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WP 5.1: ADC Demo Board User Manual

Table of Contents

1 General

1.1 History

GUI Version	Date	Comment
0.1	11.05.18	Original version
0.2	21.11.18	add hardware description
0.3	29.11.18	Added details, description of measurements
0.4	08.01.19	Added details and more functionality for sync, trigger both ADCs
0.5	29.01.19	Added new Sync_Tab
0.6	12.03.19	Updated Analysis_Tab
0.7	03.04.19	New Layout Analysis-Tab. Change Samplerate working. Add rescue-procedure
1.4.9	04.04.19	Added new Log-Tab for better Overview
1.7.0	07.05.19	External Reference Clock is now available. New Settings window for Analysis Tab.

1.2 Purpose

The purpose of this document is to describe the use of the ADC demonstration board EV12AQ600.

1.3 Scope

This document provides a description of the ADC demonstration board hardware and GUI.

1.4 Reference documentation

[1] Product specification EV12AQ600 SP 31S 213706 Rev A
[2] Interstellar Quasar Demo Board requirements May 15th 2017
[3] The Data Conversion Handbook, 2005
[4] EV12AS350-EB-GUI.pdf

1.5 Acronyms and Abbreviations

BER	Bit Error Rate
ENOB	Effective Number of Bits
FPBW	Full power input bandwidth
NPR	Noise Power Ratio
NSD	Noise Spectral Density
PSRR	Power-supply Rejection Ratio
RMS	Root Mean Square
SFDR	Spurious Free Dynamic Range
SINAD	Signal to Noise and Distortion Ratio
SNR	Signal to Noise Ratio
THD	Total Harmonic Distortion

TD	Total Distortion
TILD	Total Interleaving Distortion

2 Quick Start

In this paragraph the first usage of the EV12AQ600 demonstration board is described step by step. In this example a 100 MHz sinus signal is digitized with ADC1 with 6 Gsps.

2.1 Setup Hardware

First the hardware has to be set up. An overview can be seen in Figure 1.

1. For a v1-Board, check if the delivered SD Card is already located the intended port. For a v2-board this is not needed.
2. Connect the power supply.
3. Connect the Lan-Cable
    a. Ethernet 0 for DHCP
    b. Ethernet 1 for a fixed IP-Address
4. Connect a 100 MHz sinus signal with 0 dBm to IN0 of ADC1. To suppress the harmonics a lowpass-filter can be used.

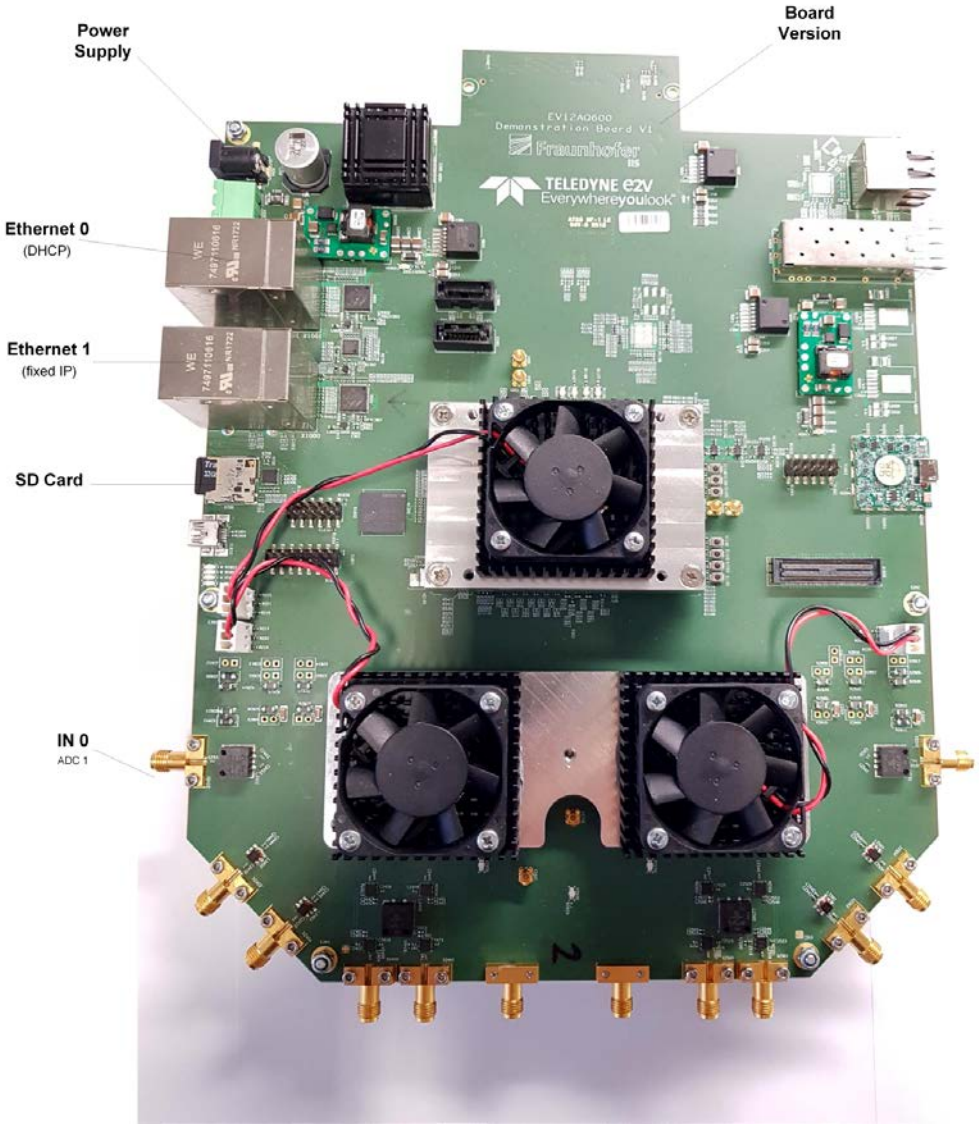


Figure 1: EV12AQ600 basic connection for v1-Board

2.2 Connect to Hardware

When the hardware is running the GUI can connect to the demoboard.

1. Run ev12aq600-gui.exe
2. Then connect to the board. Therefore fill in the host.
   a. Interface eth0 will always be set to DHCP, which means that it will get its IP address by a DHCP server in the local network
   b. Interface eth1 can be configured manually, see below. The default address is 192.168.0.13. It can also be configured as DHCP interface.

   Afterwards connect and wait until the status changes to connected. The GUI page to establish the connection to the hardware can be seen in Figure 2.

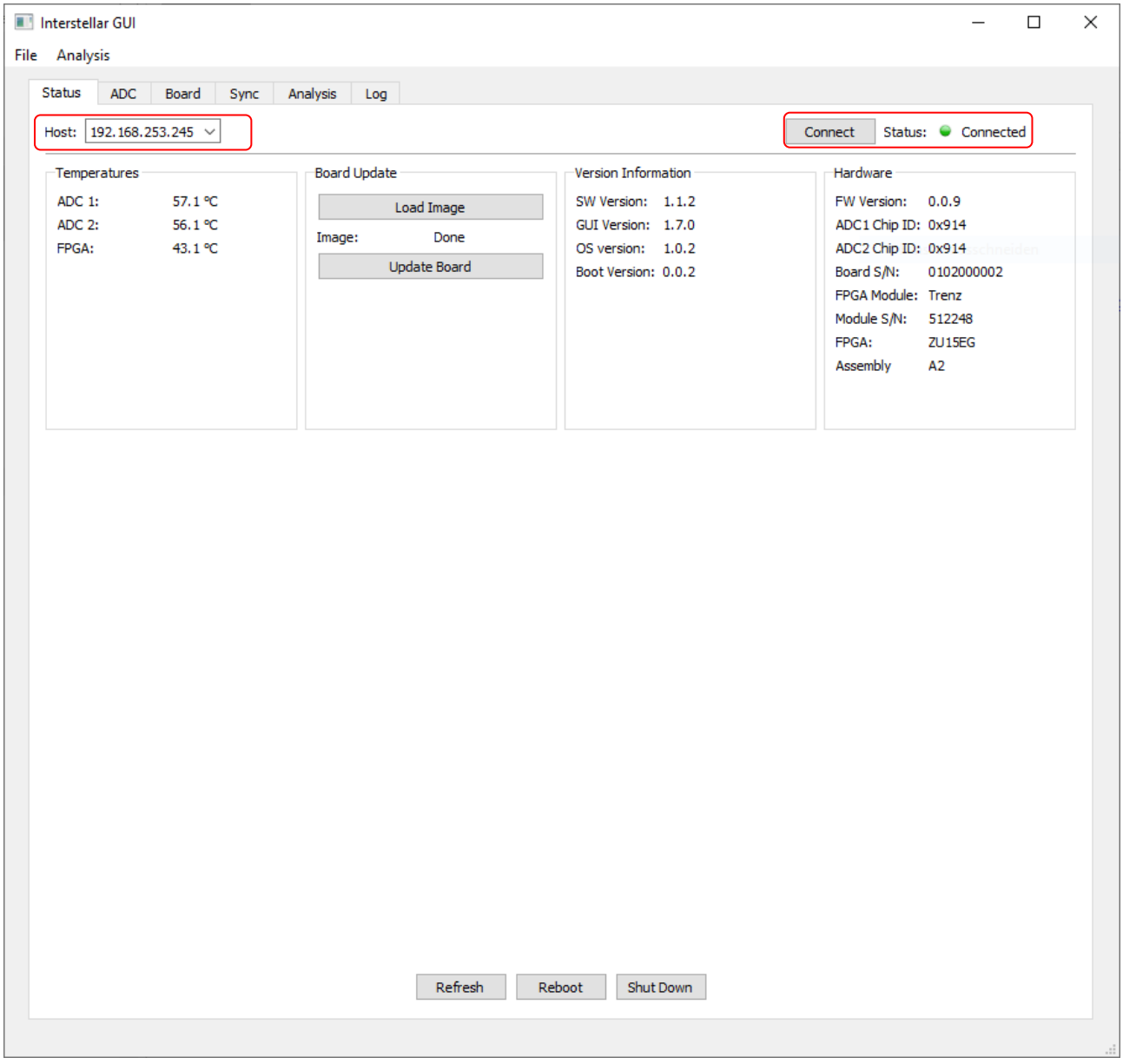


Figure 2: Establish connection

2.3 Configure the ADCs

For this example the default configuration of the demo-board can be used so nothing has to be changed.

2.4 Trigger and Analyze Snapshot

Now a snapshot can be triggered and analyzed.

1. Switch in the GUI to the Analysis tab. This tab is shown in Figure 3.
2. Click the “Trigger Snapshot” button.
3. The 100 MHz sinus is shown in the frequency-domain

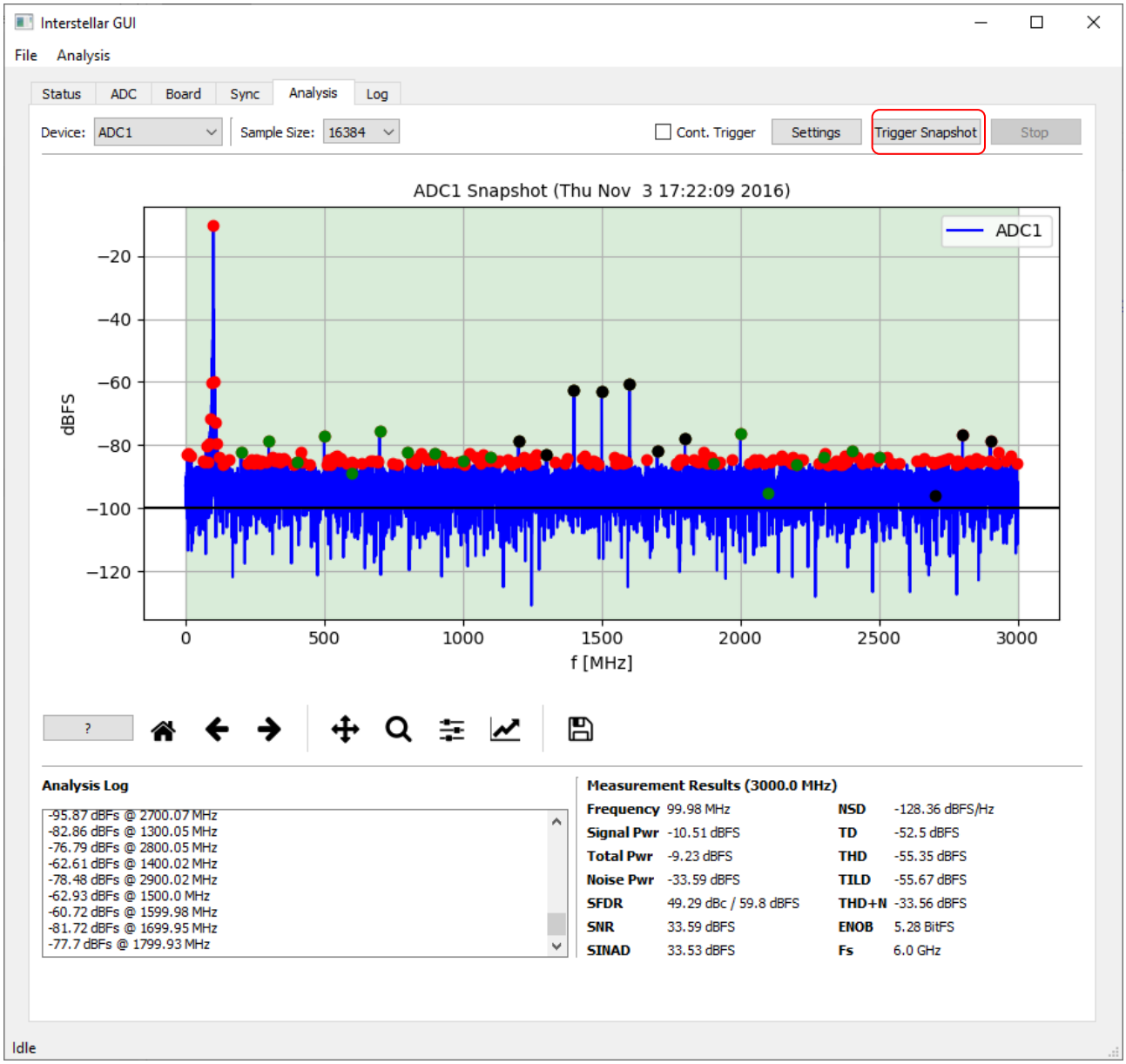


Figure 3: Trigger snapshot and analyze signal in the frequency domain

This was a simple example to show the basic function of the EV12AQ600 demo board. A more detailed description of the hardware and the GUI can be found in the following paragraphs.

3 Detailed Hardware Description

There exist two different versions of the ADC Demoboard. The v1 can be seen in Figure 4 and the v2 in Figure 5.

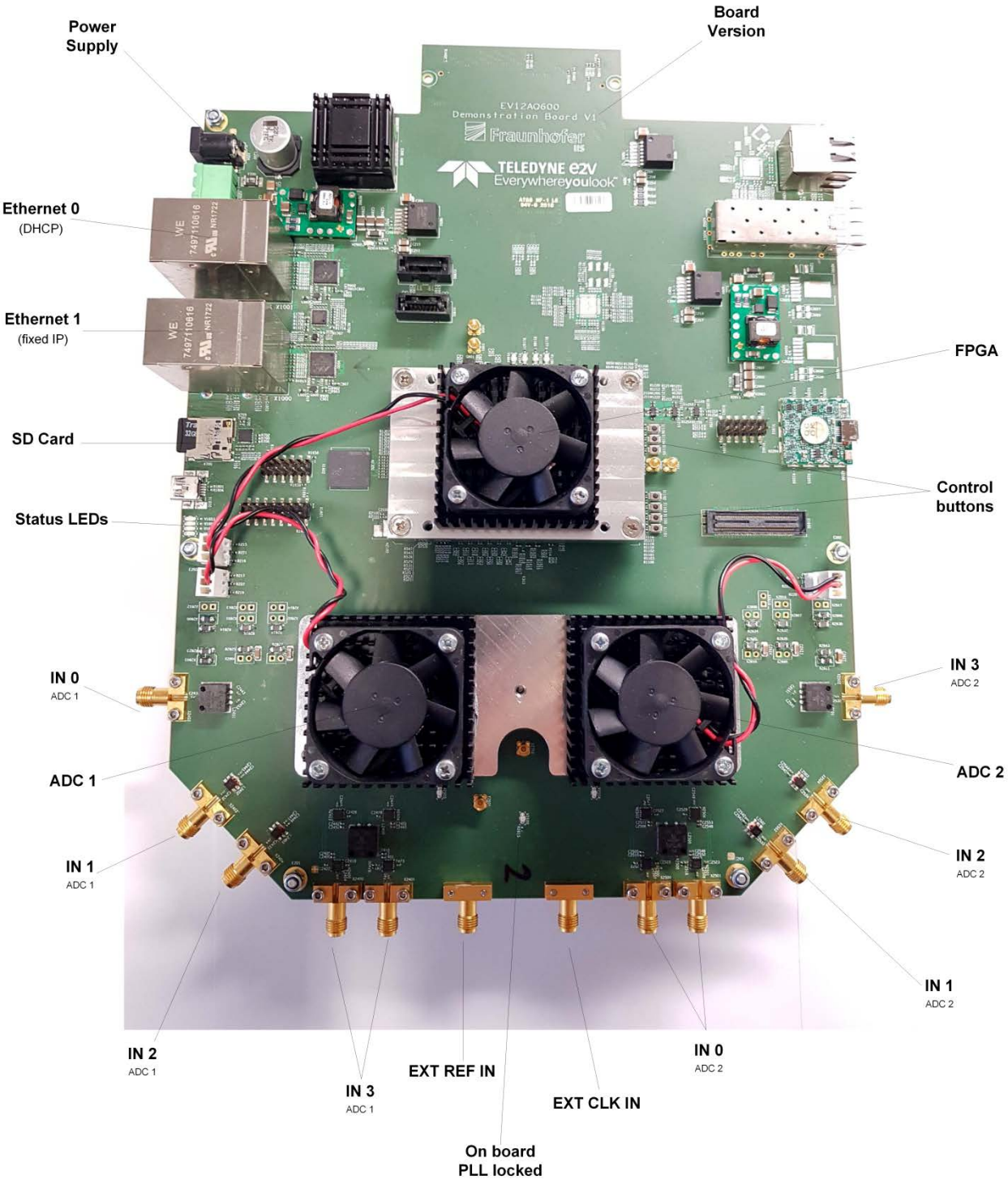


Figure 4: detailed overview of the v1 ADC-Demoboard

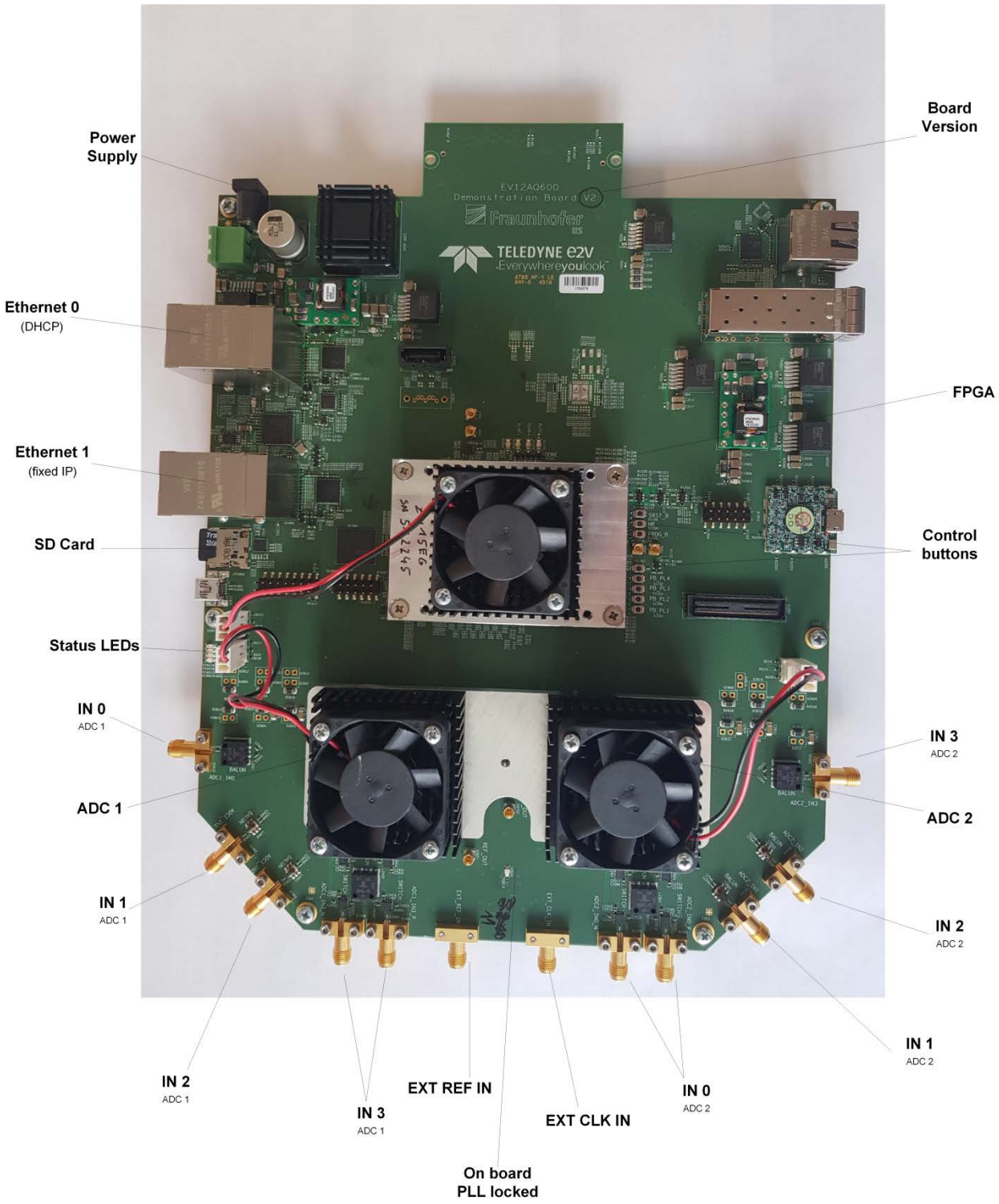


Figure 5: detailed overview of the v2 ADC-Demoboard

3.1 Difference v1 and v2

The difference in between v1 and v2 is that v1 needs a SD-Card to work. This is not the case for v2. Here the operating system is stored inside a flash memory. The v2-Boards have also an additional button S1107. The purpose of this button is to completely rewrite the internal flash memory if the operating system is broken. This is called “rescue procedure” and described more detailed in paragraph 3.2.

3.2 Rescue Procedure

This procedure is only working with v2 boards. It is needed when the connection to the ADC Demoboard can be no longer established. The procedure is as following:

1. Insert a rescue SD-Card into the ADC-Demoboard
2. Power on the ADC-Demoboard
3. Press pushbutton S1107 and keep it pressed
4. Press pushbutton S1104 for a short time
5. when all status LEDs are on (booting), pushbutton S1107 can be released
6. The rescue procedure (all LEDs flashing) is done when all status LEDs are off again.
7. The ADC-Demoboard can be powered of now and the rescue SD-Card can be removed
8. Now it should be possible to connect to the ADC-Demoboard again.

3.3 Detailed description of buttons and LEDs

In Table 1 you can see a detailed description of the status LEDs. Table 2 shows the function of the pushbuttons on the ADC-Demoboard.

LED	default mode	rescue mode	booting	shutdown
V1600	blinking slow (ca. 1 Hz) when bitfile is loaded	blinking fast (ca. 10 Hz)	on	off
V1601	on when sync of ADC1 was successful	blinking fast (ca. 10 Hz)	on	off
V1602	on when sync of ADC2 was successful	blinking fast (ca. 10 Hz)	on	off
V1603	blinking slow (ca. 1 Hz) when server is running	blinking fast (ca. 10 Hz)	on	off

Table 1: description status LEDs

pushbutton	function
S1100	
S1101	
S1102	
S1103	
S1104	hard-reset
S1105	
S1106	
S1107	boot from SD card (only available on v2)

Table 2: description pushbuttons

4 Detailed GUI Description

In this paragraph the menu bar and every tab of the GUI is described in detail.

4.1 Menu Bar

File: The current GUI-Configuration can be stored (Save Configuration) to be loaded later (Load Configuration). The loaded configuration is applied directly.

Analysis: The current snapshot can be stored (Save Snapshot) or a snapshot can be loaded to be analyzed with the GUI (Load Snapshot). A more detailed description of the snapshot-format can be found at the end of paragraph 4.6. Additionally the analysis can be configured (Settings) from this menu.

4.2 Status-Tab

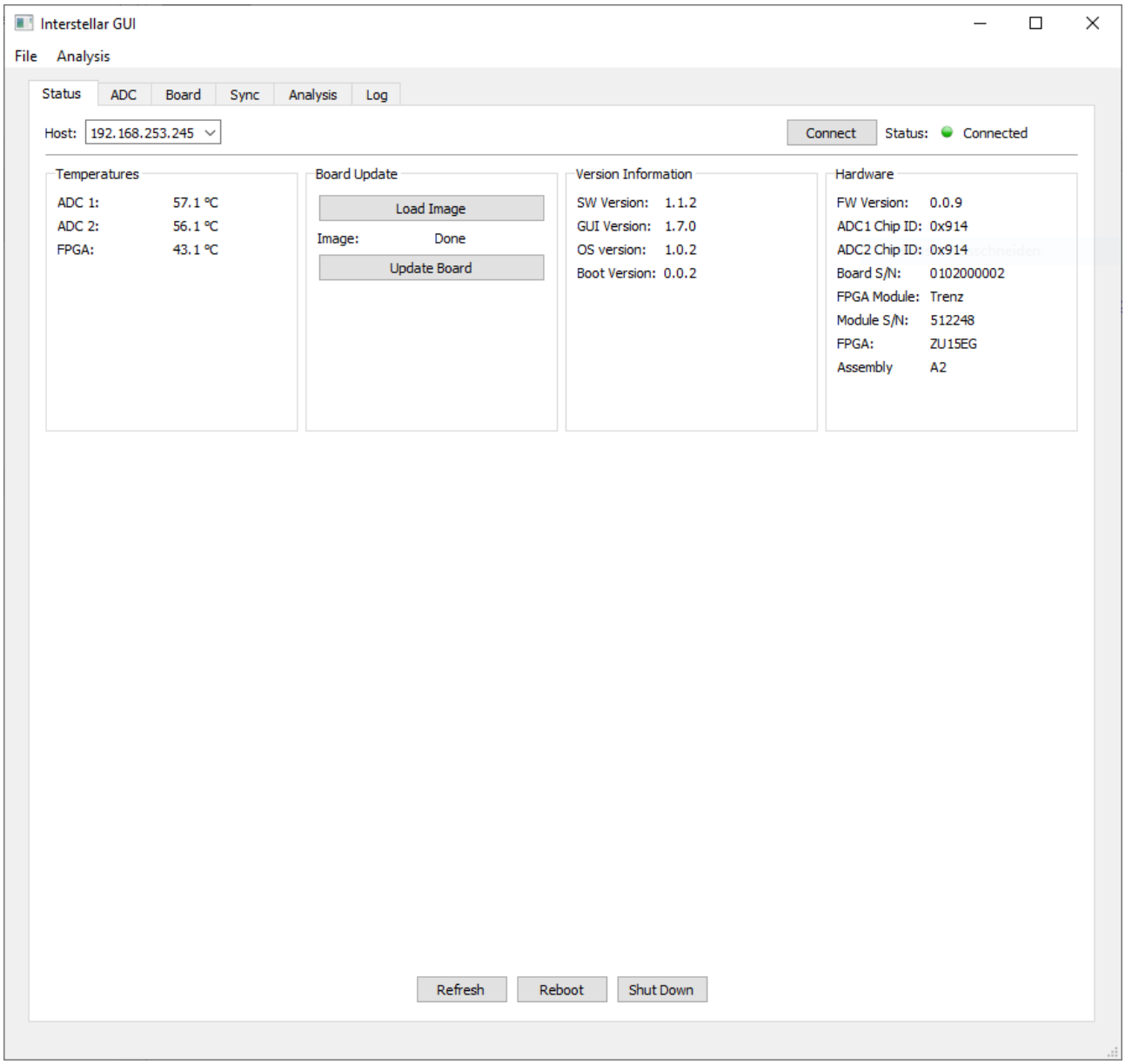


Figure 6: GUI Status-Tab

4.2.1 Description

The Status-tab is the tab that opens automatically after the start of the GUI. It shows general information about the connected board. This includes temperatures, version information and hardware information.

Just the temperature is updated automatically (every second). The rest has to be updated with the refresh button.

4.2.2 Functions

1 Connect: To connect to the board, fill in **Host** (hostname or IP-Address) and click **Connect**. The software then tries to connect. Please note that the ADCs are not reset after GUI start or connection.

2 Refresh: To refresh displayed general information press **Refresh**.

3 Reboot: To reboot the board press **Reboot**.

4 Shut Down: To shut down the Board and close the GUI press **Shut Down**.

5 Load Image and Update Board: To update the connected board, press **Load Image** and locate the desired update.img file. Then press **Update Board** and wait for completion. After that the board must be restarted with the Reboot-Button.

4.3 ADC-Tab

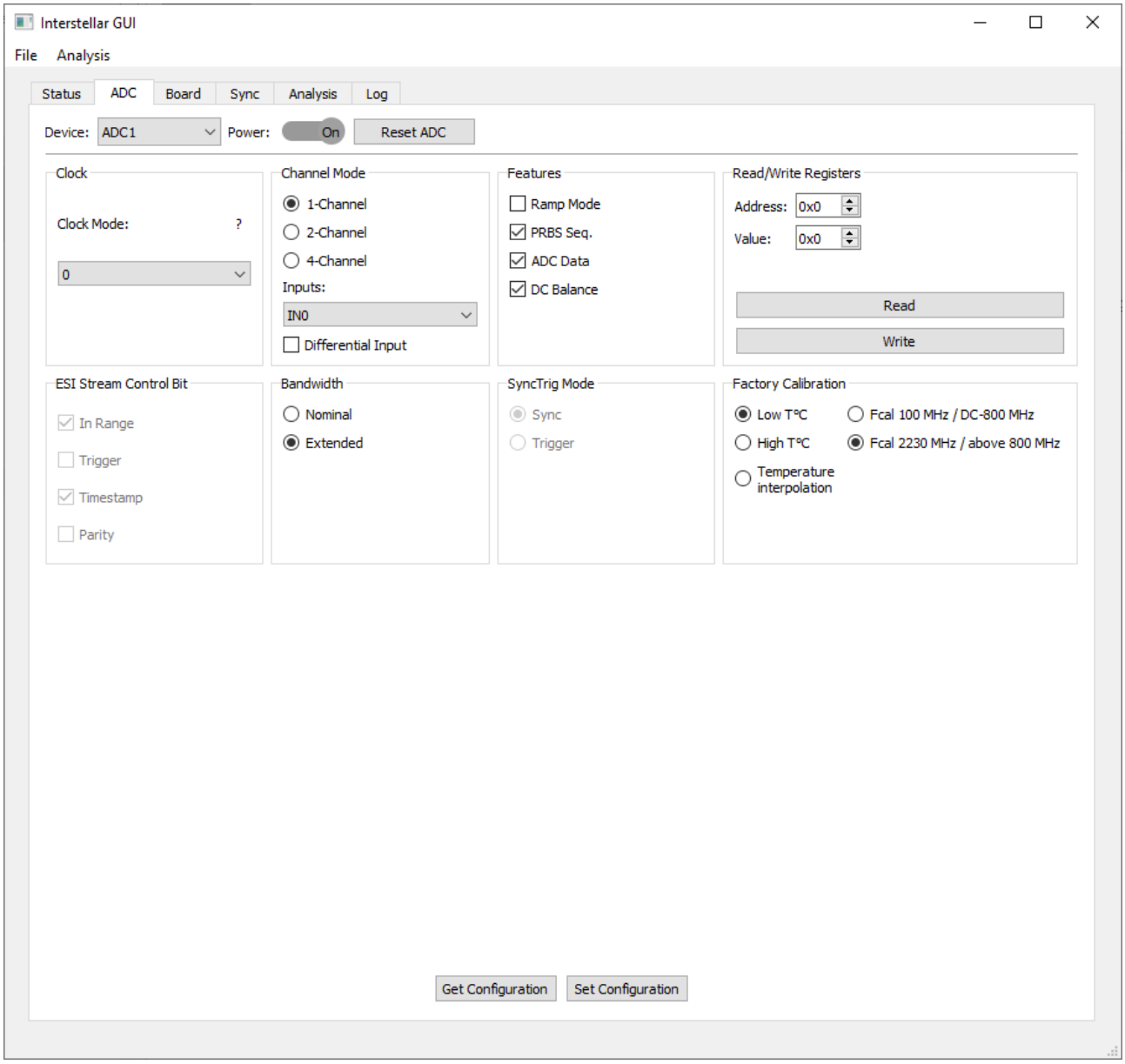


Figure 7: GUI ADC-Tab

4.3.1 Description

The ADC-tab shows information about the ADCs. In this tab the settings for the ADCs can be viewed and changed for each ADC separately. The preset settings are the default values of the ADCs. After the configuration was changed it has to be written to the ADC with the “Set Configuration”-Button.

4.3.2 Functions

1 Device: Choose either **ADC1** or **ADC2**

2 Power: Switch ADC2 **on** or **off**. Only possible for **ADC2**, since ADC1 power also supplies clock generation and other mandatory things.

3 Reset ADC: Reset selected ADC via reset pin. **Standard** register values according to the data sheet are loaded.

4 Clock: Clock modes of the selected ADC according to the data sheet (refer to section 5.7 Clock Interleaving).

1: all cores interleaved
2: Clock coreA = coreB; clock coreC = coreD
3: Clock coreA = coreC; clock coreB = coreD
4: all cores clocked interleaved

5 Channel Mode**:** Configuration of ADC cross-point switch (refer to section 5.6 of datasheet).
User can select one of the three modes and the possible inputs.

- **1-Channel:** input 0/3 to core A&B&C&D
- **2-Channel:** input 0/3 to core A&B and input 3/0 to core C&D
- **4-Channel:** input 0 to core A, input 1 to core B, input 2 to core C, input 3 to core D
- **Inputs:** Select which input is connected to which core (depends on the chosen channel-mode)
- **Differential Input:** select if IN3 (ADC1) resp. IN0 (ADC2) is differential or single-ended (with balun)

6 Features: Selection of features of serial data connection.

Ramp Mode: enable ramp mode on serial output (datasheet section 5.12.3 Ramp Mode)
PRBS Seq.: enable PRBS on serial output
ADC Data: enable ADC data on serial output
DC Balance: enable DC balance on serial output

7 Read/Write Registers: Low- level ADC register read/write function (for more details see the Register Map in the datasheet section 5.3).

8 ESI Stream Control Bit: Not available yet!
Configure functionality of Control bit 1 or Control bit 2.

- INRANGE:
- TRIG: SYNC disabled
- TIMESTAMP:
- PARITY:

9 Bandwidth: Selection of nominal (3 GHz) or extended (5 GHz) analog input bandwidth.

10 SyncTrig Mode: Not available yet!
Selection of trigger mode

11 Factory Calibration: Select the calibration set the ADC uses. There are four different calibration sets available that are optimized for a certain temperature and frequency:

1. cold (60 °C) and 2230 MHz
2. warm (100 °C) and 2230 MHz
3. cold (60 °C) and 100 MHz
4. warm (100 °C) and 100 MHz

Additional it is possible to use temperature dependent calibration values for the chosen frequency. Those are calculated from the current temperature and the stored calibration values for 60 °C and 100 °C via interpolation for the chosen frequency.

12 Set Configuration: Write the current configuration to the ADC.

13 Get Configuration: Load the ADC configuration and display it in the GUI.

4.4 Board-Tab

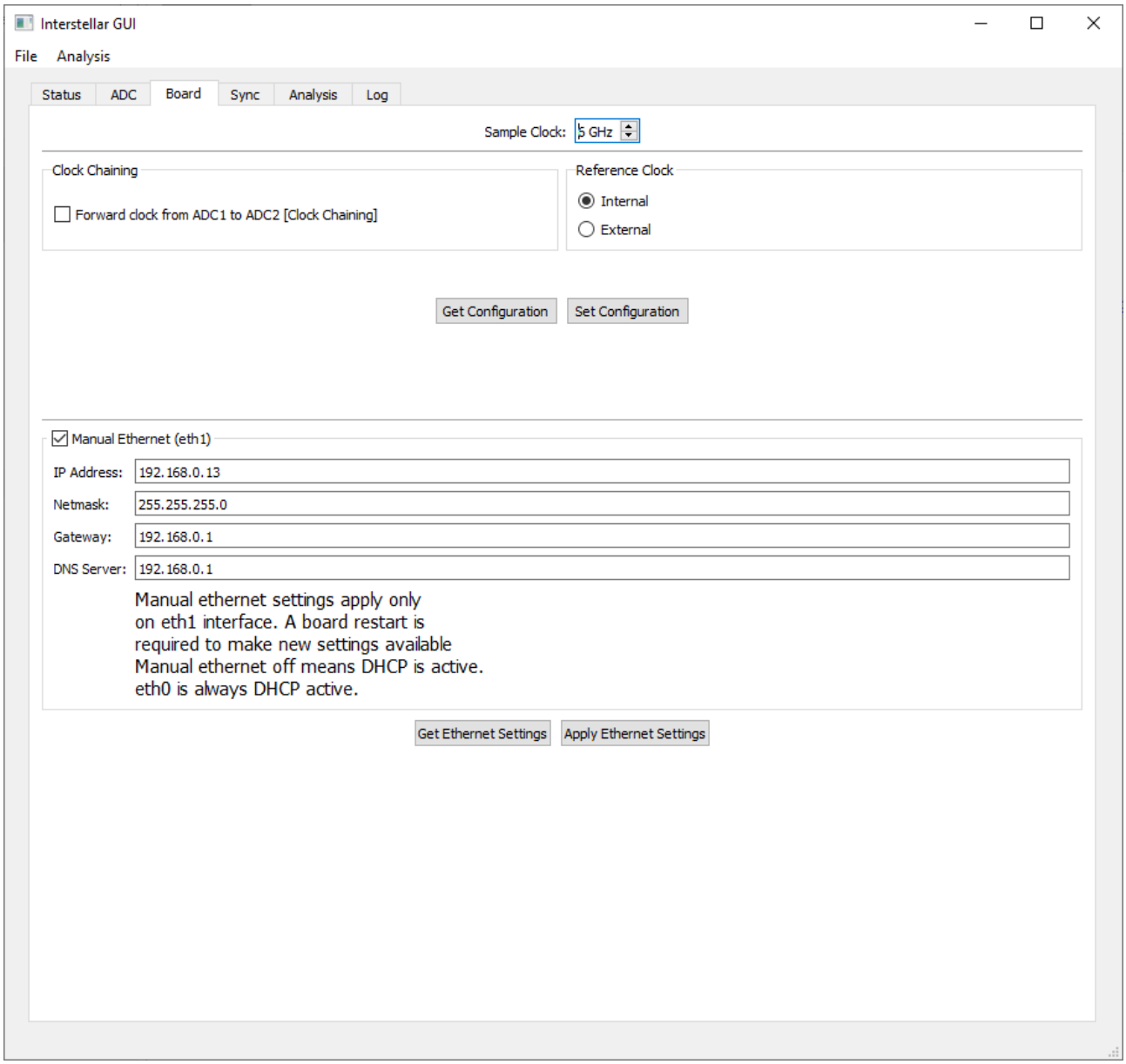


Figure 8: GUI Board-Tab

4.4.1 Description

Board settings can be viewed and changed on the Board-Tab.

4.4.2 Function

1 Sample Clock: Select sampling clock for both ADCs

2 Clock Chaining: Enable clock chaining on ADCs (connect CLKOUT of ADC1 to CLK of ADC2).

3 Reference Clock: Enable external reference clock or internal reference clock.

4 Set Configuration: Write the current configuration to the ADC.

5 Get Configuration: Load the ADC configuration and display it in the GUI.

6 Manual Ethernet: Changes made here only apply to Ethernet 1. If the manual Ethernet is deactivated DHCP for eth1 is active. Press **Set Ethernet Settings** to save changes and restart the board if IP address was changed (press Reboot-Button on Status Tab). The default address is 192.168.0.13/24.

7 Set Ethernet Settings: Write the current configuration to the ADC.

8 Get Ethernet Settings: Load the ADC configuration and display it in the GUI.

4.5 Sync-Tab

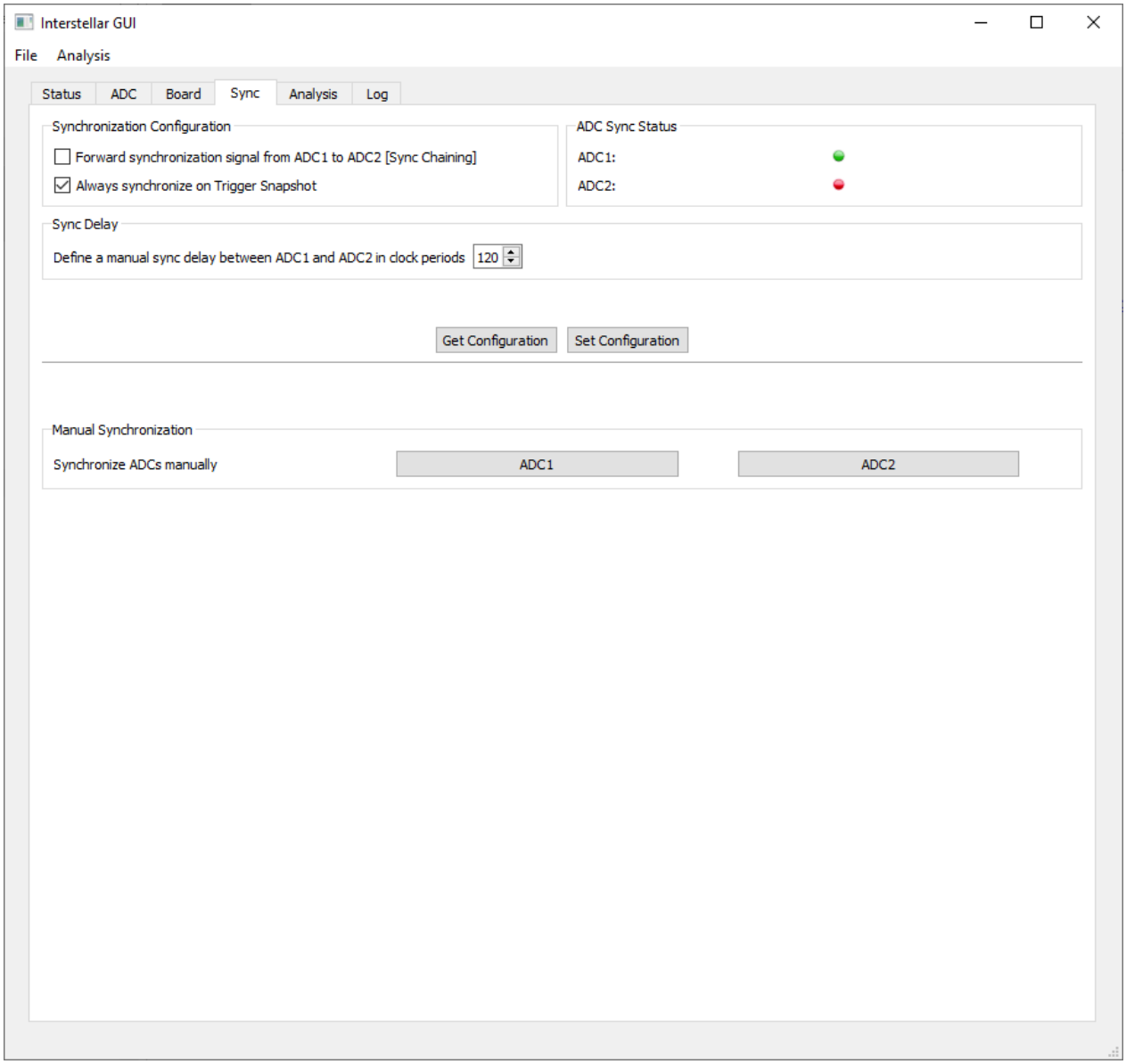


Figure 9: GUI-Sync-Tab

4.5.1 Description

ADC synchronization can be viewed and changed on the Sync-Tab.

4.5.2 Function

1 Synchronization Configuration:

- Forward synchronization signal from ADC1 to ADC2 (Sync Chaining): activate/deactivate sync-chaining (e.g. synchronization from ADC1 and ADC2)
- Always synchronize ADCs on Trigger Snapshot: send always the sync-signal (reestablish the ESIstream-Connection) before a snapshot is triggered

2 ADC Sync Status: Shows whether ADCs are synchronized or not (ESIstream-Connection is established)

3 Sync Delay: Manually define the sync delay between ADC1 and ADC2 in clock periods. This delay is just used when sync-chaining is active and every time it is changed a new sync-signal has to be send.

4 Manual Synchronization: Synchronize ADCs (establish ESIstream-Connection).

5 Get Configuration: Write the current configuration to the Demoboard.

6 Set Configuration: Load the Demoboard configuration and display it in the GUI.

4.6 Analysis-Tab

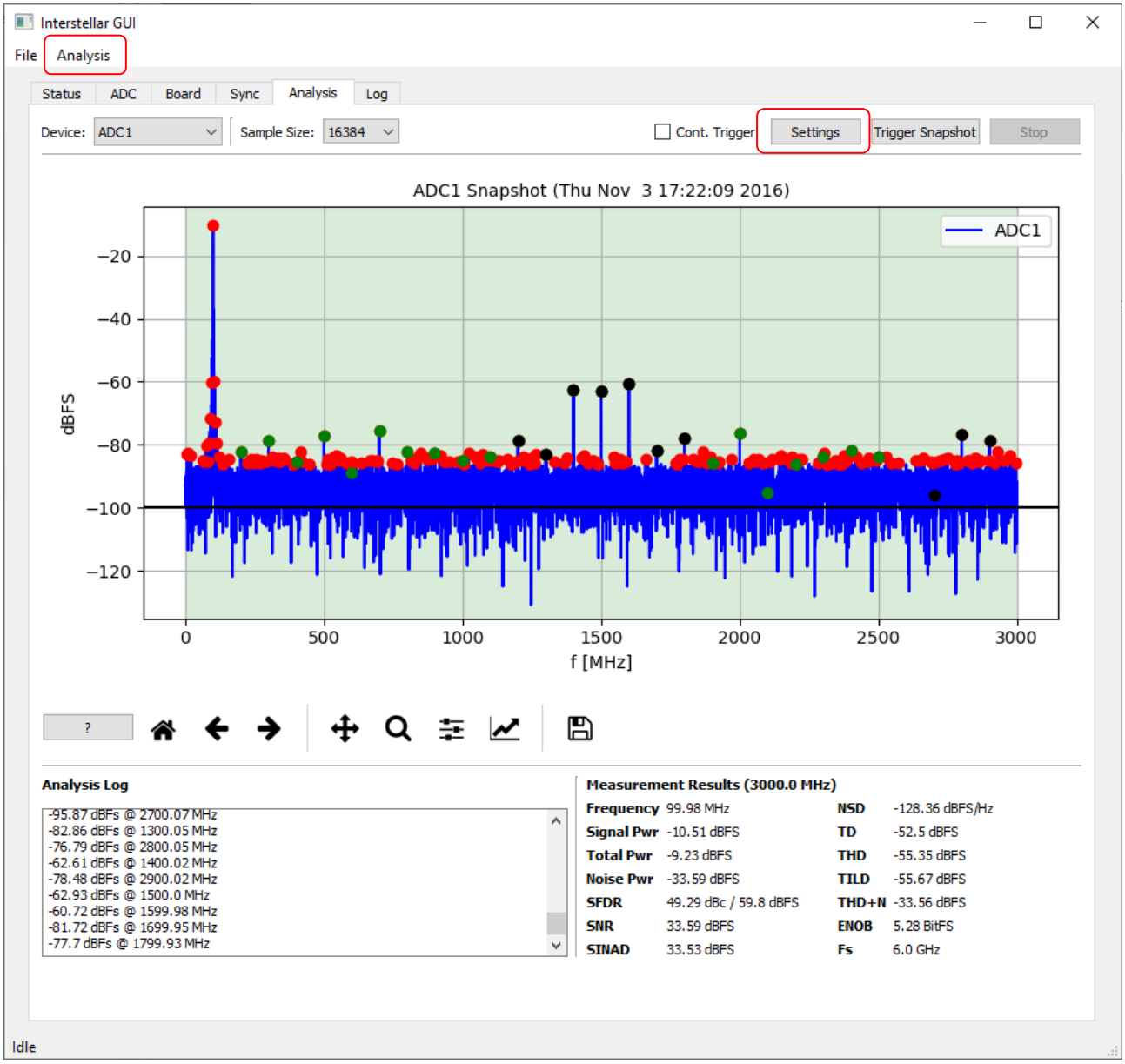


Figure 10: GUI Analysis-Tab

4.6.1 Description

The Analysis-Tab shows information and settings about triggering and analyzing snapshots. ADC snapshots can be triggered, stored and analyzed here.

4.6.2 Function

Device: Select ADC for which the snapshot will be triggered.

- ADC1,
- ADC2
- ADC1&ADC2 together

Sample Size: Select the desired snapshot size in samples (1024-524288 samples)

Cont. Trigger: Trigger snapshot for the selected ADC continuously.

Settings: Access Analysis Settings Menu to configure the following things:

Data View:

- Domain: select how to plot the ADC snapshot.

  - time: time domain plot
  - psd: power spectral density plot using Welch's method
  - fft: frequency domain plot
  - histogram: probability density function of the signal over time
- Unit**:** selection of x-axis scaling. Default setting is frequency domain, unit MHz.
- Window**:** choose the windowing to be used for the frequency-domain plots. Choices are: Barlett, Blackman, Hamming, Hanning or Rectangular (Boxcar).

Peak detection threshold: Select the desired threshold in dBFS. The peaks found below the latter are ignored.

Bandwidth settings:

- BW: Select the bandwidth of interest for the signal processing, measurements analysis and results calculation.
- Center Freq: manual specify center frequency for BW-setting.
- Snap to sig: automatically choose the signal-frequency (frequency with the highest power) as center-frequency for the BW-setting.
- Full bandwidth: use the complete Nyquist band for analysis

Input selection: Dependent on the ADC-Mode you can choose which signal to analyze and plot.

Data Range: Number of samples from the snapshot that are analyzed. With the button "Max. Data Range" the maximum available data range is chosen (depends on the Sample Size and ADC Mode).

Apply Selection: All chosen settings are applied to the snapshot data.

Trigger Snapshot: Trigger snapshot for the selected ADC with the desired snapshot size.

Stop: Stop the continuous triggering of snapshots.

Diagram:

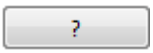
The diagram shows the plot(s) of the chosen ADC(s). Additionally the detected peaks are highlighted with colored dots. The different colors have the following meaning:

green: harmonic spurs

black: interleaving spurs

blue: signal and other spurs

Diagram controls:



Show an additional legend for the plot (e. g. the meaning of the different colors of the dots inside the plots)

Full view of plot

Previous view

Next view (applicable if previous view was clicked)

Pan/Zoom

 Zoom rectangle

 Plot settings

 Figure options (axis and curve settings)

 Save plot as image

Analysis Log: Lists the detected peaks, harmonics and interleaving distortions. The measurement results base on those values.

Measurement Results: The measurement results are calculated when a new snapshot is triggered or the settings are changed and applied. These measurements are based on a peak detection, which is automatically performed. The algorithms use the 15 most significant detected peaks inside the bandwidth of interest. The following measurements are performed:

- Frequency: displays the frequency of the highest peak; all other measurements assume, that this is the input signal
- Signal Pwr: measured power of the signal at “Frequency”
- Total Pwr: measured power over the configured bandwidth of interest
- Noise Pwr: median value of the signal power summed over the bandwidth of interest. (it does not include harmonics or interleaving distortion)
- SFDR: looks for next peak power and calculates the difference to the detected input signal
- SNR: Signal to noise power
- SINAD: Signal to noise plus distortion power
- NSD: Noise spectral density which is the median value of the signal power
- TD: Total distortion is the harmonic distortion added to the interleaving distortion summed over the bandwidth of interest.
- THD: is the total power of all detected harmonics (without input signal power) in dBFS
- TILD: ratio of the sum of all interleaving spurs to the input signal amplitude in dBFS
- THD+N: adds noise power to THD in dBFS
- ENOB: Effective number of bits
- Fs: current sampling frequency

Additionally it´s possible to export and import snapshots. This can be done with the Analysis-Menu.

Save Snapshot: Save the plotted snapshot as ~.csv file for advanced analysis. When two plots are available, two csv-files are stored _ADC1 and _ADC2 is appended to the chosen filename. The exported csv-file has the following format:

timestamp, current data and time

adc, ADC-Number

samplerate, “current samplerate”

adc-mode, configured adc-mode (correstponding spi-register value can be seen in *Table 3*: adc-mode register-value translation)

adc-bandwidth, bandwidth-configuration of ADC (extended/nominal)

snapshot-data

corea, coreb, corec, cored

0x…, 0x…, 0x…, 0x…

0x…, 0x…, 0x…, 0x…

…

Register 0x000B	CSV-File (row adc-mode)
000	one_channel_0
001	one_channel_3
010	two_channel_0AB
011	two_channel_0CD
100	four_channel

Table 3: adc-mode register-value translation

Load Snapshot: Load *.csv file to plot snapshot data and calculate the Measurement Results.

4.7 Log-Tab

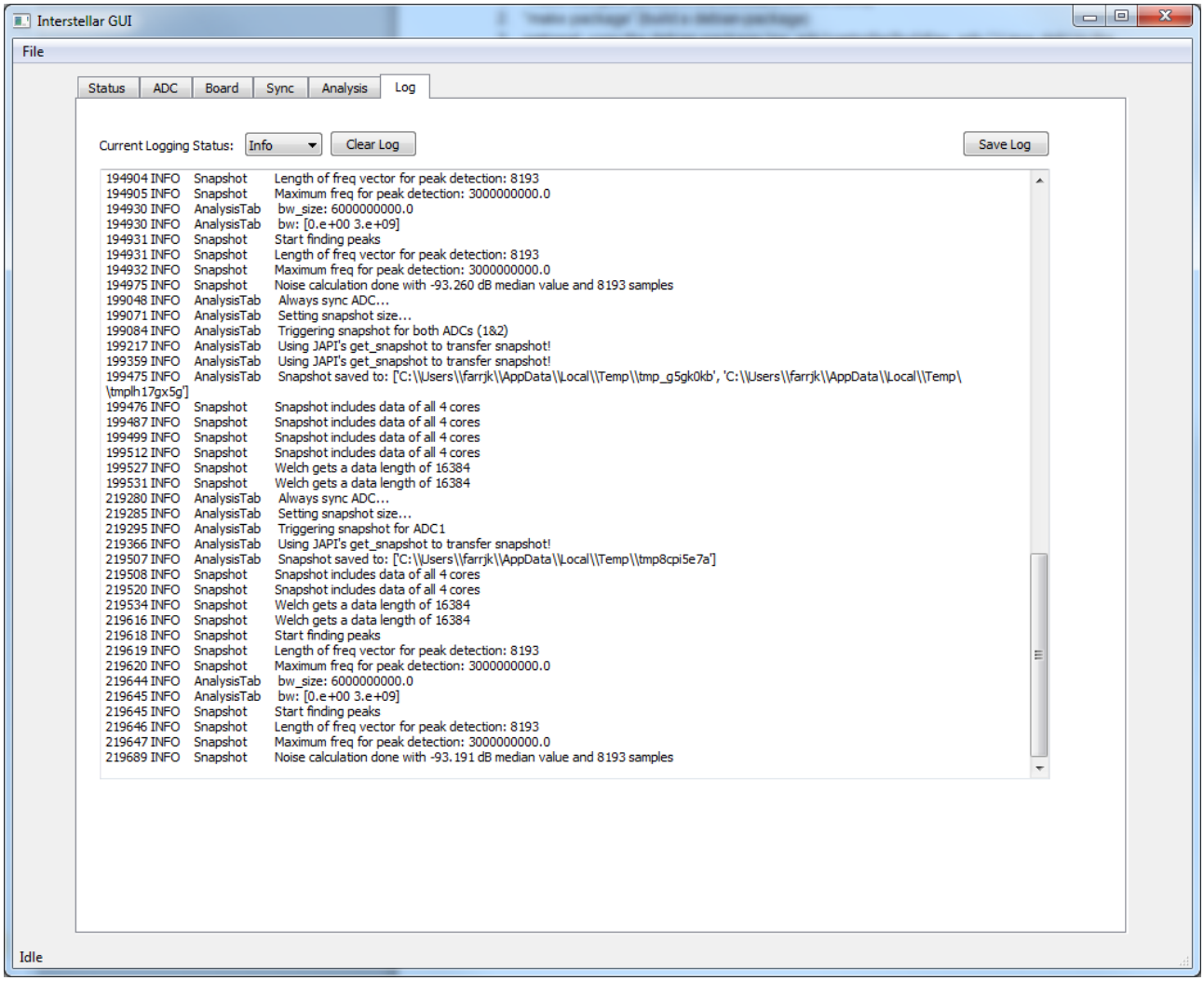


Figure 11: GUI Log-Tab

4.7.1 Description

The Log Tab provides a more detailed feedback about the GUI status.

4.7.2 Functions

1 Current Logging Status: Choose which logs should be displayed. There are four different levels possible:

Error: Just log error messages

Warning: Log error messages and warnings

Info: Log errors, warnings and additional information

Debug: log everything including debugging information

2 Clear Log: Clear the Text in the Log Window.

3 Save Log: Save the output text to an external file.