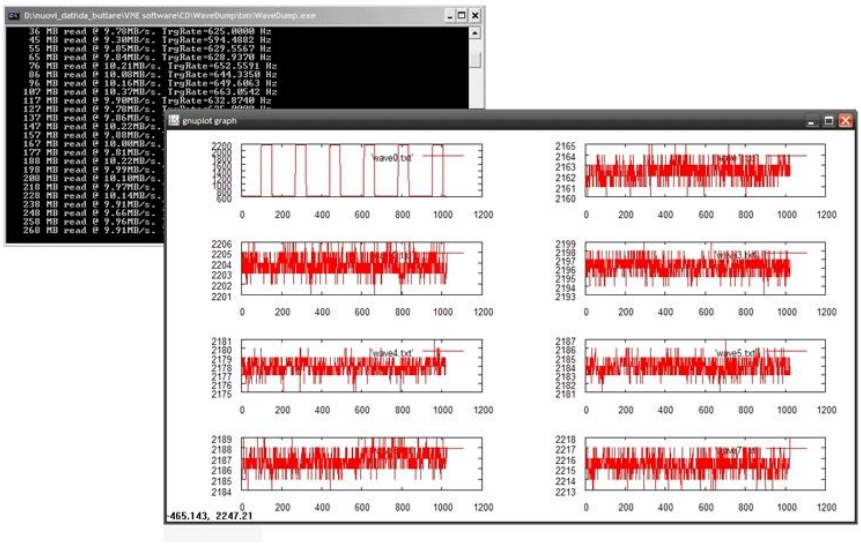
CAEN
Tools for Discovery

Electronic Instrumentation



User Manual UM2091

WaveDump

CAEN Digitizer Readout Application

Rev. 13 - December 22nd, 2017

Purpose of this Manual

This document is the WaveDump User Manual, aligned to the **rel. 3.8.2** of the software. It contains information for the installation, the complete command list explained and the syntax of the configuration file.

Change Document Record

Date	Revision	Changes
April 14th, 2011	04	Revised all chapters, new document format.
March 1st, 2012	05	Revised Chap. **1**
June 7th, 2012	06	Updated sections: Sect. System requirements & installation setup
April 3rd, 2014	07	Updated sections: Chap. **4**
February 2nd, 2015	08	Revised all chapters, new document format. Major updates in Chap. **2** and **4**. Added Chap. **5 7**.
November 9th, 2015	09	Updated Chap. 1, **3**, **5**; added Chap. **6**
April 28th, 2016	10	Updated Chap. **2**, **4** and **6**
January 13th, 2017	11	Updated Chap. **3** and **4**
May 31st, 2017	12	Updated Chap**. 2, 3** and **4**
December 22nd, 2017	13	Updated Sect. **Block Diagram**. Extended the Decimation support to the 724 family in Chap. **4**. Added note on software compatibility with A3818 driver in Chap. **2.**

Symbols, Abbreviated Terms and Notation

ADC	Analog to Digital Converter
DPP	Digital Pulse Processing
FFT	Fast Fourier Transform
FSR	Full Scale Range
PCB	Printed Circuit Board

Reference Document

[RD1] GD2483 - WaveDump QuickStart Guide

[RD2] GD2783 – First Installation Guide to Desktop Digitizers & MCA

[RD3] Technical Information Manual of V1718 and VX1718 VME – USB2.0 Bridge

[RD4] Technical Information Manual of A3818 PCI Express Optical Link Controller

[RD5] Technical Information Manual of A2818 PCI Optical Link Controller

[RD6] UM1935 - CAENComm User & Reference Manual

[RD7] UM1935 – CAENDigitizer User and Reference Manual

[RD8] Technical Information Manual of x742 Digitizers

[RD9] AN2472 - CONET1 to CONET2 migration

[RD10] GD2512 - CAENUpgrader QuickStart Guide

[RD11] UM5698 - 742 Register Description

[RD12] GD5695 - 742 Quick Start Guide

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

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Index

List of Figures

List of Tables

1 Introduction

The WaveDump User Manual contains information for the installation, the complete command list explained and the syntax of the configuration file. The user can refer to WaveDump QuickStart Guide (see **[RD1]**) for a practical first use example.

WaveDump is a C-based console application developed to control all CAEN digitizer models running the waveform recording firmware. Digitizers running CAEN special Digital Pulse Processing (DPP) firmware must be controlled by dedicated readout software, as indicated in the relevant DPP web page.

WaveDump has been thought to demonstrate the use of CAEN libraries and methods for an efficient readout and data analysis. Besides being a ready to use software, WaveDump is provided with C source files and Visual Studio project to let the users customize the code for personalized solutions.

Multi-board management is not supported.

WaveDump supports the CAEN digitizers families as in the table below:

Supported Digitizer Families
720
V1721 – V1731
724
725
730
740
742
751
761

WAVEDUMP MANAGES ONLY CAEN DIGITIZERS RUNNING THE DEFAULT FIRMWARE FOR WAVEFORM RECORDING

WAVEDUMP PERMITS ONLY SINGLE BOARD CONTROL

2 Software Interface

Overview

WaveDump is a C-based console application for data acquisition management of CAEN digitizer families equipped with the waveform recording firmware (DPP firmware is not supported). Only a single board can be programmed according to a text configuration file containing a list of parameters and instructions (see Chap. **4**).

Specifically, WaveDump can perform the following operations:

- connect to the digitizer through a physical communication interface (USB, Optical Link);
- read and view information about the board (model, serial number, FW revision, etc.);
- program the digitizer according to parameters written in a configuration file (text file);
- perform channel calibration (automatically at start-up and manually) required by specific digitizer families
- start and stop the acquisition (run on / off);
- enable the software trigger (single shot or continuous);
- read the event data and display the data throughput rate (MB/s) and the trigger rate. The readout can take place with or without the use of interrupts;
- perform some simple data analysis (post processing) such as the signal FFT and the histogram of the samples amplitude (energy histogram is not supported);
- save the waveforms (sequence of samples) into ASCII or binary output files; the writing can be 'one shot' (i.e. single event) or continuous (recording of a sequence of events);
- plot, using an external graphical tool (gnuplot), the acquired waveform, the FFT or the histogram of the selected channels.

WaveDump C-source files and the Visual Studio project are provided for advanced users, allowing for customized implementations.

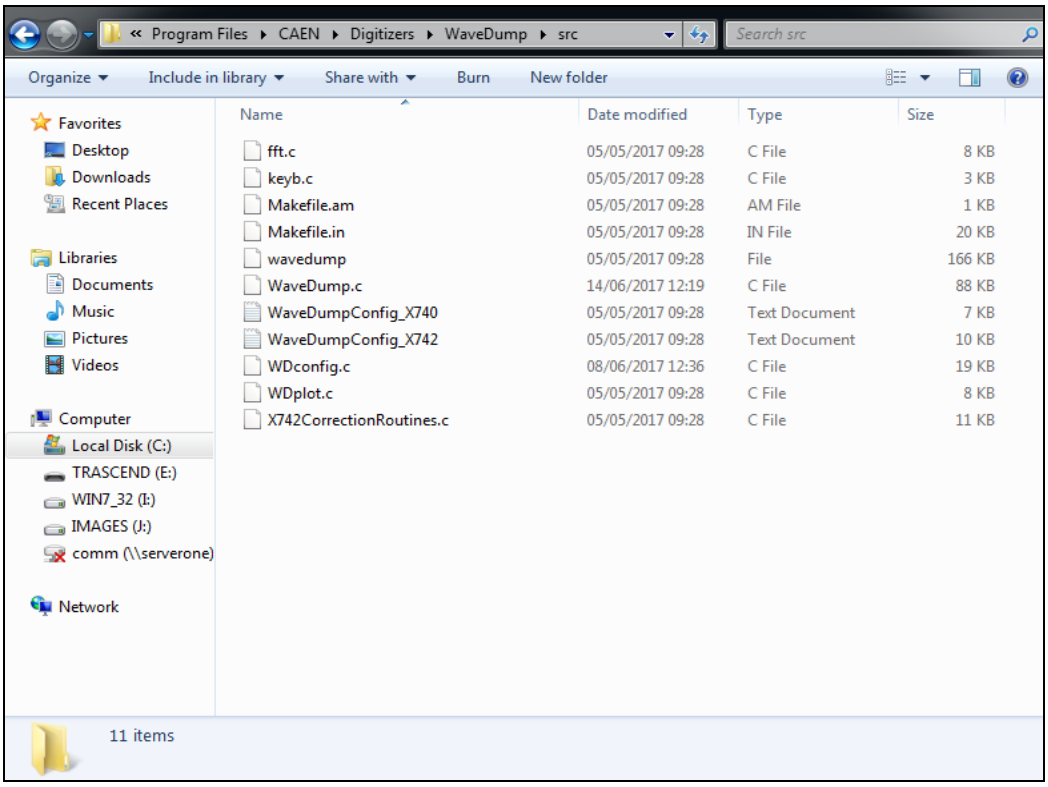

Figure 2.1: C-source files for Windows version. The path is visible in the top bar.

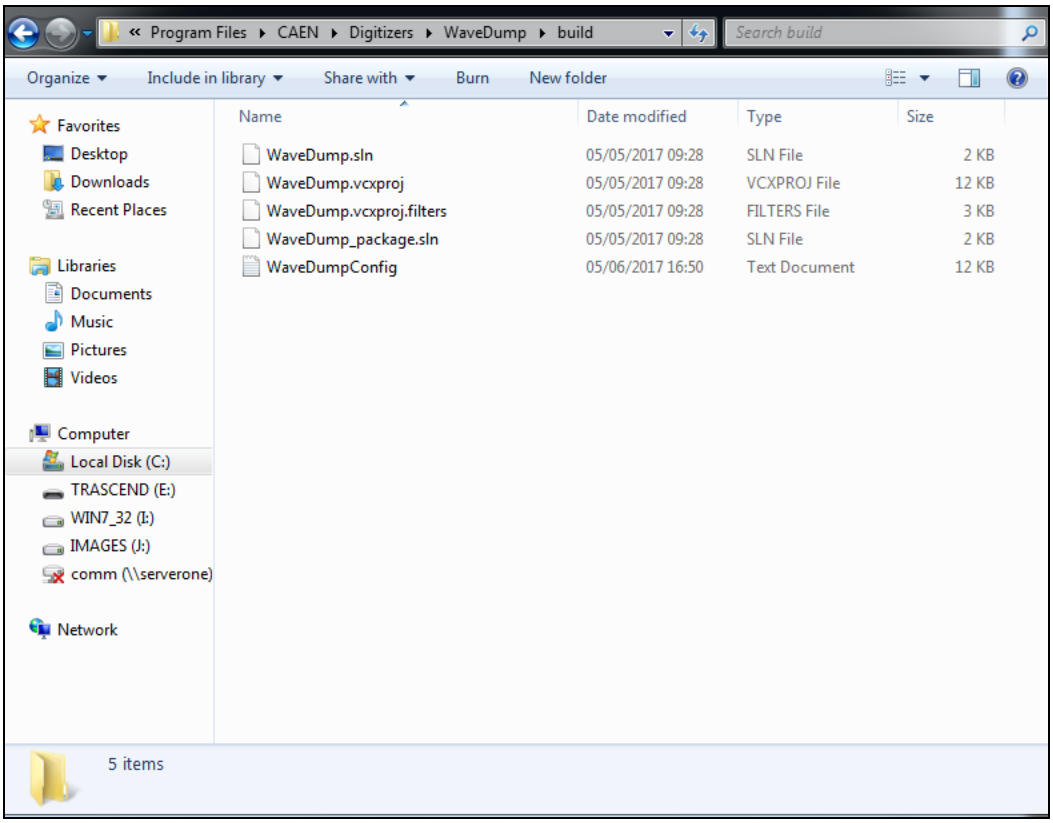

Figure 2.2: Visual Studio project files for Windows version. The path is visible in the top bar.

For Linux version, the C-code files are contained in the “src” subfolder, in the “WaveDump” directory.

The source code of WaveDump shows the sequence of steps to do to program the digitizer and manage the data acquisition.

Since WaveDump is capable of handling different digitizer types, some parts of the code may be redundant because they must foresee various cases. Users who want to use a specific digitizer, can remove all those pieces of code that are not of interest. In case of digitizer with channels managed by groups (e.g. 740 family), to simplify the use of WaveDump, only 8 channels of one group at a time can be plotted, although all channels are simultaneously enabled for the acquisition (and so the output files saving.

Beyond the readout, the plot and save of raw data, WaveDump implements also some simple examples of data analysis (FFT and histogram); starting from them, the user can easily develop his own post-processing algorithms.

Thanks to the C programming language and the absence of a GUI, WaveDump is portable to any platform; the code is compatible with both Windows and Linux OS.

Block Diagram

The block diagram of the WaveDump architecture is schematized in **Figure 2.3** below.

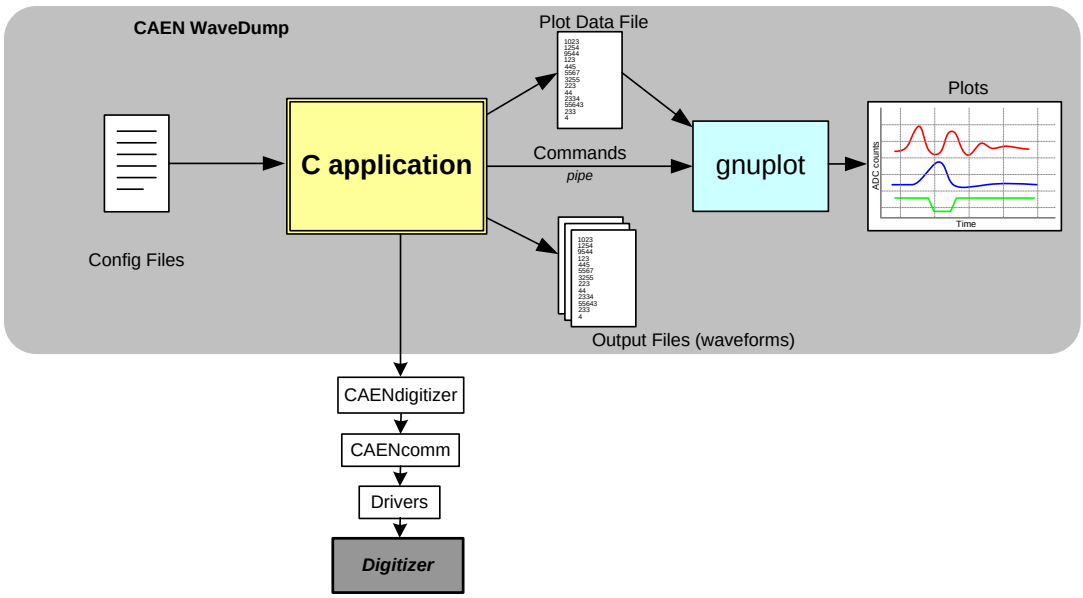

Figure 2.3: CAEN WaveDump software architecture

The program core is a C application that programs the Digitizer according to a set of parameters as written in the configuration text file, starts/stops the acquisition and manages the data readout. Data (waveforms, FFTs or histograms) are plotted using *gnuplot*, an external plotting tool, or saved to output text files

WaveDump installation directory includes different configuration text files, each one containing a list of possible parameters including elucidatory comments (see also Sect. **Installation** and Chap. **4**):

- ***WaveDumpConfig.txt***
- ***WaveDumpConfig_X740.txt***
- ***WaveDumpConfig_X742.txt***

The user can edit the configuration file or create a GUI that allows to set the parameters through a control panel and then generate the configuration file.

As mentioned, to plot the data, *WaveDump* relies on an external program (namely ***Gnuplot***); data for the plot are written into a file, while the plot commands are passed from *WaveDump* to *Gnuplot* through a pipe. All functions related to the plotting are contained in a source file separated from *WaveDump*; the user can replace the calls to *Gnuplot* to use other tools. *Gnuplot* (by version 4.2) is automatically copied to the proper working directory during the installation of *WaveDump* (only for Windows installation). Linux users must install *Gnuplot* apart.

Drivers & Libraries

Drivers

To deal with the hardware, CAEN provides the drivers for all the different types of physical communication interfaces featured by the specific digitizer and compliant with Windows and Linux OS:

- **USB 2.0 Drivers for NIM/Desktop** boards are downloadable on CAEN website (www.caen.it) in the "Software/Firmware" tab of the digitizer web page (**login required**).

Note: Windows OS USB driver installation for Desktop/NIM digitizers is detailed in **[RD2]**.

- **USB 2.0 Drivers for V1718** CAEN Bridge, required for VME boards interface, is downloadable on CAEN website (www.caen.it) in the "Software/Firmware" tab of the V1718 web page (**login required**).

Note: For the installation of the V1718 USB driver, refer to the User Manual of the Bridge **[RD3]**.

- **Optical Link Drivers** are managed by the A2818 PCI card or the A3818 PCIe card. The driver installation package is available on CAEN website in the "Software/Firmware" area at the A2818 or A3818 page (**login required**)

IMPORTANT:

WAVEDUMP REL. 3.8.1 BUILD DECEMBER 2017 (OR HIGHER) FOR WINDOWS WORKS ONLY WITH A3818 DRIVER REL. 2.0.0 (OR HIGHER)!

Note: For the installation of the Optical Link driver, refer to the User Manual of the specific Controller **[RD4] [RD5]**.

Libraries

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

- **CAENDigitizer** is a library of functions designed specifically for the Digitizer family and it supports also the boards running the DPP firmware. The CAENDigitizer library is based on the CAENComm library. For this reason, **the CAENComm libraries must be already installed on the host PC before installing the CAENDigitizer**.

  The CAENDigitizer installation package is available on CAEN website in the 'Download' area at the CAENDigitizer Library page. Reference document **[RD7]**.

- **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 requires the CAENVMELib library (access to the VME bus) even in the cases where the VME is not used. This is the reason why **CAENVMELib has to be already installed on your PC before installing the CAENComm**.

  The CAENComm installation package, and the link to the required CAENVMELib, is available on CAEN website in the 'Download' area at the CAENComm Library page. Reference document **[RD6]**.

Currently, the CAENComm (and so the CAENDigitizer) supports the following communication interfaces:

- PC → USB → Digitizer (either Desktop or NIM models)
- PC → USB → V1718 → VME → Digitizers (VME models only)
- PC → PCI (A2818) → CONET → Digitizers (all models)
- PC → PCI (A2818) → CONET → V2718 → VME → Digitizers (VME models only)
- PC → PCIe (A3818) → CONET → Digitizers (all models)
- PC → PCIe (A3818) → CONET → V2718 → VME → Digitizers (VME models only)

CONET (Chainable Optical NETwork) indicates the CAEN proprietary protocol for communication on Optical Link. Refer to **[RD9]** for useful information.

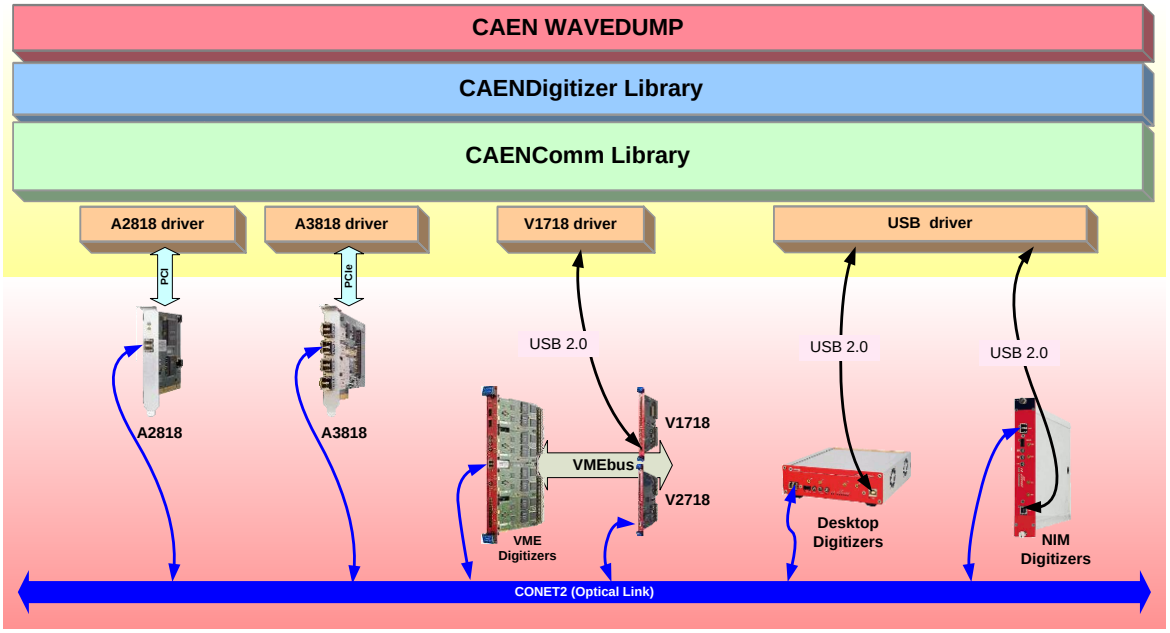

Figure 2.4: Required libraries and drivers

Installation

The CAEN WaveDump Software is compliant with both Windows and Linux OS, 32 and 64 bits.

Before installing WaveDump, perform the following steps:

- **Make sure that your hardware (Digitizer and/or Bridge, or Controller) is properly installed** (refer to the related User Manual for hardware installation instructions).
- **Make sure that the appropriate firmware is running on the board**. You can use the CAENUpgrader tool to read the digitizer firmware revision (see **[RD10]**). The waveform recording firmware, which is managed by WaveDump, can be discriminated by the AMC FPGA firmware revision formatted as:

  W.Z

  where the major revision number of the AMC FPGA must be less than 128 (i.e. W < 128).

  If a not supported firmware is found, WaveDump displays a specific message, as shown in **Figure 2.5**, and the user must quit the software.

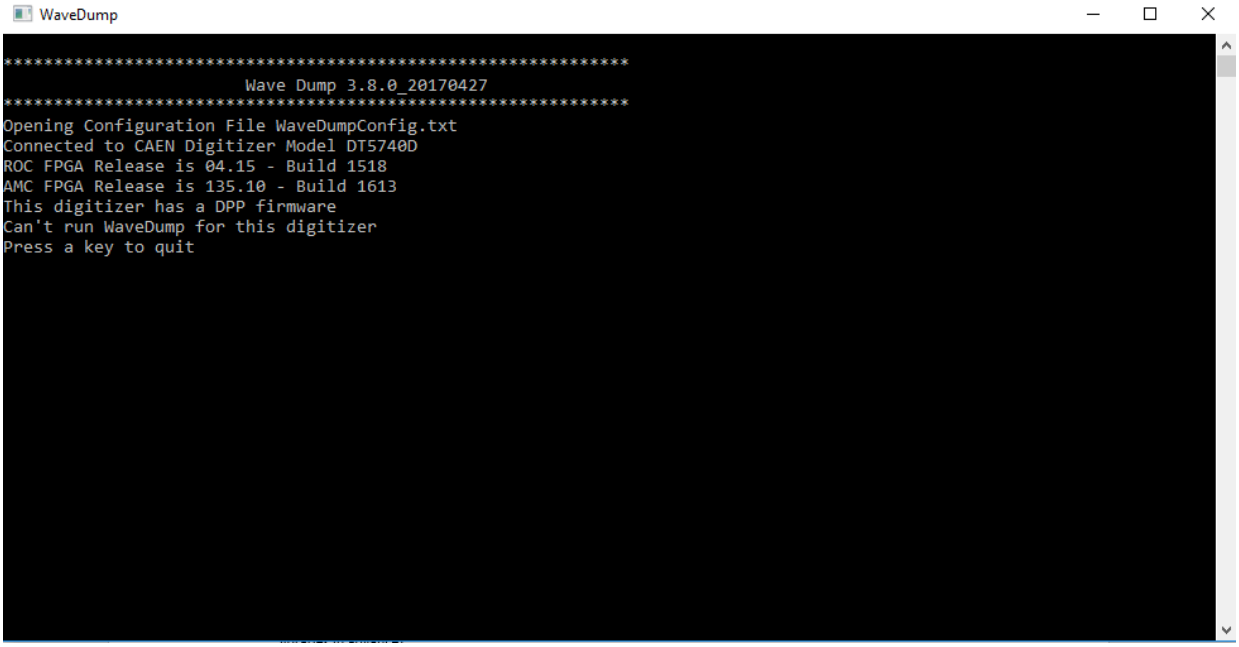

Figure 2.5: WaveDump message for not supported firmware found

- **Make sure you have installed the driver for your OS and the physical communication layer to be used**. Driver installation packages are downloadable on CAEN website (**login required**) as reported in the **Drivers** paragraph.

For Windows users:

CAEN provides the full installation package for WaveDump software in a **standalone version** for **Windows OS**. This version installs all the binary files required to directly use the software (i.e. no need to install the required CAEN libraries in advance).

- **Download the installation package** compliant with your OS from CAEN on the WaveDump page (**login required**)
- **Extract** the **files** to your host.
- **Run the installer and complete**.

WaveDump is then installed under the folder:

C:\Program Files\CAEN\Digitizers\WaveDump

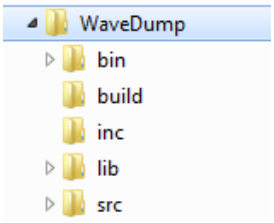

Figure 2.6: Subfolders structure of WaveDump main directory

The "*bin*" subfolder contains the executable file (WaveDump.exe), a ***general-purpose default configuration file*** **(WaveDumpConfig.txt)**, the ***X742 models default configuration file*** **(WaveDumpConfig_X742.txt)** and the ***X740 models default configuration file*** **(WaveDumpConfig_X740.txt)**.

Note: In case of a X742 Digitizer, the user should modify directly the X742 configuration file. WaveDump will use that configuration file when recognizing a X742 board.

Note: In case of a X740 Digitizer, the user can choose to modify the general-purpose file or to modify the X740 template and rename it 'WaveDumpConfig.txt'.

Note: Administrator rights are required to modify the *configuration file* WaveDumpConfig.txt of WaveDump under the "*Program Files*" folder. To modify the file, the options are to enable full permissions in the original folder or to use the software without the administrator rights by copying the entire "bin" folder under another location, as for example the "Documents" folder.

The *"build"* folder contains the Visual Studio project, while the header and the source code of the WaveDump are in the *"inc"* and *"src"* folders, respectively.

For Linux users:

Linux users must also take care of proper installation of **gnuplot** graphical tool, as well as of the **CAEN Libraries**: CAENVMElib, CAENComm and CAENDigitizer. The libraries can be downloaded from CAEN website (**login required**). **Installation instructions** can be found in the **README file** inside each library folder.

- **Download** the WaveDump installation package for Linux from CAEN website on the WaveDump page (**login is required**).
- **Unpack** the **installation package** (tar –zxf <WaveDump-x.y.z.tar.gz).
- **Follow** the instruction on the **INSTALL** file

  Type: ./configure

  make

  sudo make install

  Launch the software typing **wavedump**

The default configuration file location is:

/etc/wavedump/WaveDumpConfig.txt or **/etc/wavedump/WaveDumpConfig_x742.txt** for X742 boards

Note: Administrator rights are required to modify the *configuration file* of the WaveDump software under the "/etc/wavedump" folder.

Alternatively, the user can modify the WaveDumpConfig.txt file that is under the local WaveDump folder:

./wavedump-x.y.z/Setup/WaveDumpConfig.txt

and launch the software typing **wavedump** and the **path** of the configuration file.

Note: In case of a **X740** or a **X742** Digitizer, the user is recommended to modify and use the **specific configuration files WaveDumpConfig_X740.txt** and **WaveDumpConfig_X742.txt,** under the local WaveDump folder

./wavedump-x.y.z/Setup/WaveDumpConfig_X740.txt

./wavedump-x.y.z/Setup/WaveDumpConfig_X742.txt

These files must be loaded typing **wavedump** and the **path** of the configuration file.

3 On-line Commands

Once started (following the instructions in the Sect. **Installation**), WaveDump parses the configuration file; if a formal error occurs, it is displayed in the shell.

It is also possible that the parameters and commands are formally correct but some of them are not valid for that type of digitizer, or a syntax error in the configuration file occurred; this is indicated when programming the digitizer by a warning message. Although this may not affect the operation of WaveDump, the command that caused the error shall be found and the wrong value corrected.

Once the digitizer is programmed, WaveDump waits for the start of the acquisition ('**s**' key). The table below lists the accepted WaveDump on-line commands associated to specific keys.

Key	Function
s	Start / Stop acquisition
q	Quit WaveDump
R	WaveDump restart; this command allows you to reload the configuration file and restart with a new acquisition
t	Single Software Trigger; this command sends a software trigger (single shot), useful especially when the card has no data (no trigger) because it forces the acquisition of an event. In analogy with the oscilloscope, this command corresponds to the “Force trigger” button.
T	Continuous Software Trigger; this command enables / disables the continuous generation of software trigger at a fixed rate. Inside the acquisition loop, the program sends a trigger, reads the corresponding event and executes data analysis. It corresponds to the "Auto trigger” of the oscilloscope.
p	Single-event plot of the waveforms of each channel enabled for plotting (which does not necessarily coincide with the n channels enabled for acquisition). The plot is single-shot.
P	Continuous Plot; this command enables / disables the continuous plot of the enabled channels**.** When enabled, the input signal trace of channel 0 is plotted by default. Check the “c” command to enable the other channels.
w	Save Single Event to Disk; this command causes the writing of a file for each enabled channel, named wave_n.txt, where n is the channel number. **Warning:** the files are overwritten each time. Each file can be ASCII or binary and may contain a header or not, depending on the settings assigned in the configuration file.
W	Continuous Event Saving; this command enables / disables the continuous events saving to file. As for the “w” command, it creates one file per channel; then it writes the events consecutively. **Attention:** in this mode, the file size can grow up very quickly**.**
0 .. 7	This command insert / remove channel n (n = 0 .. 7) from the plot (if such a channel is enabled). In case of x740, n refers to the channel within the currently active group, for example, if it's on group 2 (channels 16 to 23), press 3 to insert / remove the channel 19. In case of V1725 and V1730, n refers to channel n or n+8, depending on the visualization mode enabled by the command ‘g’ (see below).
g	In case of 740 and 742 series, this command switches to the next group of 8 channels (only for). **Note:** the active group refers only to the plot (in fact, the plotter can handle only 8-traces), while the acquisition is always enabled on all groups. In case of V1725 and V1730, this command switches the plot visualization from 0-7 channels to 8-15 channels and vice versa (se also the “0..7” description).
f	This command toggles between waveform plot and FFT plot.
h	This command toggles between waveform plot and histogram samples amplitude plot (not supported by 742 series).
m	This command displays the temperature values (in °C) of the ADC channels. It is supported only by 725, 730 and 751 digitizer families.
c	This command performs the channel calibration required by 725, 730, 751, and 761 digitizer families.
[Space]	This command displays the online help

Tab. 1: WaveDump on-line commands

Inside the *Gnuplot* window, there are active bindkeys and functions associated to the mouse:

Key	Function
a	Autoscale to be x-axis and y
r	Enable / Disable ruler
g	Enable / Disable grid
y	Set the scale y at full scale for the specific digitizer (scale x remains unchanged)
p	Return to previous zoom

Tab. 2: Gnuplot window commands

Zoom Area: right click on one corner of the area, release the button, left click on the opposite corner.

Click with the right button on the window bar to open a menu that allows to make the print, copy the screen-shot to the clipboard, change colours, etc.

4 Configuration File Syntax

This section describes in detail the ***WaveDumpConfig.txt*** general purpose default configuration file; the other text files include a subset of the settings here defined, which are supported by the relevant digitizer model (740 or 742), to simplify the use of the software.

The configuration file is located into the *"bin"* subfolder of the main WaveDump folder (see **Figure 2.6**), and it is divided in two parts: **common settings**, indicated in the `[COMMON]` section, and **individual settings** for individual channel settings indicated in the `[n]` section, where n is the number of channel (or group in the case of 740 and 742 series). The common settings are set equal to all channels, while the individual settings can be set individually for each channel (group).

The individual settings can be performed also in the common settings part: in this case, they are applied to all channels.

Note: Settings are executed sequentially, therefore commands written at the end of the file may overwrite settings written at the beginning, except for the `WRITE_REGISTER` command that is executed at the end of the file.

Note: The special commands `@ON` and `@OFF` allow to skip entire blocks of lines: indeed, the WaveDump software can ignore all the configurations from the `@OFF` command to the `@ON`.

Common Settings

OPEN `LinkType LinkNumber NodeNumber BaseAddress`

Specifies the path of the physical channel to open communication with the digitizer:

`LinkType`	Identifies the type of communication channel, choosing between **`USB`** and **`PCI`**. USB corresponds to both the direct connection from PC to digitizer (Desktop models or NIM), and the connection through V1718 and VME bus (VME models). PCI corresponds to both the direct connection from PC A2818 (PCI controller) or A3818 (PCIe controller) to the digitizer through optical fibre (all models), and connection through V2718 and VME bus (VME models).
`LinkNumber`	The number of the connection. Typically, it is 0 (only one digitizer connection to the PC). In case of more digitizers connected it is necessary to specify which has to be accessed. Remember that WaveDump can handle only one digitizer at a time. `LinkNumber` identifies which USB or A2818/A3818 is in use. Be aware that it is not known in advance which `LinkNumber` corresponds to which USB port or PCI slot
`NodeNumber`	This parameter must be specified only when connected via optical link (PCI) and indicates the node number in the daisy chain. Typically, it is `0` (only one digitizer in the optical chain), it may be different if more than one digitizer (or V2718) is connected in a daisy chain.
`BaseAddress`	Indicates the Base Address (32-bit hexadecimal number) to access the digitizer via the VME bus. This number should be 0 for the direct connection from PC to digitizer.

CORRECTION_LEVEL `<CORR_MASK> <CUST_TABLE_MASK> <FILENAME1> <FILENAME2> ...`

This command allows to apply the data correction (742 digitizer family only). There are three types of corrections: cell offset, index sampling, and time correction (see **[RD8]** for further details). The three correction files are available on each digitizer flash and they can be automatically applied during the event decode. The user can also use his/her custom correction files. Custom files should have the following name structure:

a. BaseInputFileName + "_cell.txt" for the cell offset corrections

b. BaseInputFileName + "_nsample.txt" for the index sampling correction

c. BaseInputFileName + "_time.txt" for the time correction

`CORR_MASK` (correction mask) allows to select the combination of corrections to be applied. Options are:

- `CORR_MASK = AUTO` the three corrections are automatically read and applied to the event (this is the default configuration). The following fields must be blank.
- `CORR_MASK` corresponds to a 3-bit number, where bit[0] corresponds to the cell offset correction, bit[1] to the index sampling correction, and bit[2] to the time correction. For example: if you want to apply only the first and the third correction, `CORR_MASK = 5`, etc.

CUST_TABLE_MASK identifies the groups to which the corrections are applied.

This field must be filled only when CORR_MASK value is different from AUTO. Options are:

- CUST_TABLE_MASK = AUTO: the corrections specified in CORR_MASK are applied to all groups.
- CUST_TABLE_MASK corresponds to a 4-bit number, where *n* bit corresponds to the *n* group to be enabled for corrections. For example, if you want to set the corrections for groups 0, 2 and 3, CUST_TABLE_MASK = 13, etc.

When CUST_TABLE_MASK is different from AUTO the user must specify the file name to be used for each group of interest.

FILENAME1, FILENAME2, … corresponds to the BaseInputFileName of the correction files to be used for the group enabled by the CUST_TABLE_MASK value.

EXAMPLES:

1. Use of the default configuration. The software automatically reads the three correction files from the digitizer flash and applies them to the events.

   ```
   CONFIGURATION_LEVEL AUTO
   ```

2. Only some of the corrections are enabled and applied to all groups. For example, you can apply the cell offset and the time corrections.

   ```
   CONFIGURATION_LEVEL 5 AUTO
   ```

   Analogously it is possible to disable all corrections.

   ```
   CONFIGURATION_LEVEL 0 AUTO
   ```

3. Different corrections are applied to different groups. The specific file name for each group must be specified. For example, if you want to apply the cell offset and time corrections to group 0, 1 and 2 (VME form factor) you should write:

   ```
   CONFIGURATION_LEVEL 5 7 FILE_GR0 FILE_GR1 FILE_GR2
   ```

   Where "FILE_GRn" is the "BaseInputFileName" for group n. All files must be available in the working folder of WaveDump, otherwise the full path must be specified.

DRS4_FREQUENCY option

Set the DRS4 chip frequency (742 digitizer family only).

option can be:

0: 5 GHz (default value);

1: 2.5 GHz;

2: 1 GHz.

3: 750 MHz

Note: Option 3 (750 MHz) requires a 742 AMC firmware release 1.00 or higher. Furthermore, the board should have the data corrections for this frequency. In case your board does not have the 750 MHz corrections, contact CAEN (see Chap. **7**) for the upgrade.

GNUPLOT_PATH "path"

Path for the *gnuplot* executable file; for Windows installation, it is normally ".\" since *gnuplot* is copied into the working directory. For Linux systems it is "/usr/bin/"

OUTPUT_FILE_FORMAT `option`

This command defines the format of the output file.

`option` can be:

`BINARY` (2 bytes per sample. 1 byte in case of 721 and 731 series).

`ASCII` (column of decimal values).

The data format is the following:

Block CH0;

Block CH1;

...

Block CHn (according to which channels have data available);

where each block is:

<header0> (32bit)

<header1> (32bit)

...

<header5> (32bit)

<Nsamples*16bit> (where Nsamples depends on RECORD LENGTH)

In case the HEADER is disabled, each Block is made simply by the <channel> + <samples>.

Note: each sample is in units of the digitizer Trigger Clock, depending on the family: 8 ns for 720-725-740-751-761; 10 ns for 724-743; 8.5 ns for 742 (see the digitizer User Manual)

OUTPUT_FILE_HEADER `option`

A header for each event can be included in the output file.

`option` can be:

`YES` to include the header;

`NO` to exclude the header.

The HEADER is so composed:

<header0> EventSize (i.e. header + samples)

<header1> Board ID

<header2> Pattern (meaningful only for VME boards)

<header3> Channel

<header4> Event Counter

<header5> Trigger Time Tag

RECORD_LENGHT `Ns`

Indicates the number `Ns` of samples to be acquired for each trigger (acquisition window).

Note: Due to constraints on the granularity of this setting, it is possible that the real number of acquired samples is approximated to a value close to what set. The maximum value of `Ns` depends on the memory size and varies from model to model (see specifications); for 742 family, the options available are only `1024`, `520`, `256` and `136`.

TEST_PATTERN option

Data from the ADC can be replaced by an internal test pattern, that is a triangular wave ranging from 0 to full scale.

option can be:

YES to enable the TEST_PATTERN;

NO to disable it.

ENABLE_DES_MODE option

This command enables the Dual Edge Sampling (DES) mode for 731 and 751 series only. When DES_MODE is enabled, only half of the channels is enabled (even for 731 and odd for 751), regardless the ENABLE_INPUT setting in the configuration file. When enabled those channels will work at the double of the sampling frequency of the digitizer (i.e. 1 GSps for 731 and 2 GSps for 751). option can be:

YES to enable it;

NO to disable it.

EXTERNAL_TRIGGER option

This command manages how the External Trigger is used.

option can be:

ACQUISITION_ONLY: the arrival of a trigger on the front panel causes the acquisition of one event in all the channels of the board.

ACQUISITION_AND_TRGOUT: the same as ACQUISITION_ONLY. In addition, the external trigger is also propagated to the TRG-OUT (or GPO for the Desktop and NIM versions) front panel connector.

DISABLED: the external trigger is ignored.

FAST_TRIGGER option

This command allows to use the fast trigger inputs TR0 and TR1 to trigger the data acquisition of groups 0-1, and 2-3 respectively (742 digitizer family only). option can be:

ACQUISITION_ONLY to enable it;

DISABLED to disable it.

ENABLED_FAST_TRIGGER_DIGITIZING option

Signal from fast trigger (742 digitizer family only) can be digitized and made available for readout on the eighth channel of each group.

option can be:

YES to enable it;

NO to disable it.

MAX_NUM_EVENTS_BLT Ne

It indicates the maximum number of events Ne that can be transferred in a block transfer. Higher values of Ne may lead to a more efficient usage of the readout bandwidth, requiring more memory allocation for the block transfer.

Ne is an integer value ranging from 1 to 1023.

DECIMATION_FACTOR `Ns`

This command sets the decimation factor, corresponding to the number of samples `Ns` to be averaged in the decimation algorithm.

`Ns` is an integer value selectable amongst 1, 2, 4, 8, 16, 32, 64, 128.

Data are accordingly stored in the FPGA at a frequency of:

740 Family $\frac{62.5\text{MS/s}}{\text{Ns}}$

724 Family $\frac{100\text{MS/s}}{\text{Ns}}$

Note: This parameter is meaningful only for 740 and 724 series

Note: This parameter is supported only by 740 series running a ROC FPGA firmware revision ≥ 0.7

POST_TRIGGER `value`

This command indicates the post-trigger size in percentage of the total record length. In case of x742 digitizers there is an additional delay of 35 ns.

`value` is an integer value ranging from `0` to `100`.

PULSE_POLARITY `option`

This command determines whether the channel input signal polarity is positive or negative

`option` can be:

`POSITIVE` if the input signal has positive polarity;

`NEGATIVE` if the input signal has negative polarity.

USE_INTERRUPT `value`

This command enables/disables the interrupt acquisition mode. If enabled, the digitizer can give an interrupt to the reading process; the interrupt can occur either when a number `N` of events is reached, or when a timeout occurs. It is useful to set the same number of interrupts as the `MAX_NUM_EVENTS_BLT` value. Refer to **[RD7]** for all the parameters to be set for a correct use the of interrupts (as for example the Rora or Roak release mode, the interrupt level on the VME bus, the time-out, etc. that must be defined in the source code). `value` can be:

`0` to disable the interrupt acquisition mode;

`0 < value < 1024` to set an interrupt after `N` event read from the board.

FPIO_LEVEL `option`

Indicates the electrical level for the front panel LEMO I/Os (TRG_IN, TRG_OUT and S_IN for VME; TRG_IN, GPI and GPO for Desktop and NIM).

`option` can be:

`TTL` if the desired I/O level is TTL,

`NIM` if the desired I/O level is NIM.

WRITE_REGISTER `address data mask`

This command allows to write register values on the board.

`address` is the hexadecimal address offset of the register (16-bit value);

`data` is the data to be written into the register (16 or 32-bit value);

`mask` is the bit masking for the `data` writing (16 or 32-bit value).

EXAMPLES:

1. Set only bit [12] of register 1080 to 1, leaving the other bits to their previous value:

   ```
   WRITE_REGISTER 1080 1000 1000
   ```

2. Set bit [12] = 1 and bit [13] = 0 of register 1080, leaving the other bits to their previous value:

   ```
   WRITE_REGISTER 1080 1000 3000
   ```

3. Set register 1080 to the value of 0x45:

   ```
   WRITE_REGISTER 1080 45 FFFFFFFF
   ```

Note: Writes are executed at the end of the digitizer programming, therefore they can overwrite common or individual settings**.**

SKIP_STARTUP_CALIBRATION `option`

This command controls the start-up automatic channel calibration. It is possible to perform the start-up ADC calibration (default) or skip it and perform it manually later by a specific procedure (see Chap. **6**).

This parameter affects only digitizers which require ADC calibration (725, 730, 751, and 761 families).

`option` can be:

`YES` if channel calibration is not to be performed automatically by the software at WaveDump start-up

`NO` if channel calibration is to be performed automatically by the software at WaveDump start-up (default)

Note: The user is recommended to perform the channel calibration manually (see Chap. **3**) if the channel temperature varies significantly, or after a DC offset change, or Reset (refer to the relevant digitizer User Manual for details).

Individual Settings

The following settings are usually individually applied on each channel; however, the user can put them also in the [COMMON] section to apply them to all channels. Parameters not specified into the Individual Settings section are intended to assume the value defined in the Common Settings section.

The list of individual parameters for each channel has to be reported after the [i] keyword, where "i" is the number of the selected channel (or group for 740 and 742 series).

Example:

```
[0]
ENABLE_INPUT            YES         # setting 1 of channel "0" section
DC_OFFSET               10          # setting 2 of channel "0" section
[1]
ENABLE_INPUT            NO          # setting 1 of channel "1" section
DC_OFFSET               0           # setting 1 of channel "1" section
...
```

ENABLE_INPUT `option`

This command enables or disables the corresponding channel for the acquisition.

`option` can be:

`YES` to enable it;

`NO` to disable it.

Note: For 740 and 742 series, this setting refers to a group of 8 channels: all channels belonging to the group are enabled/disabled at the same time.

Note: `DES_MODE` can overwrite the `ENABLE_INPUT` command. Channels disabled by the `DES_MODE` remains disabled.

BASELINE_SHIFT `value`

The `BASELINE_SHIFT` command allows to shift the input dynamics accordingly to the input signal polarity (the signal dynamics is 0 to FSR for positive input polarity or -FSR to 0 for negative input polarity, where FSR is the full-scale range). The `BASELINE_SHIFT` value is expressed in percentage of the FSR.

Note: For 740 series, the `BASELINE_SHIFT` value is the same for all channels in the group. This option automatically enables the channel DAC calibration. **This option is not supported by 742 series**.

`value` is a float number that ranges from 0 to `100.0`, where `0` corresponds to the full signal dynamics. Some examples are provided in the table below

value	PULSE_POLARITY=POSITIVE	PULSE_POLARITY=NEGATIVE
0	0 to +FSR	-FSR to 0
50	+FSR/2 to +FSR	-FSR/2 to 0
100	null (usually not used)	null (usually not used)

Default value is `50.`

Note: When using `BASELINE_SHIFT` option, a preliminary check is done on every active channel to check whether DAC calibration is feasible or not. A temporary 50% `BASELINE_SHIFT` value is set, and a single waveform acquisition is performed, with the user-defined record length. In case the baseline samples in the acquired waveform are <60% of the total record length, or in case the baseline deviates by 25% from the expected value, the calibration will not be executed. A message will appear in the software interface: "DAC calibration failed for channel n". The instructions to recalibrate the channel are given.

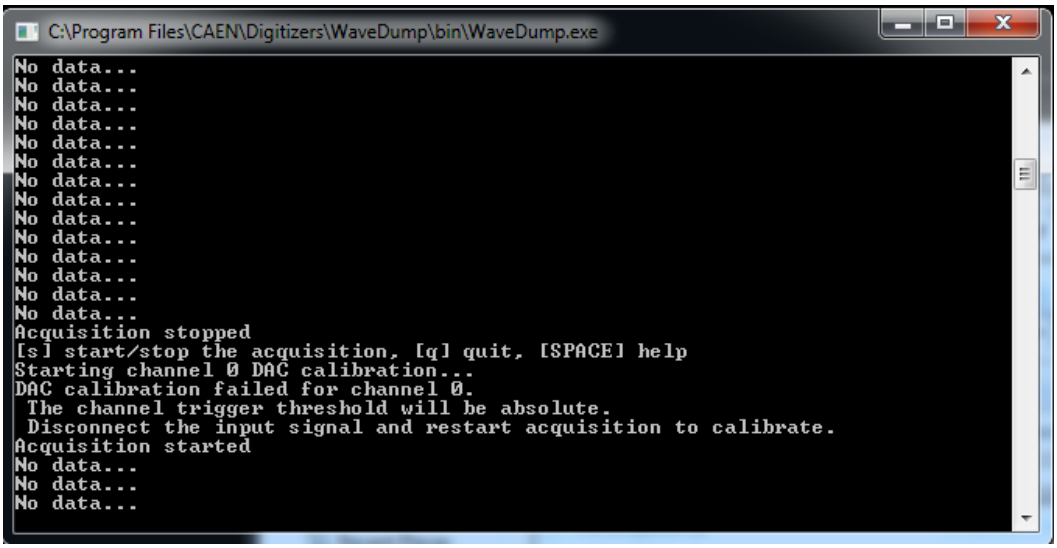

Figure 4.1: Channel baseline calibration failure when using BASELINE_SHIFT

DC_OFFSET `value`

The `DC_OFFSET` command allows to shift the input dynamics (-FSR / 2 to +FSR / 2, where FSR is the full-scale range) towards negative or positive values. The `DC_OFFSET` value is expressed in percentage of the FSR. **NOTE**: For 740 and 742 series, the `DC_OFFSET` value is the same for all channels in the group, though it is possible to set different values for each channel of a x742 digitizer through the **GRP_CH_DC_OFFSET** command.

`value` is a float number that ranges from `-50.0` to `50.0`, where `-50.0` corresponds to a signal dynamic from -FSR to 0 (completely negative signal), and `50.0` corresponds to a signal dynamic from 0 to FSR (completely positive signal). Default value is `0`, which corresponds to a signal dynamics of-FSR / 2 to +FSR / 2 (bipolar signal).

Note: ranges are different for 742 digitizer series. See **GRP_CH_DC_OFFSET** command.

Note: `DC_OFFSET` and `BASELINE_SHIFT` are intended to be used one alternatively to the other.

GRP_CH_DC_OFFSET `dc_0, dc_1, dc_2, dc_3, dc_4, dc_5, dc_6, dc_7`

The `GRP_CH_DC_OFFSET` command allows to adjust the DC_OFFSET level for each channel of a group (742 digitizer series only).

`dc_0 ... dc_n` are float numbers that indicate the DC offset level for channel `0, …, n` of the groups. Values range from `-50` to `50`, where `-50` corresponds to a dynamic from -3FSR/2 to -FSR/2 (maximum negative signal), `50` corresponds to a dynamic from +FSR/2 to +3FSR/2 (maximum positive signal). Default value is `0`, which corresponds to a signal dynamic of -FSR / 2 to +FSR / 2 (bipolar signal).

TRIGGER_THRESHOLD `value`

Set the trigger threshold (in ADC counts) for the generation of the channel self-trigger.

`value` is an integer value that ranges from `0` to `2^Nbit-1`, where `Nbit` is the number of bits of the ADC.

Note: if `DC_OFFSET` is used, the threshold is absolute, while, if `BASELINE_SHIFT` is used, the threshold is relative to the baseline. In the latter case, the threshold is calculated as follows:

- POSITIVE PULSE POLARITY: threshold = baseline + TRIGGER_THRESHOLD
- NEGATIVE PULSE POLARITY: threshold = baseline - TRIGGER_THRESHOLD

CHANNEL_TRIGGER option

This command enables/disables the self-trigger function for a specific channel (or group in case of 740 series). The OR of all the enabled channel self-trigger is used as a global trigger for the board. Moreover, as for the EXTERNAL_TRIGGER command, the CHANNEL_TRIGGER decides how the channel self-triggers generated from the threshold crossing are used.

option can be:

ACQUISITION_ONLY: the self-trigger causes the acquisition of one event in all the channels of the board, regardless the channel(s) that generated it.

ACQUISITION_AND_TRGOUT: the same as ACQUISITION_ONLY. In addition, the global trigger is also propagated to the TRG-OUT (or GPO for the Desktop and NIM versions) front panel connector.

TRGOUT_ONLY: the self-trigger does not cause the acquisition of an event, but the trigger signal is propagated to the TRG-OUT (or GPO for the Desktop and NIM versions) front panel connector.

Note: ACQUISITION_AND_TRGOUT and TRGOUT_ONLY features are not available on x742 Models.

DISABLED: the self-trigger of the relevant channel is ignored.

CHANNEL_TRIGGER with x730 digitizers:

Specifically with x730 boards, where even and odd channels are paired, their 'CHANNEL_TRIGGER' value will be equal to the one specified on the even channel, unless one of the two channels of the pair is set to 'DISABLED'. If so, the other one behaves as usual.

Please, refer to the specific x730 digitizer User manual for details on the trigger management.

GROUP_TRG_ENABLE_MASK mask

This command enables the channels of a specific group (740 series only) to generate a self-trigger. The OR of the enabled channels generates the group trigger. Then the OR of all groups generates the global trigger for the board.

mask is a hexadecimal number ranging from 0 to FF.

Note: When using BASELINE_SHIFT option, it is recommended to **enable the self-trigger only for those channels receiving an input signal**, to avoid problems in the trigger management.

Individual Settings for x742 Fast Trigger Channels

The following settings are valid for x742 models only, where Fast Trigger channels (TR0 and TR1) are available.

For a complete description of Wave Dump practical use with 742 models, specifically for trigger management, please refer to the Quick Start Guide [RD12]

The list of individual parameters for each group and Fast Trigger channel must be reported after the [i] keyword, where "i" is the number of the selected group or the Fast Trigger channel name.

Example:

```
[0]
ENABLE_INPUT          YES                    # setting 1 of group "0" section
GRP_CH_DC_OFFSET      0,0,50,0,-50,0,0,0     # setting 2 of group "0" section
...
[TR0]
DC_OFFSET              32768       # setting 1 of Fast Trigger 0 section
TRIGGER_THRESHOLD      20934       # setting 2 of Fast Trigger 0 section
```

Note: signal TR0 is the Fast Trigger for both groups 0 and 1 (all form factor versions), while signal TR1 is the Fast Trigger for groups 2 and 3 (VME only).

For the Fast Trigger channels TR0 and TR1 the following parameters are available:

DC_OFFSET `value`

Set the `DC_OFFSET` level of the Fast Trigger channel.

`value` is a float number ranging from `-50.0` to `50.0`, where `-50.0` corresponds to a signal dynamic from -3/2 FSR to –FSR/2 (maximum negative dynamics), `0` corresponds to a signal dynamic from –FSR/2 to +FSR/2 (bipolar signal) and +50.0 corresponds to a signal dynamic from +FSR/2 to +3FSR/2 (maximum positive dynamics).

TRIGGER_THRESHOLD `value`

Set the `TRIGGER_THRESHOLD` for the comparison level of the Fast Trigger channel.

`value` ranges from `0` to `65535`.

According to the PCB revision of the board (refer to **[RD7]** for further details) and to the TRn type of signal we suggest different values of `DC_OFFSET` and `TRIGGER_THRESHOLD`. Here some examples:

1. PCB rev. 0:
   a. NIM signal on TR:
      `DC_OFFSET 4096`
      `TRIGGER_THRESHOLD 29053`
   b. AC signal on TR:
      `DC_OFFSET 4096`
      `TRIGGER_THRESHOLD 27776`
   c. TTL signal on TR:
      `DC_OFFSET 16384`
      `TRIGGER_THRESHOLD 29016`

2. PCB rev. 1:
    a. NIM signal on TR

```
DC_OFFSET 32768
TRIGGER_THRESHOLD 20934
```

    b. AC signal on TR

```
DC_OFFSET 32768
TRIGGER_THRESHOLD 26214
```

    c. +2V signal on TR

```
DC_OFFSET 43520
TRIGGER_THRESHOLD 26214
```

5 Temperature Protection (725 and 730 series only)

The 725 and 730 digitizer families feature a temperature protection procedure saving the hardware from possible damages due to internal over-temperature conditions. Substantially, this consists in monitoring the channels temperature and, as soon as it exceeds a fixed limit, the firmware automatically:

- turns off all the channel ADCs;
- stops the acquisition, if running (data possibly stored at that moment can be readout in any case).

Please, refer to the board User Manual for details on the temperature protection procedure.

TEMPERATURE PROTECTION IS NOT SUPPORTED BY ROC FPGA FIRMWARE RELEASES < 4.5

WaveDump manages this feature as follows:

- If the over-temperature condition is reached by the board during the acquisition, while the firmware performs the channels turning off, a message of “Over Temperature” is displayed, the acquisition is stopped, and the user is required to quit the program.
- As long as the board remains in over-temperature condition, it is not possible to restart the acquisition (“Over Temperature” message is still displayed).
- As soon as the board exits the over-temperature condition, a new acquisition can be started by the user.

TEMPERATURE PROTECTION IS NOT MANAGED BY WAVEDUMP SOFTWARE RELEASES < 3.6.6

6 Channel Calibration (725, 730, 751 and 761 series only)

Digitizers in the 725, 730, 751, and 761 families perform a self-calibration of the ADCs at power-on. Anyway, to achieve the best performance, the calibration procedure is recommended to be executed, on command, after the ADCs have stabilized their operating temperature.

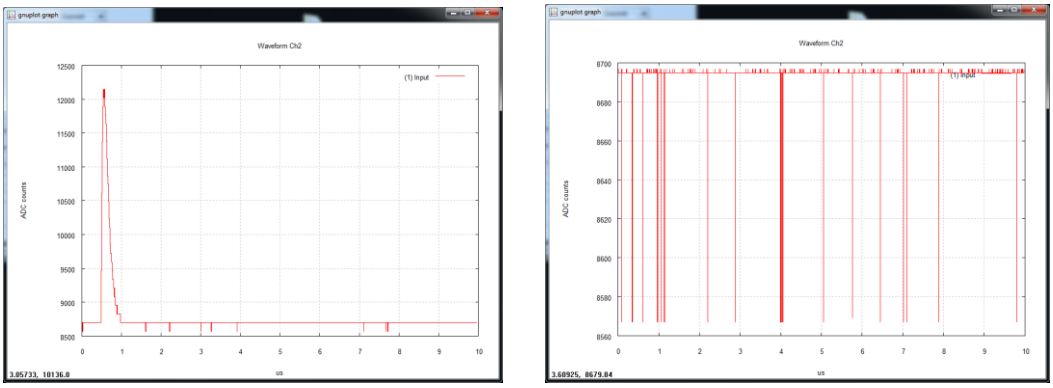

Figure 6.1: Example of uncalibrated input channel (baseline case on the right).

The calibration will not need to be repeated at each run unless the operating temperature changes significantly, or clock settings are modified (e.g. switching from internal to external clock).

Channel Calibration Procedure

1. Launch WaveDump software. A message of ADC calibration successfully executed will be displayed (see **Figure 6.2**).

NOTES:

a) If the digitizer doesn't need calibration, calibration is not performed, and the message shown is:

"ADC Calibration not needed for this board family"

b) If SKIP_STARTUP_CALIBRATION parameter is set to YES in configuration file (see Chap. 4), the automatic start-up calibration is not performed, and no message is displayed

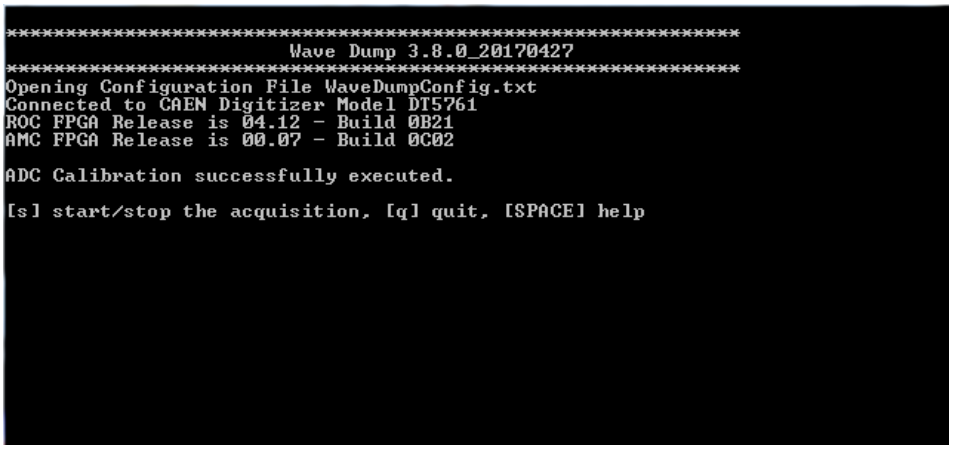

Figure 6.2: Automatic calibration at WaveDump first run

The user can start using the program sure that the digitizer has been calibrated at least once.

2. At any time, the user can check the channel temperatures (with the acquisition not running) by issuing multiple "m" commands from the keyboard.

3. In case of significant variations, issuing a “c” command provokes a manual channel calibration to be executed.

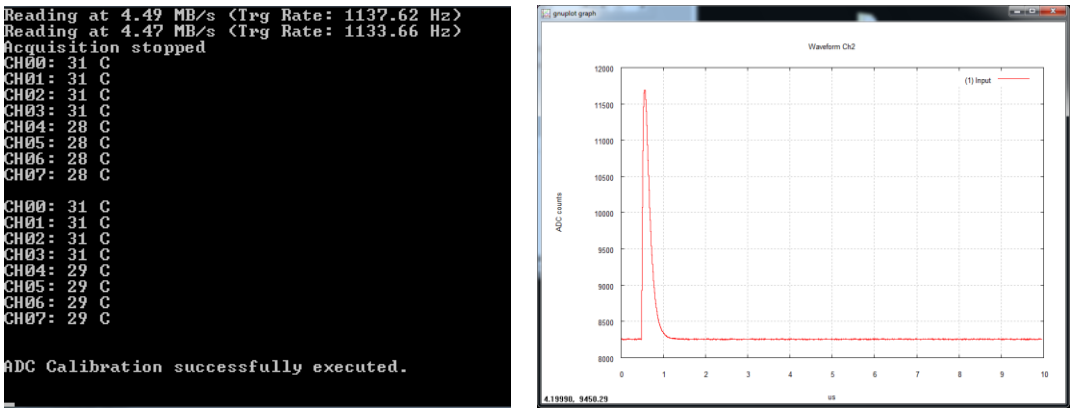

Figure 6.3: Temperature monitoring with manual calibration command (left) and calibrated input signal (right)

4. A new acquisition can start.

Please, refer to the User Manual of the specific board for a detailed explanation of the channel calibration.

7 Technical Support

CAEN experts can provide technical support 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)

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