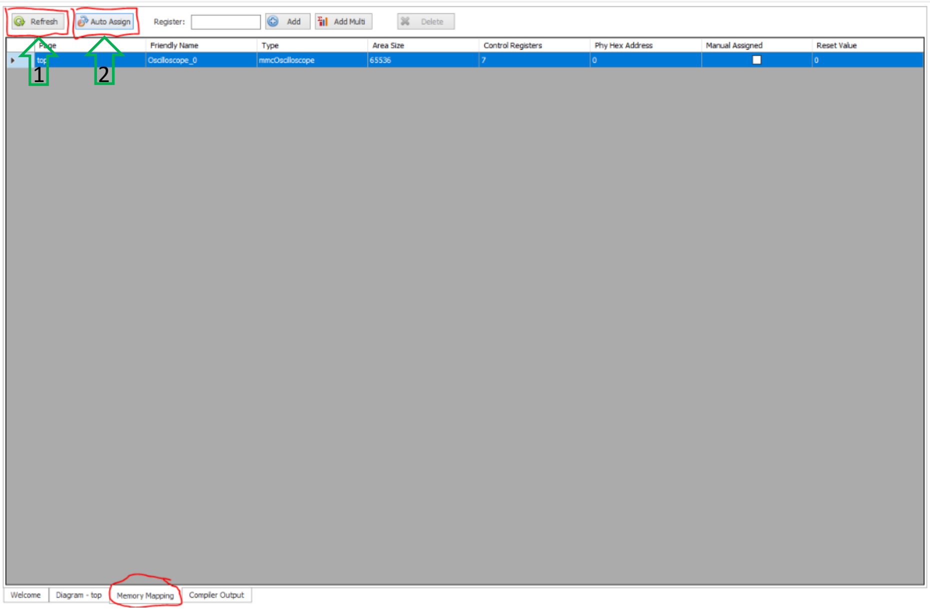
- From the top toolbar, pick DAQ → Oscilloscope. The corresponding block will be added to the diagram
- Right-click on the block and set the parameters as shown below, then press *Apply*



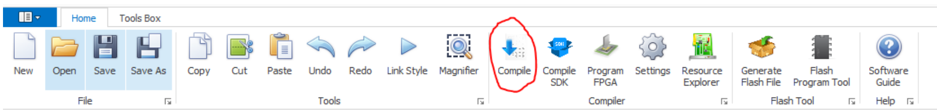
- Connect the blocks on the diagram as shown below.



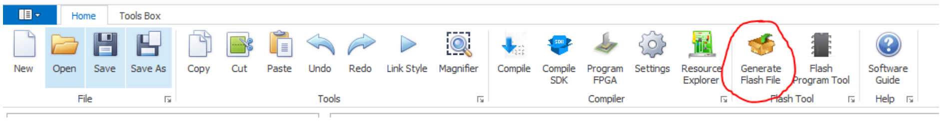
- Go to Memory Mapping tab and press first *Refresh* and then *Auto Assign* in order to assign the memory address of the oscilloscope.



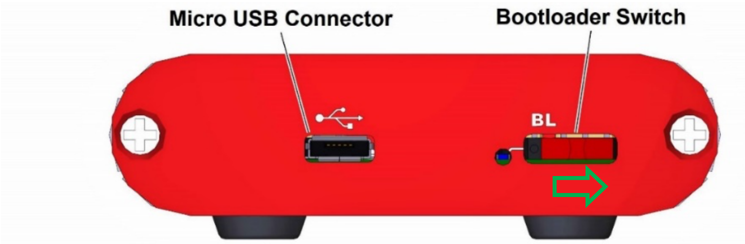
- In the top toolbar, go to *Home* → *Compile*



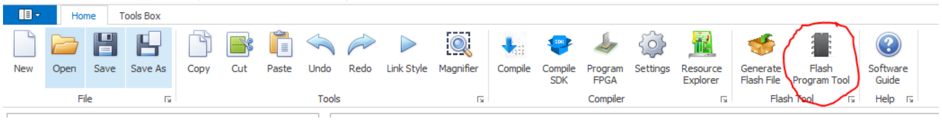
- After compilation processi is ended successful (see the results in the Compiler Output), click on *Generate Flash File.* A .niu firmware file will be generated and saved.



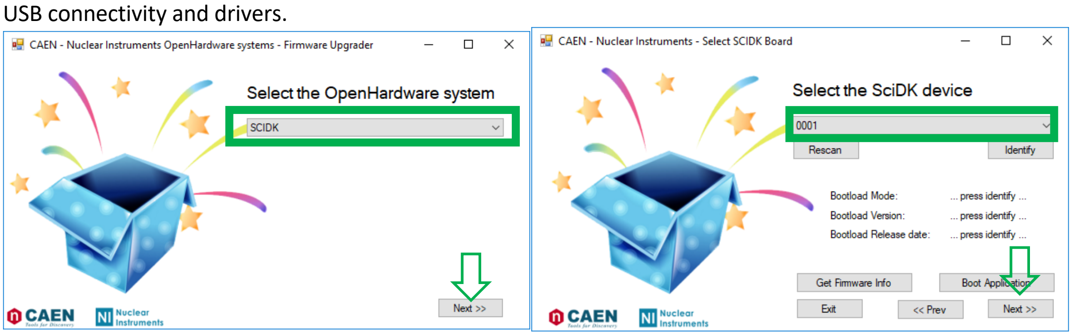
- Disconnect the DT1260 unit from USB and move the bootloader switch on the rear panel to the right. Power on the unit connecting the micro-USB cable to the PC. The BL LED should stay ON in blue.



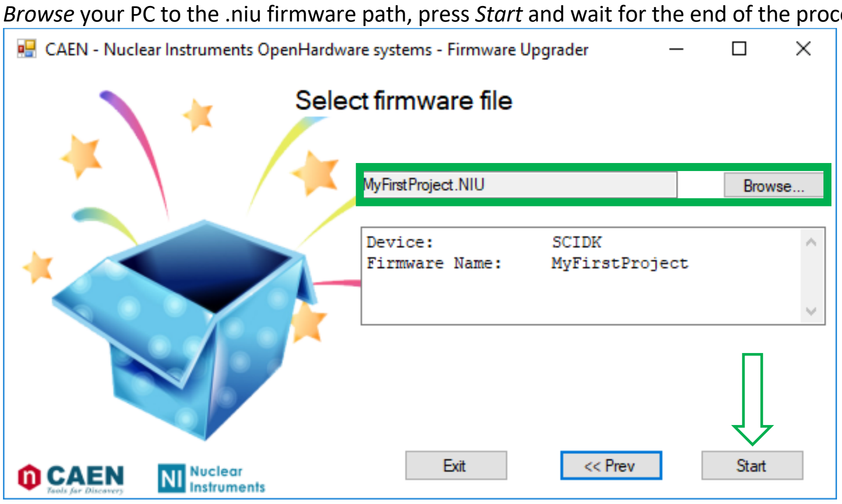
- From SCI-Compiler, press *Flash Program Tool*



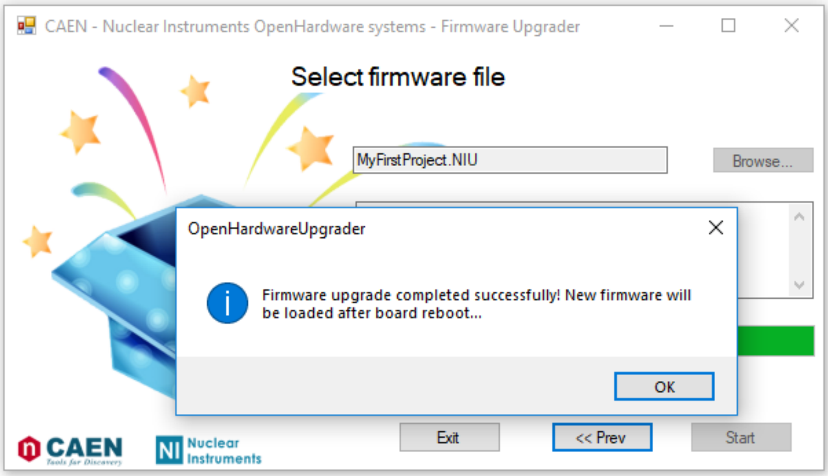
- The following window will open. Select SciDK-DT1260 from drop-down menu and press *Next*. Then select the PID of the board to be programmed and press *Next*. If no PID appears in the drop-down menu, please check USB connectivity and drivers.



- *Browse* your PC to the .niu firmware path, press *Start* and wait for the end of the process.

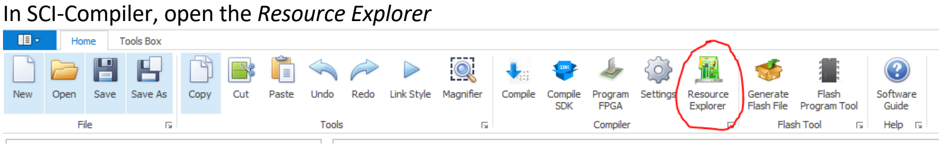


- When the process is finished, the following message will appear. Press *Ok.*

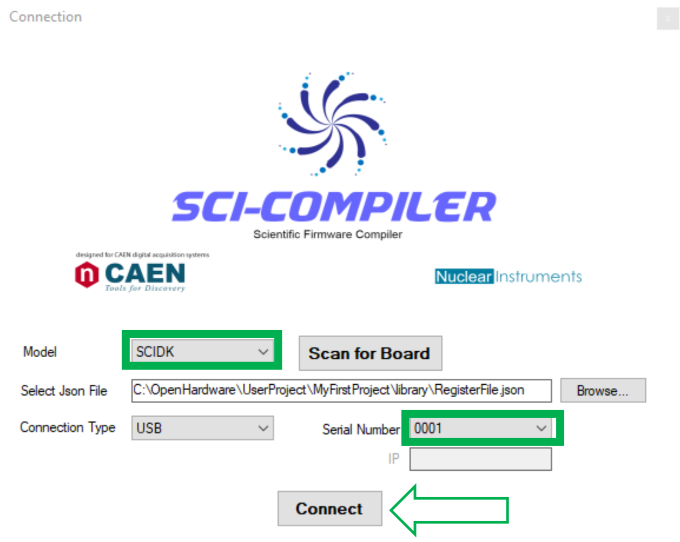


- Disconnect the DT1260 unit from USB to power it OFF, move the bootloader switch to normal operation position (left hand-side) and reconnect the board again. After a while you should see the BL LED blinking in blue, telling that the board is correctly running a valid firmware.

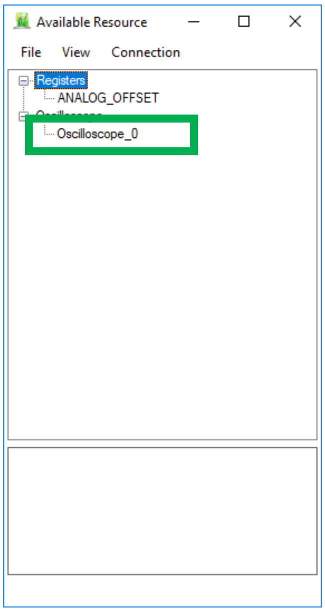
- In SCI-Compiler, open the *Resource Explorer*



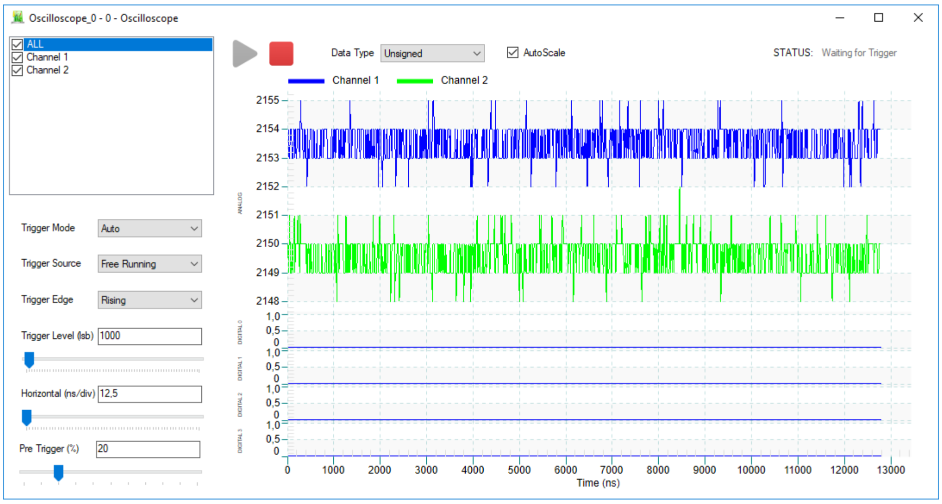
- Check that the DT1260 unit is correctly connected to the PC via USB. Select *DT1260* model from the drop-down menu and choose the correct SerialNumber/PID among the ones listed. Press *Connect.*



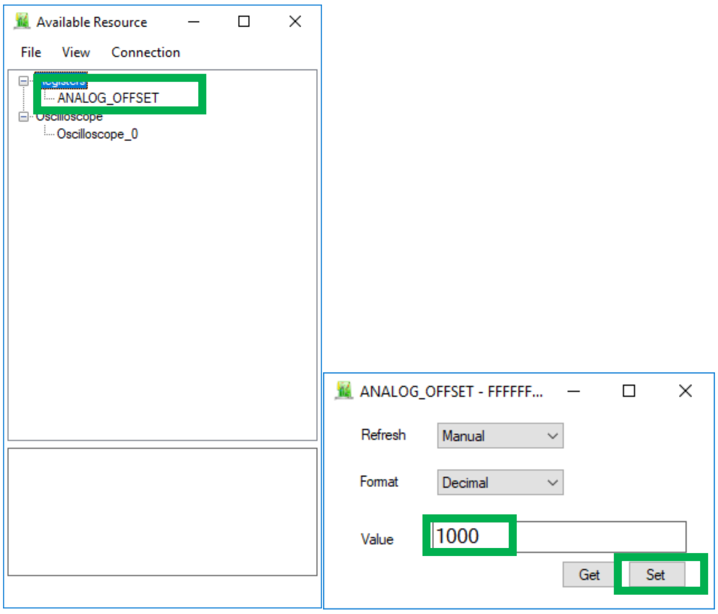
- The Resource Explorer window opens and enumerates the Memory Mapped Peripheral available for the firmware installed on the board. Right click on the *Oscilloscope*_0 and select *View*.



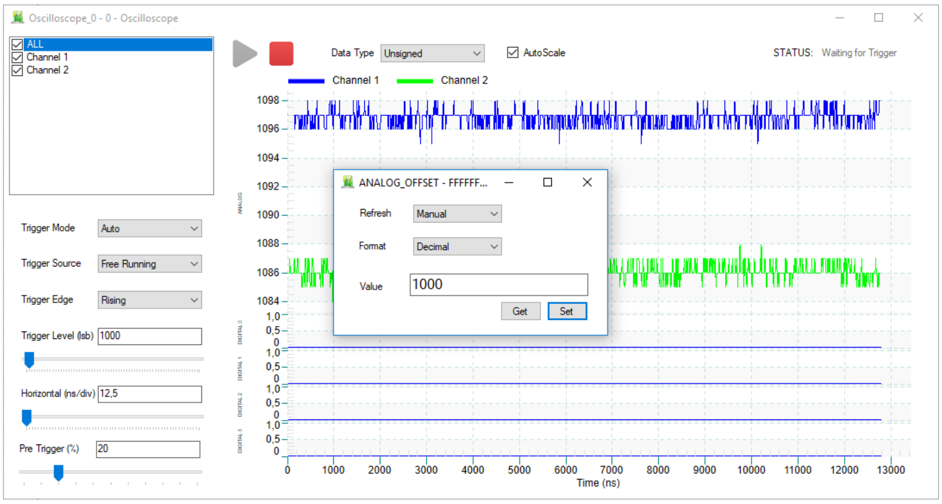
- Configure the settings as shown in the figure below, then press *Play*. Be careful to select free running as Trigger Source because there is no input signal connected to the DT1260 unit. You should see the baseline of the two analog input channels (blue and green traces).



- In the Resource Explorer right click on ANALOG_OFFSET REGISTER and select *Set/Get*. Enter *1000* in Decimal mode, as shown below. Then press *Set*. In this way you have accessed the input offset register and set it to 1000, which means shifting the input channels baseline at nearly 1000 levels of the dynamic range (over a total of 4k)



- After pressing *Set*, in the Resource Explorer plot, it is possible to see the two baseline traces shifted by nearly 1000 levels of the input dynamic range.



✎ **Note:** SCI-Compiler includes many examples diagram compatible with the DT1260-SciDK board. The user can start from there in order to take confidence with FPGA programming under SCI-Compiler.

12 Firmware

The SCI-Compiler SMART kit is a programmable platform and it is designed in order to encourage the user to develop its own custom firmware using **SCI-Compiler** to generate and compile the firmware code.

Note: a set of full working SCI-Compiler diagrams to generate firmware with different functions is available in the SCI-Compiler example folder.

A full working **default firmware** is provided as a pre-compiled file: this is a fully featured solution and it is developed not as a basic example to start developing with SCI-Compiler but as a full DAQ readout system firmware. The DT1260 comes with the default firmware already uploaded.

Note: the latest release of the default firmware file (.NIU extension) can be downloaded from CAEN website and easily installed on the board with the OpenHardware – Firmware Upgrader tool (see Sec. **Firmware Upgrade)**

Note: the default firmware is available as a compiled file on CAEN website or as a SCI-Compiler example diagram in C:\OpenHardware\SCIDK\firmware\MCA folder, which is installed together with the SCI-55x0 Readout Software – refer to Par. **Software installation** -. The user can start from this design to perform modifications of the default firmware

The **default firmware** implements the typical features of Waveform Recording Digitizers and PHA algorithms. It is fully managed by the free-downloadable and open-source SCI-55X0 Readout Software. In more details, the default firmware implements the following pulse processing features:

- **Waveform digitization** of the 2 analog channels
- Leading edge trigger
- 2 independent channels **trapezoidal filter** for energy calculation

The default firmware is fully developed in SCI-Compiler (see **Figure 12.1**) and can be easily modified by the user. The default firmware project is available in the SCI-Compiler example section.

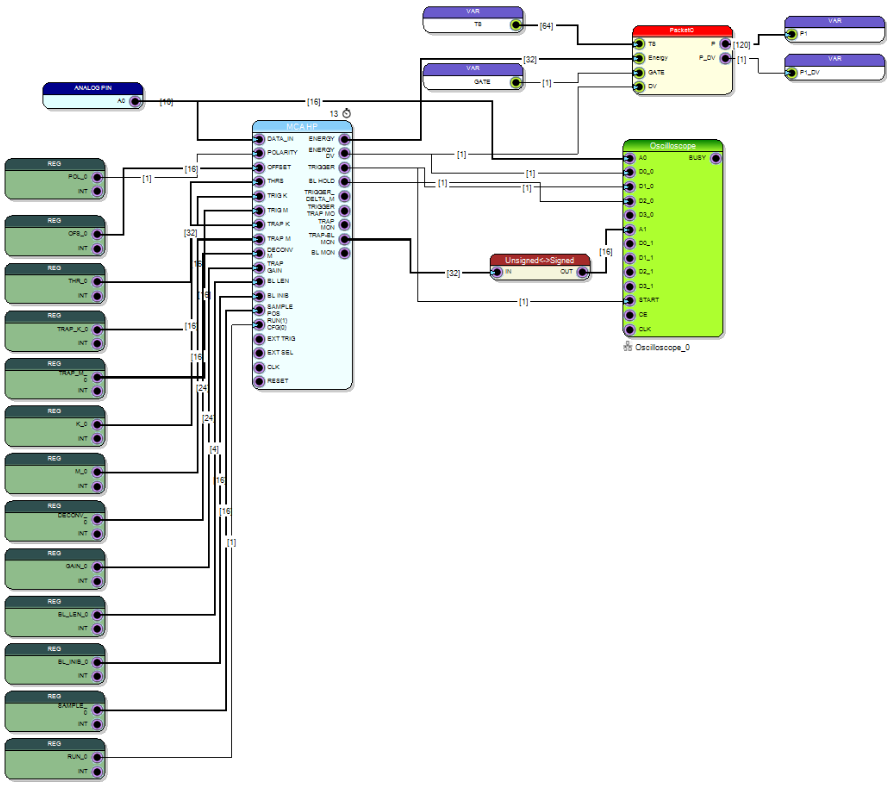


Figure 12.1: SCI-Compiler scheme for single channel data processing in the default firmware.

The default firmware implements an independent trapezoidal energy filter on each channel for energy calculation. It is based on a derivative trigger followed by a trapezoidal energy filter and gives in output a packet containing the timestamp and the energy of the input signal. The trapezoidal filter is a filter able to transform the typical exponential decay signal generated by a charge sensitive preamplifier into a trapezoid whose flat top height is proportional to the amplitude of the input pulse (that is to the energy released by the particle in the detector) (see **Figure 12.2**). The trapezoid plays almost the same role of the shaping amplifier in a traditional analog acquisition system. There is an analogy between the two systems, both have a "shaping time" constant. For both, a long shaping time gives a better resolution but has higher probability of pile-up. Both are AC coupled with respect to the output of the preamplifier whose baseline is hence removed, but both have their own output DC offset and this constitutes another baseline for the peak detection.

The output data packet contains an header, a word for the energy, two words for the timestamp and a word for the channel ID.

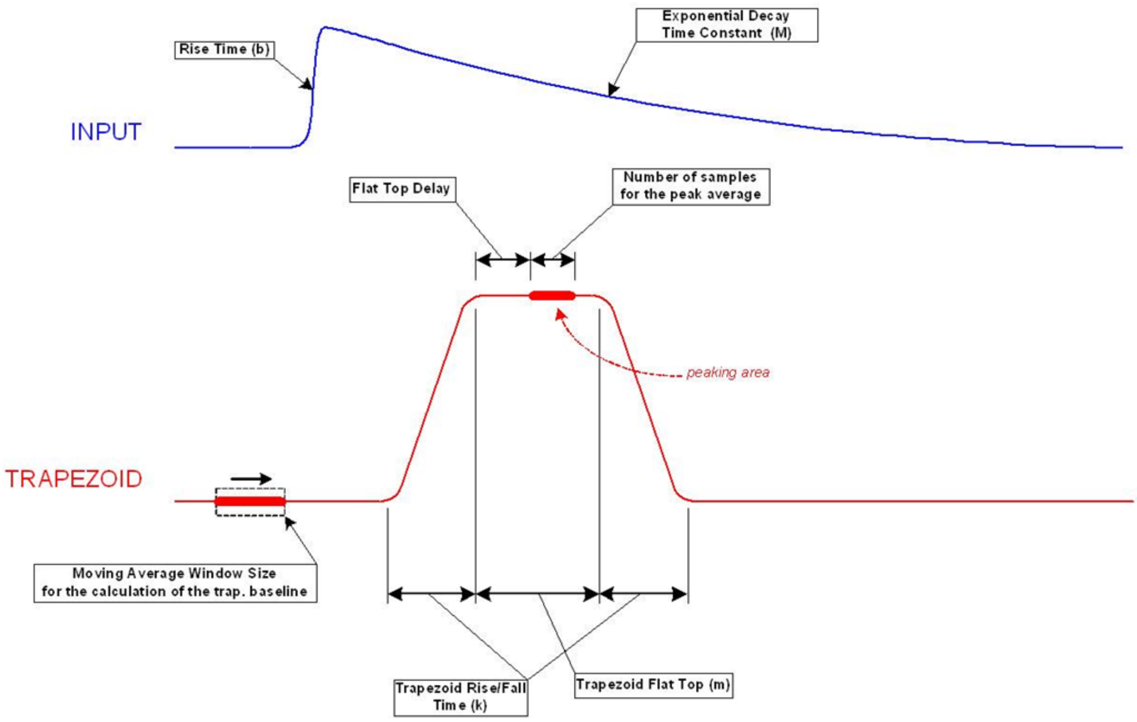


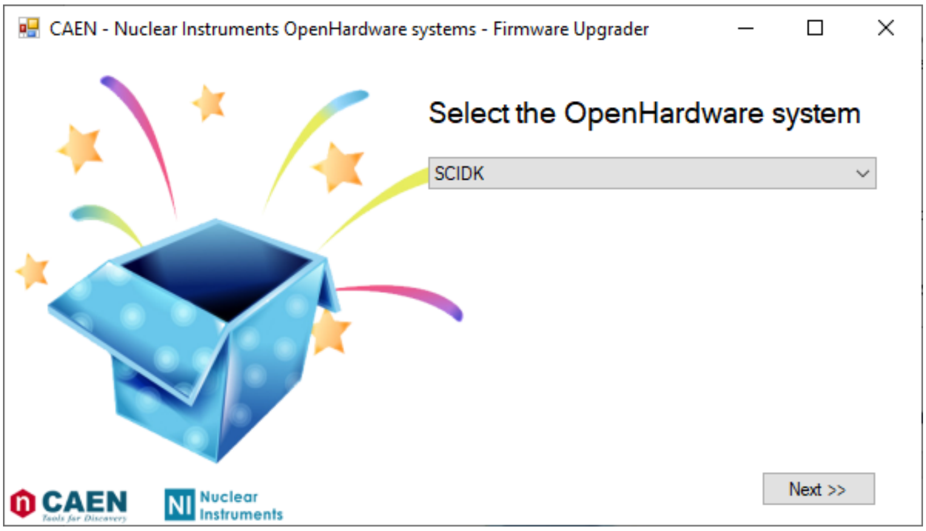
Figure 12.2: the trapezoid method used in the board default firmware

Firmware Upgrade

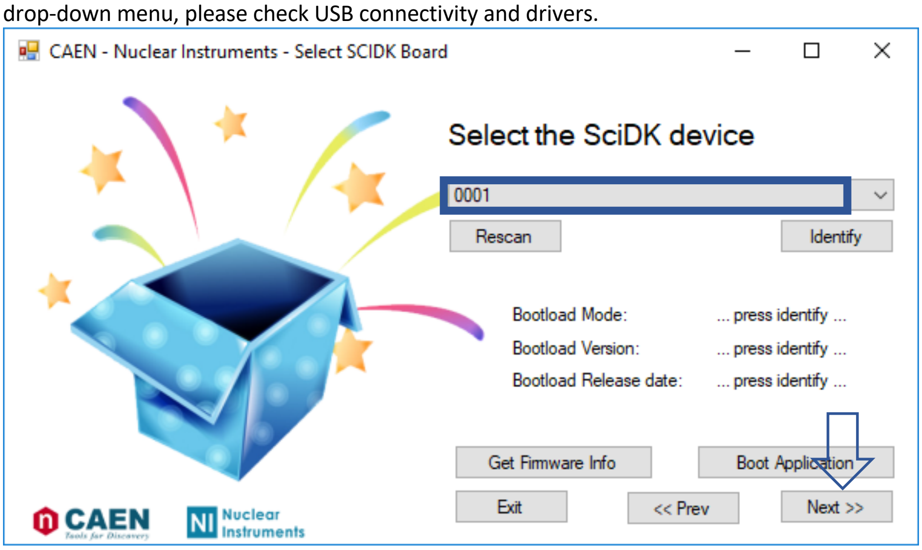
If the relevant firmware files (.NIU files) have been already generated by SCI-Compiler or in order to restore the default firmware available on SCI-Compiler SMART webpage, it is possible to directly use the firmware upgrade tool *(OpenHardware – Firmware Upgrader),* included both with SCI-Compiler installation.

In order to upgrade the firmware, follow the steps below:

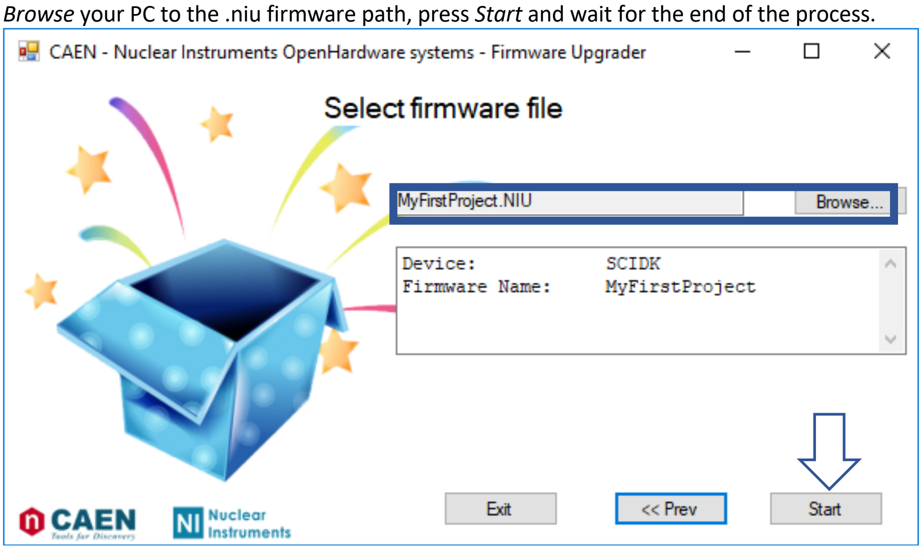
- Move the rear BL switch of the DT1260 on the right
- Connect the board to the PC through the micro-USB
- After installing SCI-Compiler, go to C:\OpenHardware\FirmwareUpgrader and open the ***OpenHardwareUpgrader.exe***
- A wizard will guide you in the firmware upgrade process. **Select SCIDK** among the available listed hardware and press **Next**.



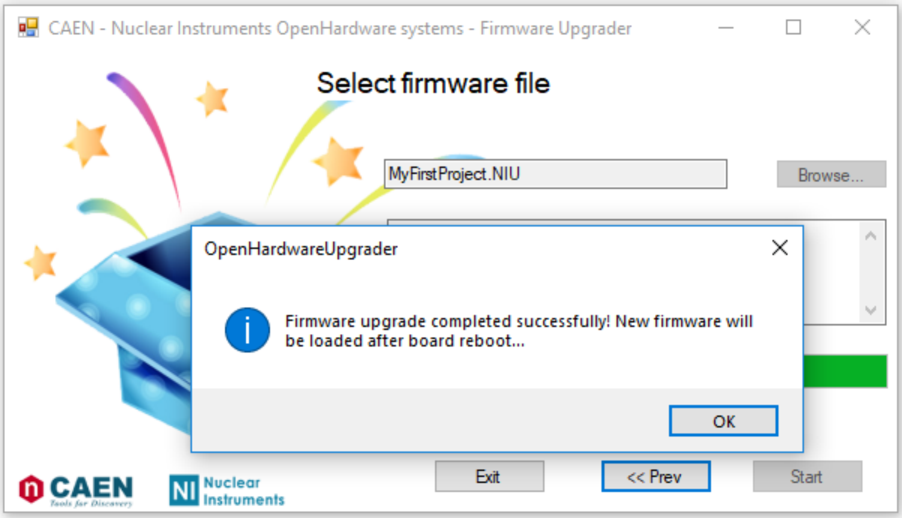
- Then select the Serial Number/PID of the board to be programmed and press *Next*. If no PID appears in the drop-down menu, please check USB connectivity and drivers.



- *Browse* your PC to the .niu firmware path, press *Start* and wait for the end of the process.



- When the process is finished, the following message will appear. Press *Ok.*



- Disconnect the DT1260 unit from USB, move the bootloader to normal operation position (left position) and reconnect it again. After a while you should see the BL LED blinking in blue. The board is correctly running the loaded firmware

⚠ **WARNING:** There is no way for the system to recognize if a firmware is correct for a particular hardware. For example, a firmware designed for another board can be loaded on a DT1260 but it can damage the board. <u>User must check the hardware target for a specific firmware BEFORE loading it on the flash memory.</u>

13 SCI-55X0 Readout Software

SCI-55X0 Readout Software is a **free and open-source** software developed for Windows OS to operate **in conjunction with the default firmware** of the DT1260, in order to provide a ready-to-use solution.

The software implements typical features needed to acquire and process data in nuclear spectroscopy and particle physics:

- Waveform monitor with common or independent channel trigger
- List mode readout (energy, time) in channel independent mode and in frame mode (all channels readout after a common trigger)
- Energy Spectrum plot for all channels
- Bidimensional heatmap visualization for imaging, with configurable detector shape
- Spectrum fitting and energy calibration
- Data saving with waveform dump on file

The software is distributed both as compiled application and as source code. The source code is written in VB.NET and C# and it can be easily customized by the user to adapt to a custom firmware and for any other need. In order to recompile the SCI-55X0 Readout Software, a free version of Visual Studio .NET 2015 or later must be installed on the user's PC.

The following guide and screenshots refer to SCI-55x0 Readout Software version 2021.06.28.0

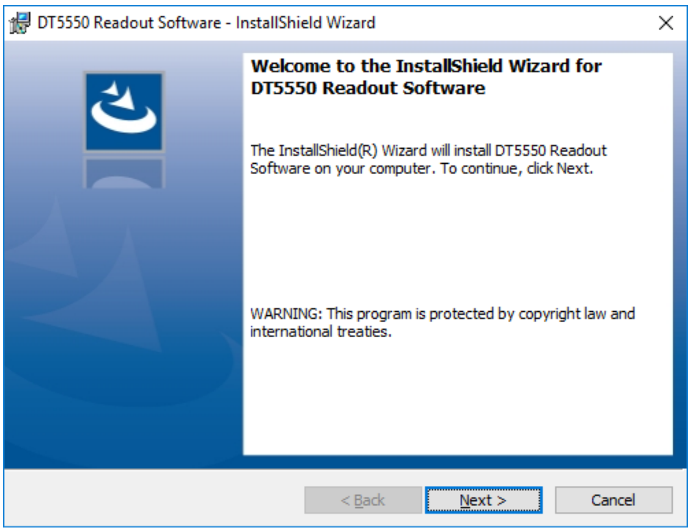
Software installation

SCI-55X0 Readout Software is compliant with Windows 7 or later.

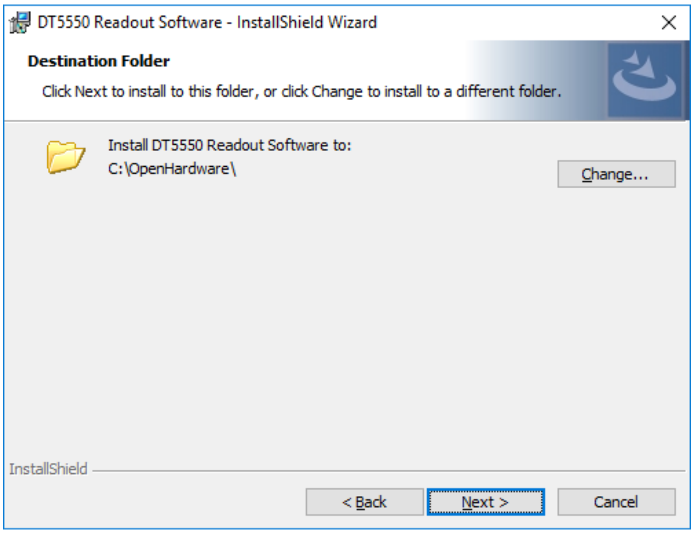
Note: The software is standalone and does not require the prior installation of any library. The installation setup also installs the Open Hardware Firmware Upgrader tool.

In order to install the SCI-55X0 Readout Software and the Open Hardware Firmware Upgrader, follow the steps below:

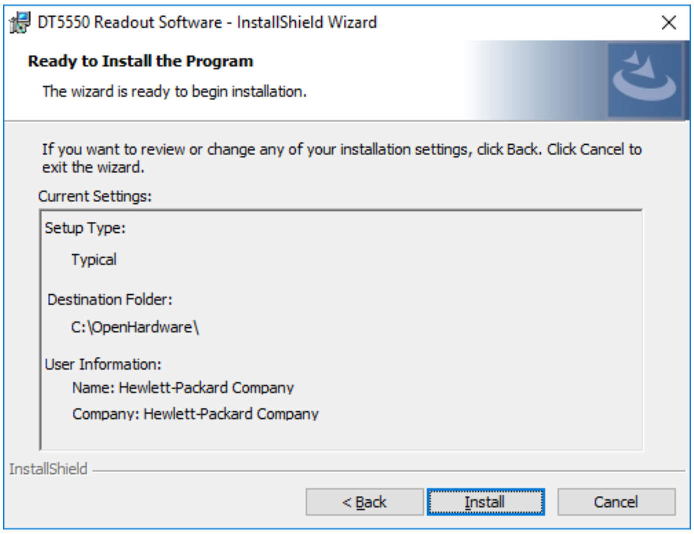
- Download the software package from the DT5550 product page on the CAEN website (**login required**)
- Unzip and run the executable.
- A setup wizard will start. **Press "Next" to continue.**



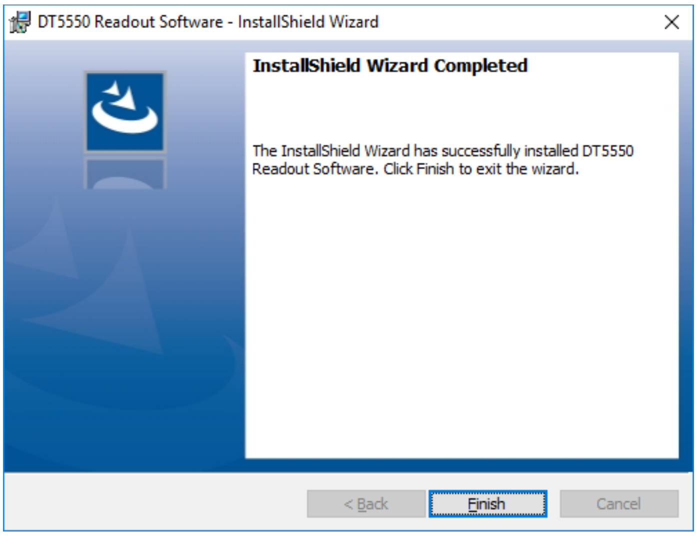
- Choose the destination folder and **press "Next".** By default, the readout software is installed in C:\OpenHardware\DT5550 and the firmware upgrader in C:\OpenHardware\FirmwareUpgrader



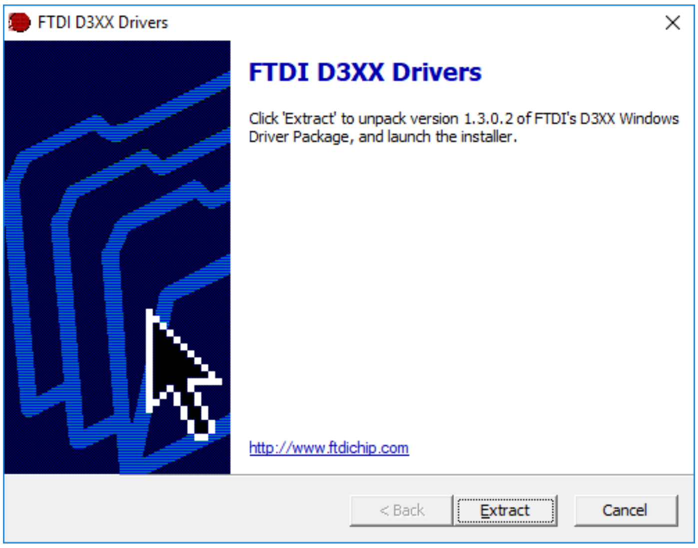
- **Click "Install"** to complete software installation.



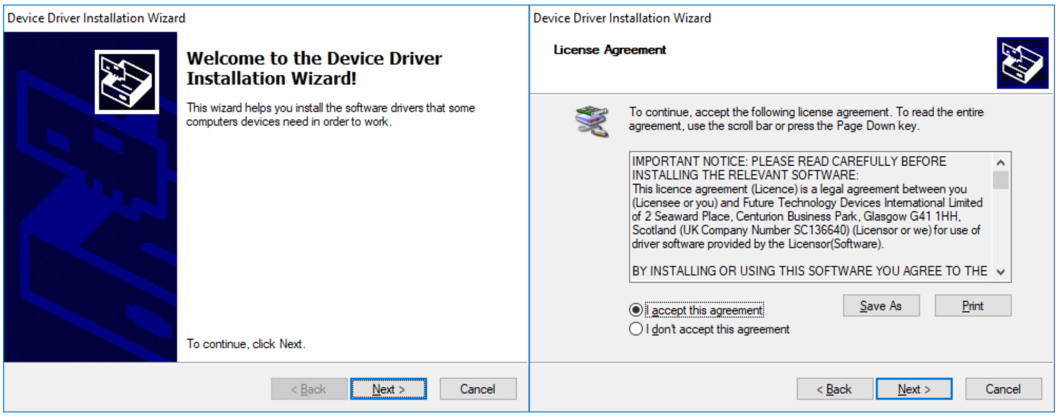
- Wait until installation is completed and press "**Finish**" to complete the setup.



- Once SCI-55X0 Readout Software installation is complete, the Wizard will ask to extract and install FTDI USB Drivers (if needed). Press "**Extract**" to continue.



- **Press "Next"** in the following window to continue and **accept the License Agreement**.



- The driver will then be installed. **Press "Finish"** to exit the Wizard.
- Now it is possible to launch the software.

Note: the software is open source: it is possible to find the software VB.NET source code and the default firmware project (developed with SCI-Compiler) in the installation folder, to allow user customization.

Board connection

After launching the software, the "Connection" window will open. In the *SCIDK* tab, it is possible to select the *Serial Number* of the DT1260 board to be connected, which should automatically appear in the box. Press "Refresh" to update the serial number of the connected board. Press "Connect" button to initialize the software GUI.

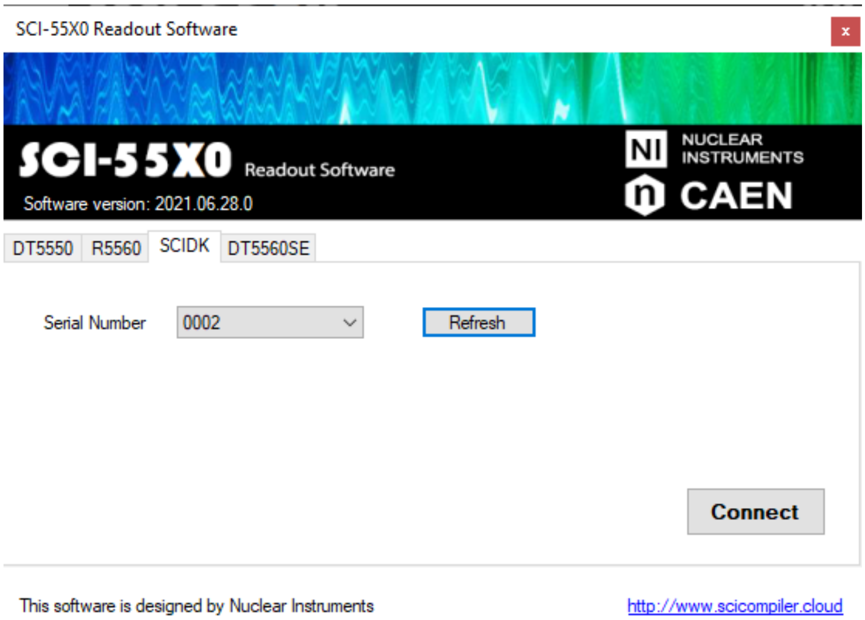


Figure 13.1: the "Connection" window at startup of the SCI-55X0 Readout Software

Software GUI Description

After successful connection, the main window will appear. The window is divided in four areas:

- Control bar: here there are all the buttons needed to control the acquisition process.
- Main working area: all tabs like "Settings", "Spectrum" and "Oscilloscope" are shown here.
- Log Area: all messages related to the user actions are displayed in the history log.

All panels can be undocked and rearranged also outside the main window in order to organize the software layout on multiple monitors.

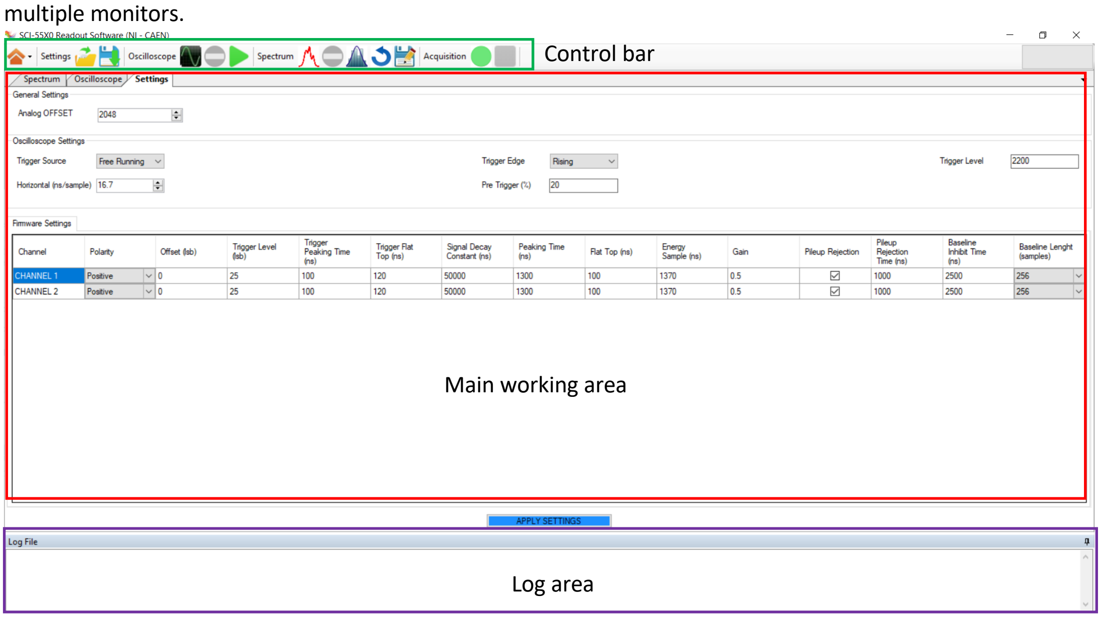


Figure 13.2: the main window of the SCI-55X0 Readout Software. The main areas are highlighted.

Control Bar

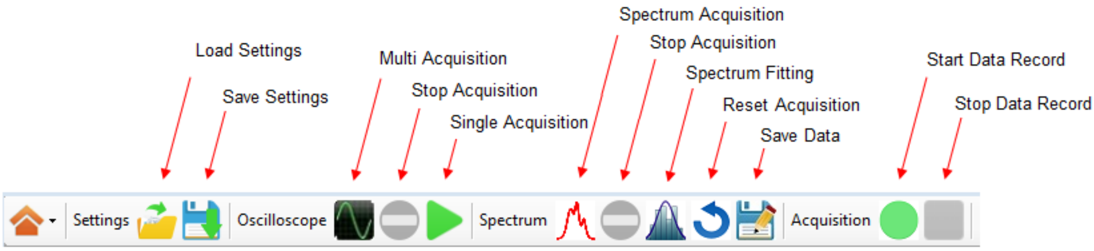
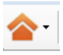


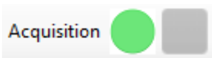
Figure 13.3: the Control Bar of the SCI-55X0 Readout Software.

The "Control Bar" contains the following buttons:

- 
    - **Spectrum**: change the visualization features of the spectrum (semi-logarithmic or linear on Y axis, rebinning on the X axis, graphical plot type)
    - **View**: select the zoom type
    - **File**: export and print plots
- 

:
    - **Load** settings from file
    - **Save** Settings to file
- 

    - **Multi Acquisition**: start to acquire waves until stop acquisition button is pressed
    - **Stop Acquisition**: abort waves acquisition
    - **Single Acquisition**: acquire a single waveform every time the button is pressed
- 

    - **Spectrum Acquisition**: start spectrum and image acquisition process
    - **Stop Acquisition**: abort spectrum acquisition
    - **Spectrum Fitting**: open the fitting tool window
    - **Reset Acquisition**: reset spectrum and image
    - **Save Data**: save on disk the spectrum for each channel and the cumulative images
- 

    - **Start Data Record**: open the data dump window to configure and start saving data (waves or list) event by event
    - **Stop Data Record**: stop current data dump process

Settings Tab

The Settings Tab allows to configure all digitizer parameters. It is divided in three areas, as shown in **Figure 13.4**:

- **General Settings**: it allows to adjust the common analog DC offset value in the range [0:4096]
- **Oscilloscope settings**: it allows to set the parameters to visualize the waveforms on the oscilloscope plot: it can be selected the same trigger source, trigger edge and trigger level for all the oscilloscope channels, the time scale on the plot and the length of the pre-trigger window
- **Firmware Settings**: this is a table with a row for each channel containing all configuration parameters for that channel, i.e. signal polarity and offset, all the derivative trigger parameters, all the trapezoidal filter parameters and all the baseline calculation parameters.

The user must push the button **APPLY SETTINGS**, at the bottom of the window, in order to let the settings become effective. Settings cannot be applied while an acquisition is running.

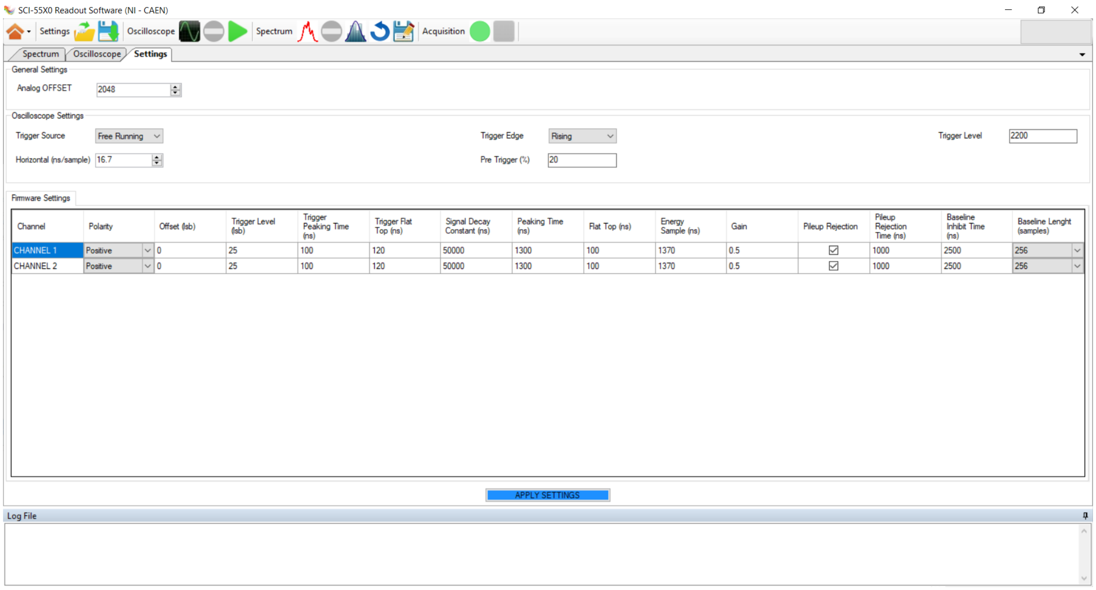


Figure 13.4: the Settings Tab of the SCI-55X0 Readout Software.

Oscilloscope Settings

These settings allow to configure the same parameters of all the oscilloscopes (i.e. of the waveform recording).

- Trigger Source: Select the trigger source for the oscilloscopes. Options are:
  - **MCA Trigger**: trigger generated by the MCA using the fast trapezoidal filter. The threshold is set on the output of the derivate of the fast trapezoidal, therefore *Trigger Level* in the *Firmware Settings* tab must be set accordingly.
  - **Free Running**: each oscilloscope operates without trigger and acquires a waveform as soon as the previous transfer is completed
  - **CHANNEL 1/2**: a leading-edge trigger on the analog input of the selected channel is implemented to trigger the correspondent oscilloscope waveform acquisition. The *Trigger Edge* and the *Trigger Level* must be properly set.
- Trigger Edge: it selects if each oscilloscope triggers on the rising or falling edge of the input signal. It works only in conjunction with *Trigger Source = Internal*
- Horizontal (ns/sample): Set the time base for each oscilloscope in ns per sample
- Pre-Trigger (%): Specify the portion of the acquisition window dedicated to the pre-trigger (signal sampled before the trigger)
- Trigger Level: Set the absolute trigger level threshold in LSB. It is taken into consideration always for Spectrum acquisition, while for Oscilloscope acquisition only if *Trigger Source = Channel 1/2*

Firmware Settings

These settings allow to configure the specific parameters of each channel, used by the MCA firmware component:

- Polarity: Select between positive and negative polarity according to the input channel
- Offset: Set the digital offset added to the analog input channel after the polarity inversion made at firmware level by the trapezoidal filter
- Trigger Level (lsb): Set the derivative trigger level threshold. It is taken into consideration always for Spectrum acquisition, while for Oscilloscope acquisition only if *Trigger Source = Channel 1/2*
- Trigger Peaking Time (ns): Set the peaking time of the trapezoidal trigger signal (between 16 ns and 800 ns)
- Trigger Flat Top (ns): Set the flat top of the trapezoidal trigger signal

- Signal Decay Constant (ns): Set the trigger inhibition time after a trigger, it must be as near as possible to the input signal decay constant.
- Peaking Time (ns): Set the peaking time of the energy trapezoidal filter (between 16 ns and 4 us)
- Flat Top (ns): Set the flat top duration of the energy trapezoidal filter
- Energy Sample (ns): Set the position where the value of the energy trapezoidal filter is sampled to measure the signal energy (should be peaking time + 0.7*Flat Top).
- Gain: Multiplication factor for the energy trapezoidal filter result. This allows to recover resolution avoiding trashing away the least significant bits of the energy filter. A low gain reduces the resolution of the measure while a too high gain will saturate the spectrum dynamic.
- Pileup rejection: enable/disable the rejection of pile-up events, according to the *Pileup Rejection Time*
- Pileup Rejection Time (ns): set a time window after a trigger signal, in which other triggering events are discarded as a source of pile-up
- Baseline Inhibit Time (ns): Inhibition time for the baseline calculation after a trigger signal. It avoids that the tail of an event is measured as part of the baseline (should be greater than 2*Decay Constant).
- Baseline Length (samples): Length in samples of the window for baseline calculation.

Note: the sum of the peaking time and of the flat top could not exceed 4096 ns.

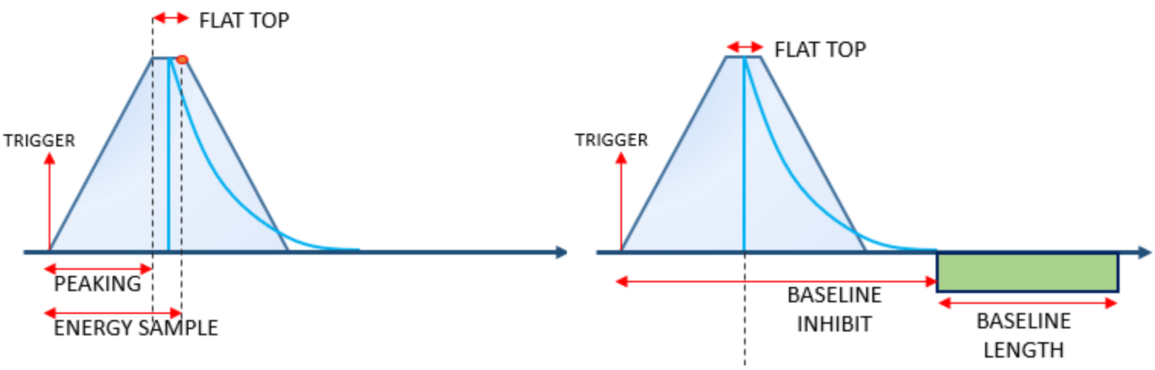


Figure 13.5: scheme of the trapezoidal energy filter parameters to be set in the SCI-55X0 Readout Software.

Oscilloscope Tab

The Oscilloscope Tab allows to monitor on plot all analog input signals and digital probes:

- The ANALOG trace displays the waveform sampled by the ADC
- The TRAPEZOIDAL trace displays the analog signal after the trapezoidal energy filter and the baseline subtraction
- The ENERGY SAMPLE digital signal indicates the position at which the value of the trapezoidal filter is sampled for the energy calculation
- The TRIGGER digital signal toggles when the trapezoidal trigger identifies a signal
- The BASELINE INHIBIT digital signal displays the state of the baseline restorer. When low, the baseline calculation is running, when high is holding

Multiple input channels can be captured and displayed on the same plot by checking the correspondent checkbox from the channels list on the left of the Oscilloscope Tab. All oscilloscope configuration parameters can be set in the *Settings* Tab.

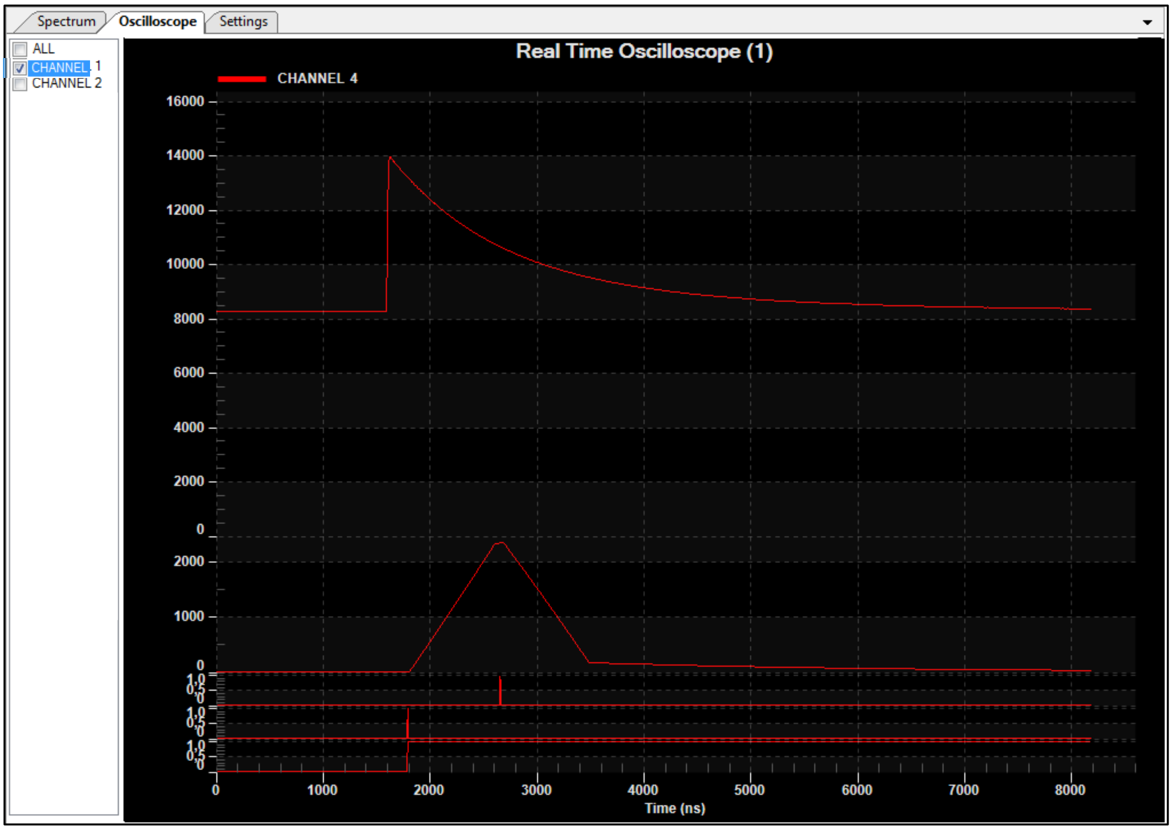


Figure 13.6: the Oscilloscope Tab of the SCI-55X0 Readout Software. Here only signals for channel 1 are displayed.

The value indicated between the parenthesis in the Oscilloscope plot title represents the current total number of waveform acquisitions.

In order to zoom the waveforms, three zoom modes are available. The zoom mode can be selected pressing a key on your keyboard. The same operation can be done from Menu → View. Options are:

- Area (press Z): enables the zoom on both axes. Drag the mouse to zoom a rectangular area.
- Horizontal Zoom (Press H): enables horizontal zoom. Drag the mouse to zoom on the X-axis.
- Vertical Zoom (Press V): enables vertical zoom. Drag the mouse to zoom on the Y-axis.
- Unzoom (press U): restores the full view of the plot.

The user can also:

- print the current view of the plot: Menu → File → Print → Oscilloscope (or press P).
- export the current view of the plot: Menu → File → Export → Oscilloscope (alternatively press X).

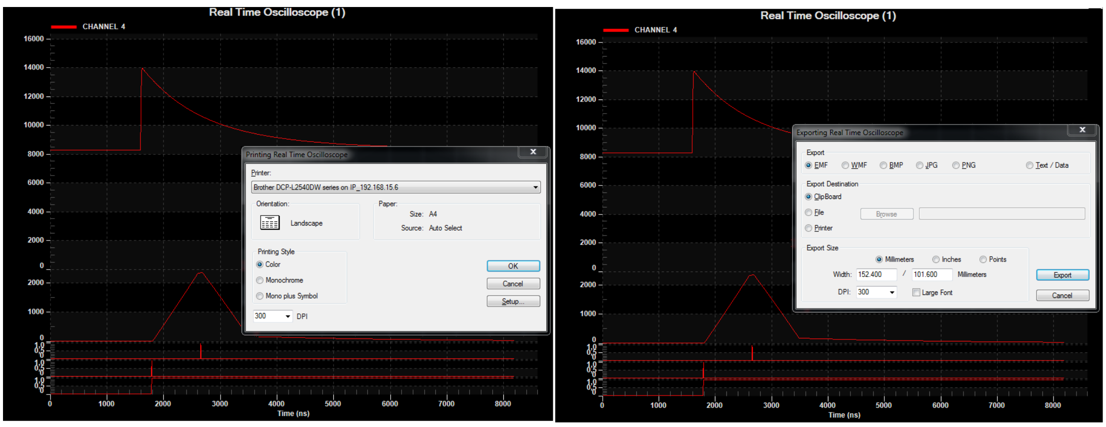


Figure 13.7: printing (left) and saving to file (right) the current view of the Oscilloscope Tab

Spectrum Tab

The Spectrum Tab allows to display the cumulative spectrum of each channel calculated in real-time by the board. The trapezoidal energy filter of the default firmware of the DT1260 generates a 64k bin spectrum for each channel. The rebinning feature can be selected from the Menu → Spectrum → Rebin. The rebinning is applied to all channels.

The spectrum of multiple channels can be displayed on the same plot by checking the relative checkboxes in the channels list on the left of the Spectrum Tab. Each time a channel spectrum is added to the display area, a new label will appear in the legend and a color will be automatically selected for the new spectrum. The plot window is divided in two areas. The main area displays the current zoom of the spectrum. On the bottom area is shown the full view of the spectrum.

In order to zoom the spectrum, three zoom modes are available. The zoom mode can be selected pressing a key on your keyboard. The same operation can be done from Menu → View

- Area (press Z): enables the zoom on both axes. Drag the mouse to zoom a rectangular area.
- Horizontal Zoom (Press H): enables horizontal zoom. Drag the mouse to zoom on the X-axis.
- Vertical Zoom (Press V): enables vertical zoom. Drag the mouse to zoom on the Y-axis.
- Unzoom (press U): restores the full view of the plot.

The spectrum can be displayed in both linear and semi-logarithmic mode. It is possible to switch between Lin/Log mode: Menu → Spectrum → Lin/Log (alternatively Press L).

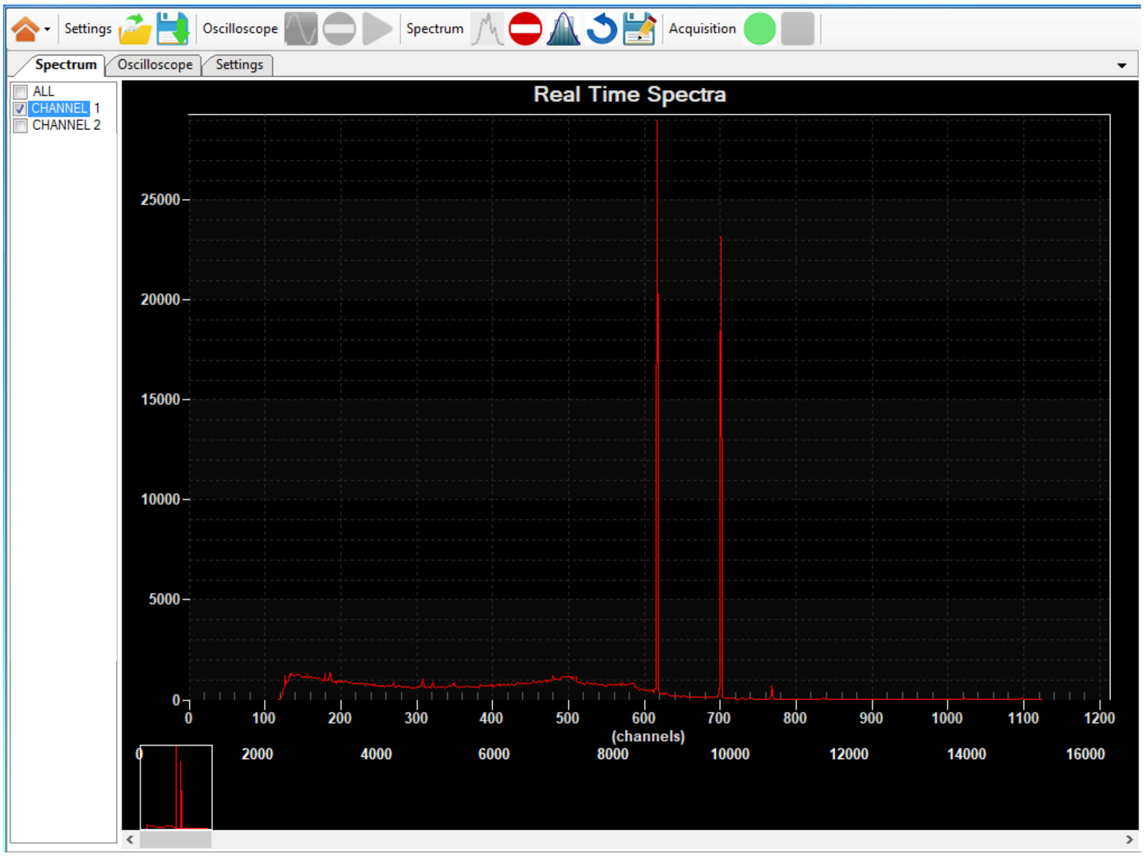


Figure 13.8: the Spectrum Tab of the SCI-55X0 Readout Software. Here only the spectrum for channel 1 is displayed.

It is also possible to change the plot type: Menu → Spectrum → Plot Mode (alternatively press O to cycle between plot modes). Available plot modes are:

- Step
- Line
- Line with interpolation
- Bar
- Area
- Area with interpolation
- Dot
- Dot with Line
- Dot with interpolation

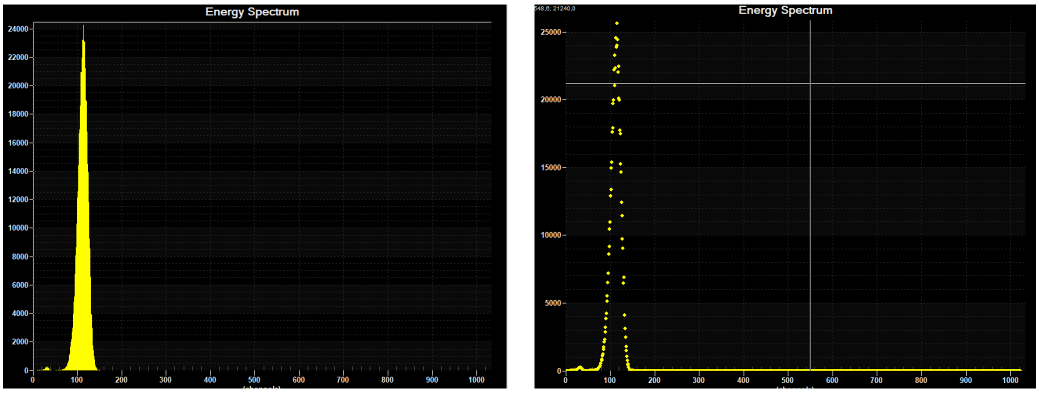


Figure 13.9: spectra shown in different plot modes (left = Area, right = Dot).

The user can:

- print the current view of the plot: Menu → File → Print → Spectrum (alternatively press P).
- save the current view of the plot: Menu → File → Export → Spectrum (alternatively press X).

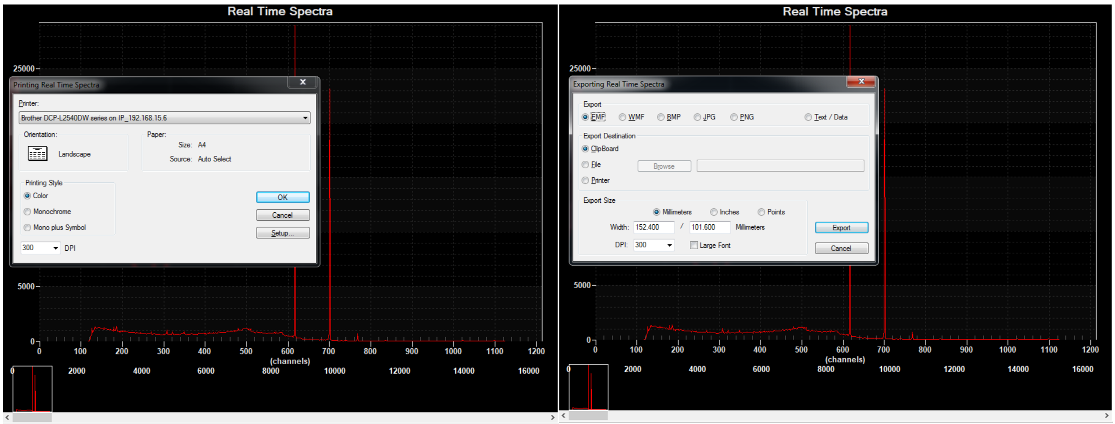


Figure 13.10: printing (left) and saving to file (right) the current view of the Spectrum Tab.

How to Perform a Fit

The fitting tool of the SCI-55X0 Readout Software allows to perform gaussian fits of the peaks in the spectrum. In order to create a new fit, follow the instructions below:

- a channel should be checked in the list of channels on the left of the Spectrum Tab.
- press the "Spectrum Fitting" button in the Control Bar to open the fitting tool at the bottom of the Spectrum Tab.
- insert a value in the Cursor 1 and in the Cursor 2 columns of the table to specify respectively the left and the right boundaries of the fit. On the spectrum, the fit boundaries are displayed with white vertical lines and identified with a number corresponding to the table row number. The fit area is shown in green.
- The fitting tool uses the spectrum data between the two cursors to calculate the Mean, the standard deviation (STD) and the Area of the selected region. For each fitted area the results extracted from the gaussian fit are also reported: the mean (Mean Fit), the standard deviation (STD Fit), the full width at half maximum (FWHM), the Resolution (R) and the fitting area (Area Fit).
- A fit can be deleted by selecting the correspondent row in the table and pressing 'Del' on your keyboard.

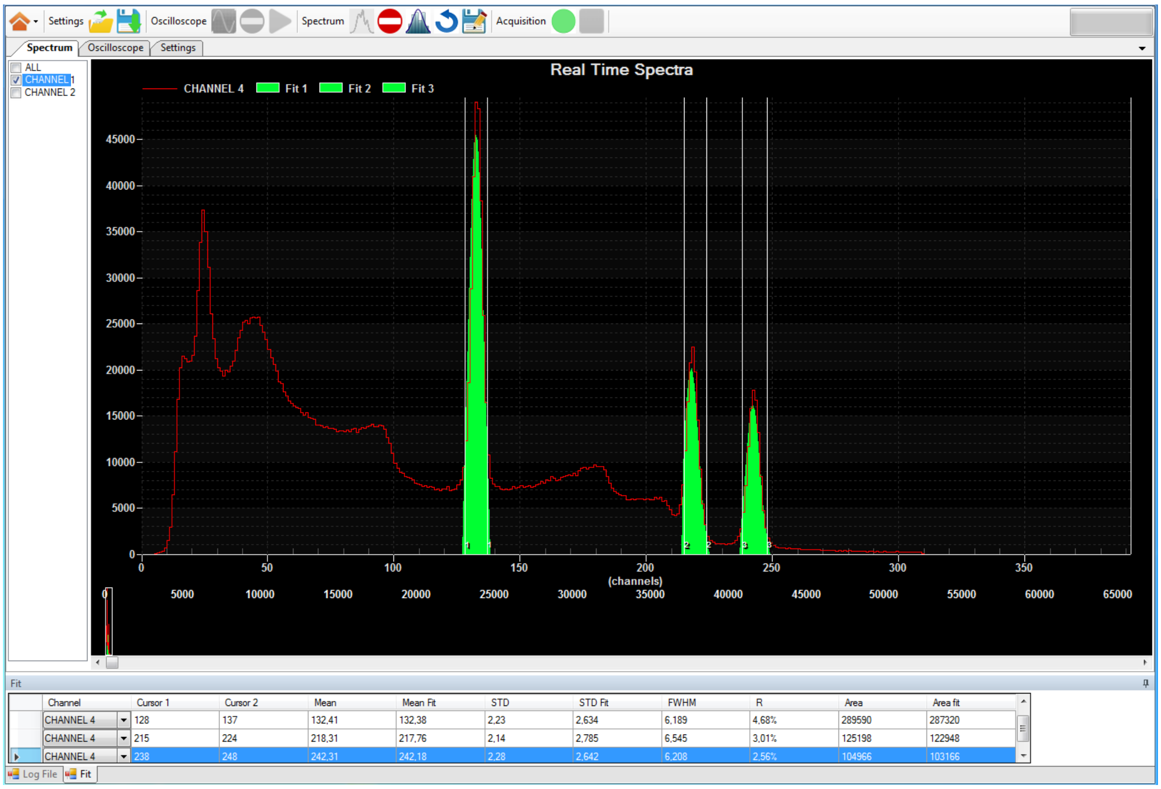


Figure 13.11: the fitting tool of the SCI-55X0 Readout Software.

How to Save Data

The "**Save Data**" button in the Control Bar allows to save both the spectrum and the cumulative image for the enabled channels on the Spectrum Tab. When the button is pressed a first dialog window is visualized to choose the file path for the spectrum data saving. A second dialog window is shown to set the file path for the cumulative image saving.

- The .csv spectrum file is made of several rows equal to the number of bins in the spectrum. Each row contains the number of events of the correspondent bin for all the channels visualized in the plot.
- The .csv cumulative image file contains the total energy information for all the channels.

The "**Start/Stop Data Record**" buttons in the Control Bar allow to store on file data from the board.
The "Data Record Configuration" window appears after pressing the "Start Data Record" button. The saved file path can be set by clicking the BROWSE button and the channels data to be saved can be set by checking the correspondent checkboxes in the channel list. The "Data Type" option can be used to choose the type of data to be stored:

- Oscilloscope: Every time the oscilloscope triggers, the downloaded waveforms from selected channels is dumped on disk (analog and digital)
- List Mode: The buffered events consisting of energy and time information from the single channel of the board that event by event fires the trigger are stored on the disk.

The "Target Mode" option allows to set how to stop data recording:

- Free: record data until "Stop Data Record" button is pressed
- Events: record data until a specified number of events is reached, to be set in the *Target Value* field.

To start the Oscilloscope or the List dumping press the START button.

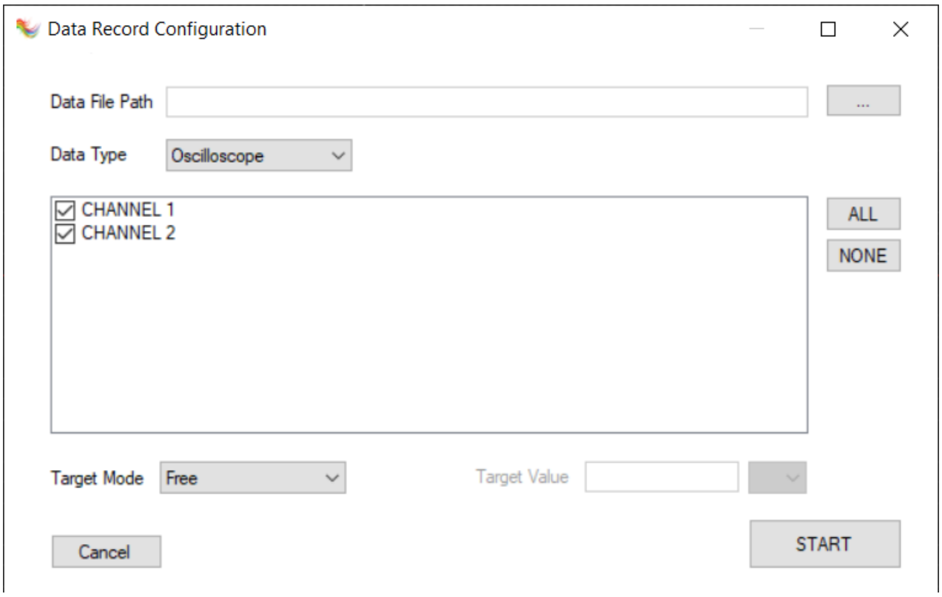


Figure 13.12: the Data Record Configuration window.

Each line of the .csv file for the Oscilloscope Mode contains the following information:

- Event number;
- Channel number;
- Number of waveform samples;
- Number of waveforms (5: two analog and three digital);
- Waveform values of the five signals.

Each line of the .csv file for the List Mode contains the following information:

- Event channel;
- Event time tag;
- Event energy.

14 Instructions for Cleaning

The equipment may be cleaned with compressed air spray, isopropyl alcohol or deionized water and air dried.

Cleaning the Touchscreen

In order 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 (if present)
5) Wear safety glasses equipped with side shields when cleaning the board

15 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 PERFORMANCE AND SAFETY WILL BE NOT GUARANTEED

16 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.

17 Technical Support

CAEN makes available the technical support of its specialists for request concerning the software and the hardware. Use the support form available at the following link:

https://www.caen.it/support-services/support-form/

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