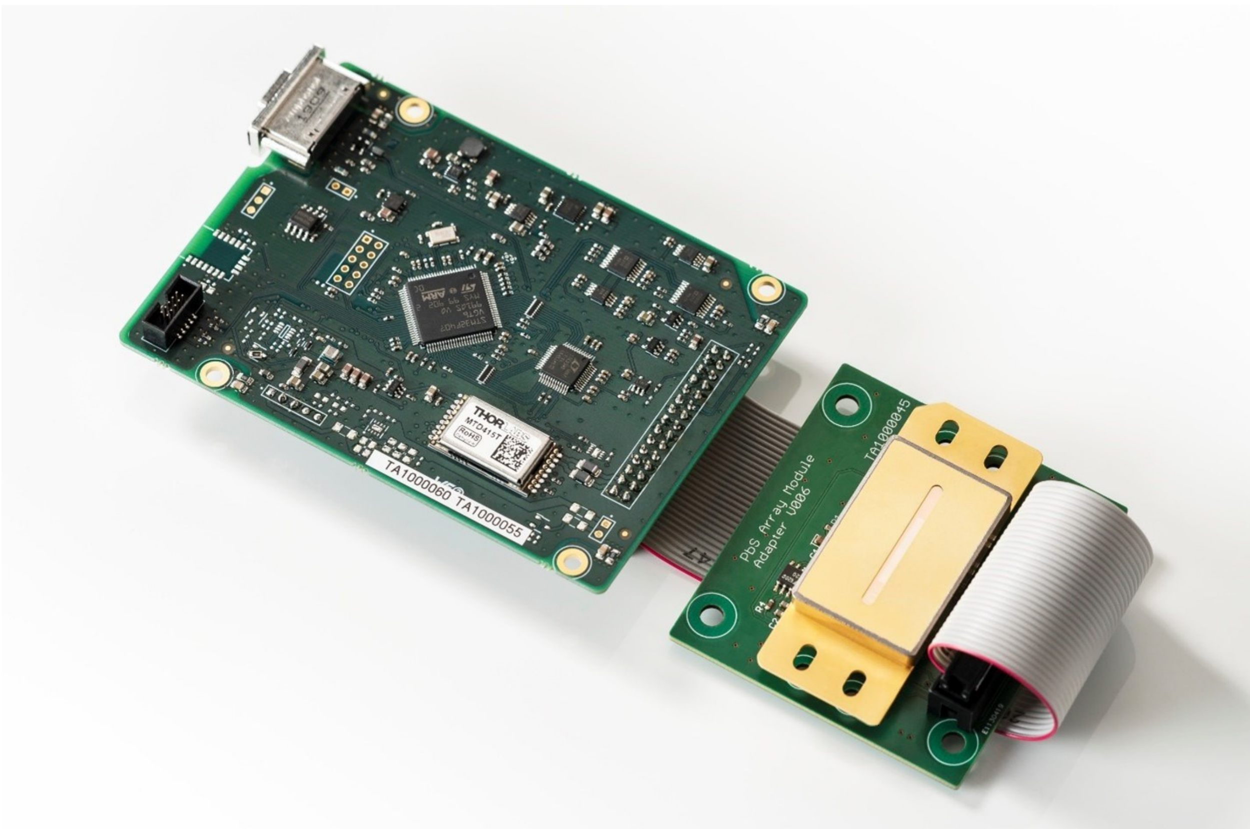
Array Module Evaluation kit

by trinamiX

User guide

Version 1.5, 2023-01-10



Key features

- 256 Pixel multiplexer readout circuit
- Up to 1000 frames per second
- All necessary voltages generated on board
- Software included

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Contents

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1. Introduction

The Array Modul Evaluation Kit is designed for measurement and testing with trinamiX PbS Array Modules. It offers a 30 Pin connector for connecting a PbS Array Module Adapter Board. This is available for mounting a PbS Array Module with a cutout for connecting a heatsink. The Evaluation Kit is designed for USB operation with an additional 9V or 12V power supply. Using the USB connection, the board transfers recorded data to a computer. With the delivered software, users can monitor and measure the signal of an Array Module as well as controlling a thermo electric cooler (TEC) to stabilize the temperature of the active element. The requirement for stable operation with the TEC is to have a sufficient heatsink connected to the hot side.

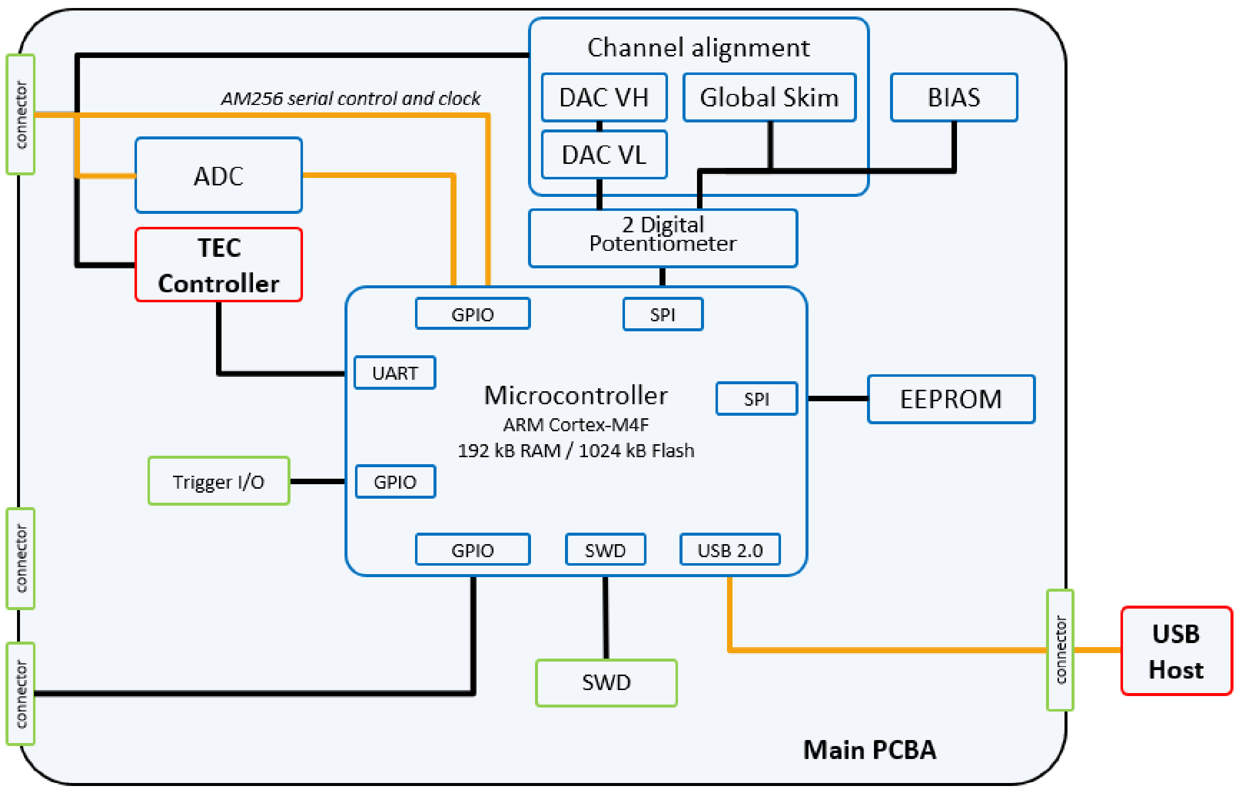

Figure 1: Control / Data connections

The board consists (as shown in Figure 1) of an ADC (analog-digital-converter), a TEC Controller, digital potentiometers for voltage regulation and a microcontroller that generates the clocks for the ROIC (read-out IC) of the Array Module, communicates with the ADC, the TEC Controller and the USB Host device, sets the values for the Pixel Calibration, and controls the Bias voltage. A USB-C cable must be used for connecting the Host device.

This guide provides information about general specifications (section 2), how to set up the hardware and delivered software (section 3), as well as two application examples to demonstrate how the Evaluation Kit can be used (section 4).

2. Specifications

The Evaluation Kit software is designed to run under the operation system Windows 10. An explanation guide for the software can be found in section 3.2.

Important electrical specifications of the Evaluation Kit are shown in Figure 2. Characteristics of the analog inputs are listed in *Table* 1. In Figure 56 the pinout of the PbS PCB socket is shown, including the applied voltages.

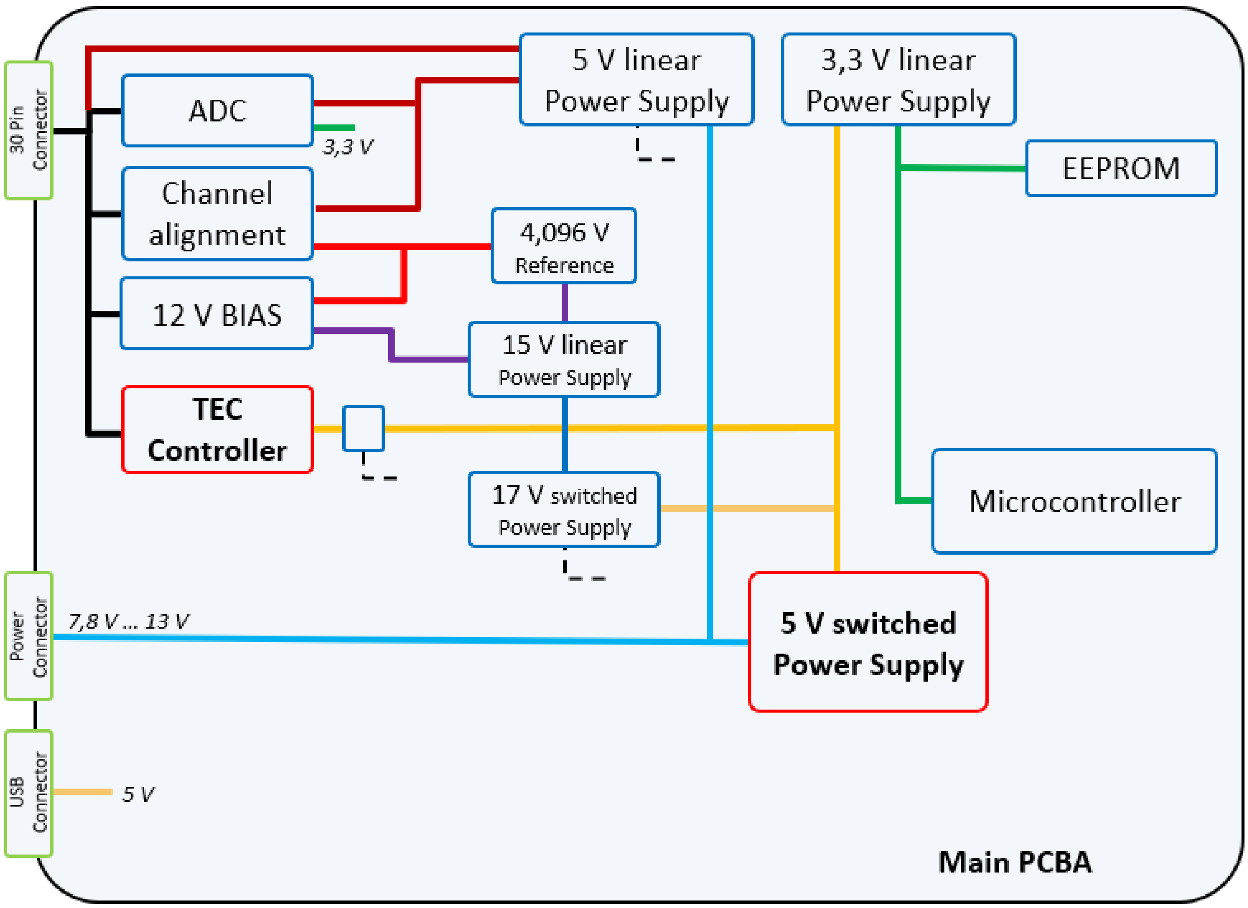

Figure 2: Power Management

Table 1. Parameter Characteristics.

Parameter		Typ.	Unit
V_bias	Detector bias voltage	6.144 - 12.282	V
f_s	Sample frequency	1 – 1024	Frames / s
t_{int}	Integration time	4-200 000	µs
C_{well}	Charge well size	1;4;7;10;11;14;17;20	pF
G_{skim}	Global Skimming voltage	0.409 – 2.456	V
DAC VH	DAC high level voltage	0.744 - 2.6	V
DAC VL	DAC low level voltage	0.744 – 2.6	V
T_{TEC}	TEC Temperature control range	5 – 45	°C
I_{TEC}	TEC Output current	-1.5 – 1.5	A
P	P Value of the PID Controller	0 – 100000	mA/K
I	I Value of the PID Controller	0 – 100000	mA/(K+s)
D	D Value of the PID Controller	0 - 100000	mA*s/K
T_{window}	Temperature window for Controller	1 - 32768	mK
d	Status delay for Controller	1 - 32768	s
t_{cycle}	Cycle time for Controller	1 - 1000	ms

3. Setup

A picture of the whole default setup is shown in Figure 3. The Evaluation Kit is connected to the computer via the USB cable. An Adapter Board with mounted PbS Array Module is connected to the Evaluation Board and the Evaluation board is powered with a 9V or 12V AC/DC converter. The Line Array can be monitored with the Software running on the USB Host device. The hardware setup steps and an explanation guide, how to use the measurement tool, are described in the following sections.

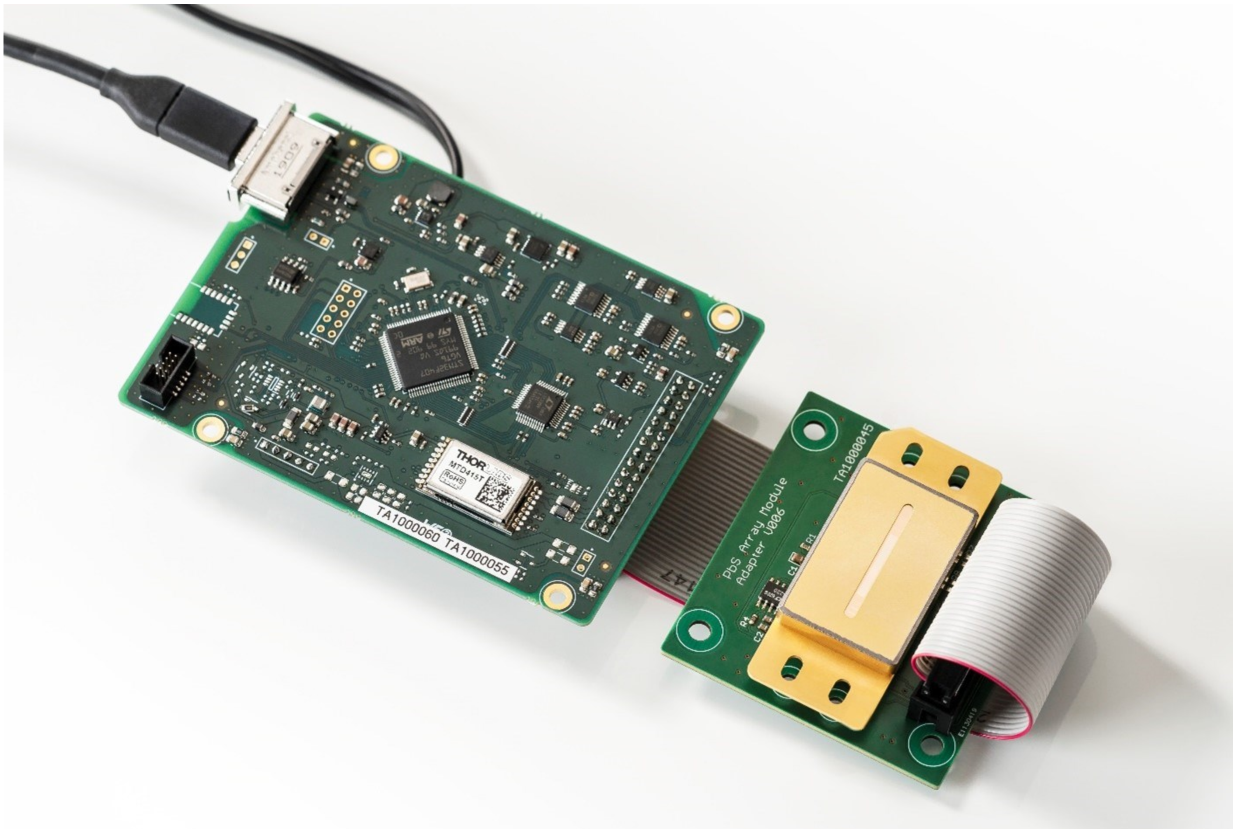

Figure 3. Picture of the Evaluation Kit.

3.1. Hardware

This Chapter describes step by step the setup of the hardware components provided with the evaluation kit.

1. The Array Module must be plugged into the PbS Array Module Adapter board as described in the following pictures. Correct orientation of the PbS Array Module with respect to the socket on the Adapter Board is paramount. <u>It is important to plug Pin 1 of the PbS Array Module into socket Pin 1 of the Adapter Board</u>. Pin 1 of the Adapter Board is indicated with a “1” besides the Connector. Pin 1 of the PbS Array Module is identified by the 45° notch of the mounting tab.

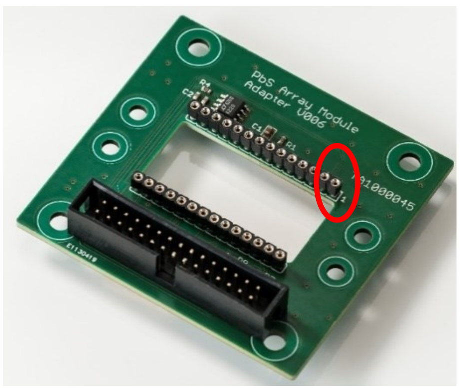

Figure 4: PbS Array Module Adapter board

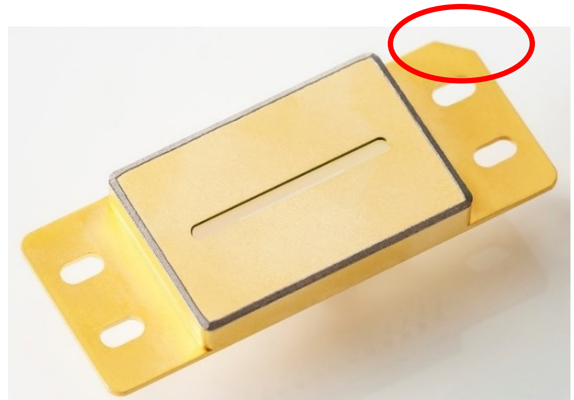

Figure 5: PbS Array Module

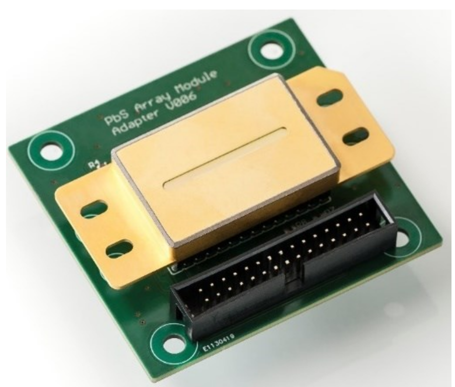

Figure 6: PbS Array Module connected to the Adapter board

If the Array Module should be temperature stabilized the Adapter Board should be prepared with a sufficient heatsink. The heatsink should be attached to the back side of the Array Module with good thermal contact.

The Adapter board needs to be connected with the Ribbon cable provided with the Evaluation Kit as seen in Figure 7. The wire marked with red should be connected to Pin 1 of the Adapter Board.

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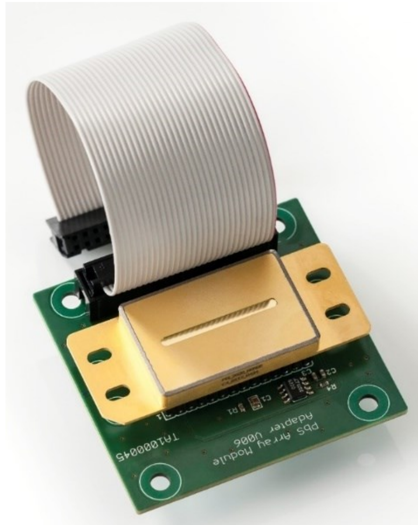

Figure 7: PbS Array Module with Adapter board and ribbon cable

The other end of the ribbon cable can now be connected to the Evaluation Board as seen in Figure 8 As before the red colored wire should be connected to the 1 pin of the Evaluation Board. The first pin on the evaluation board is marked with an arrow on the ribbon cable jack.

Figure 8:Evaluation Board connected via the ribbon cable and the adapter board to the PbS Array Module

When the Electronics are connected properly the USB and the 9V or 12V Power cable can be connected to the board and the USB also to the Computer. With this step the hardware setup is complete.

Figure 9: Fully assembled Hardware components

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3.2. Software

3.2.1. Install Drivers and Software

Please download the “Line Array Module Evaluation Kit – Software” from the following link: https://trinamixsensing.com/eval-kit

Extract the compressed archive and run the “installer.exe”.

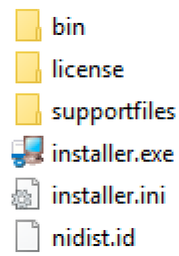


Figure 10: Content of the Evaluation Board software Folder

The installation wizard should prompt a window which asks for a destination Folder for the installation.

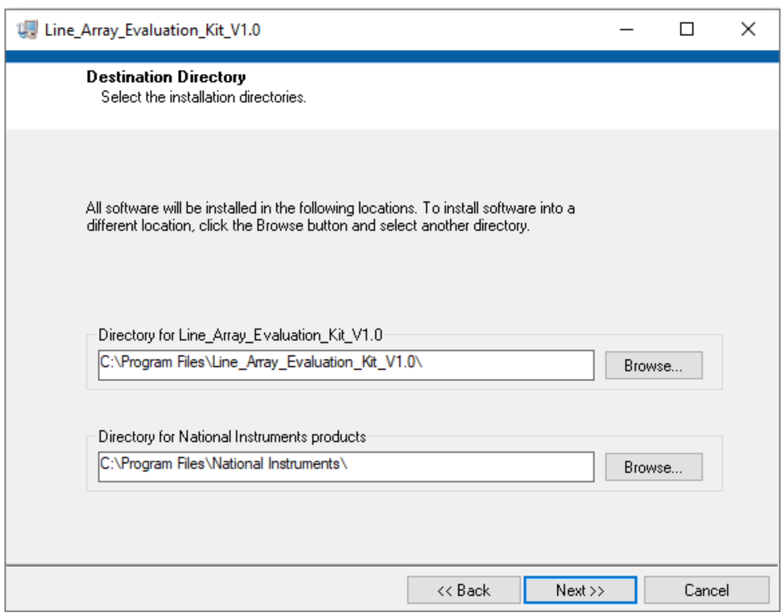


Figure 11: Installation Wizard directory selection window

When pressing the “Next” button the license agreement must be accepted. First the German version is displayed and by scrolling down the English version can be read.

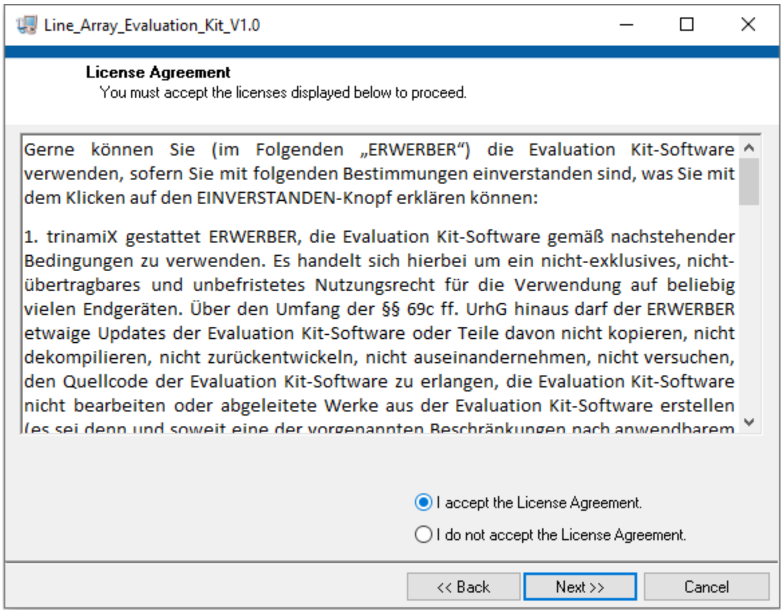


Figure 12: Installation License agreement window

Pressing “Next” after checking the “I accept the License Agreement” checkbox the wizard shows which components will be installed.

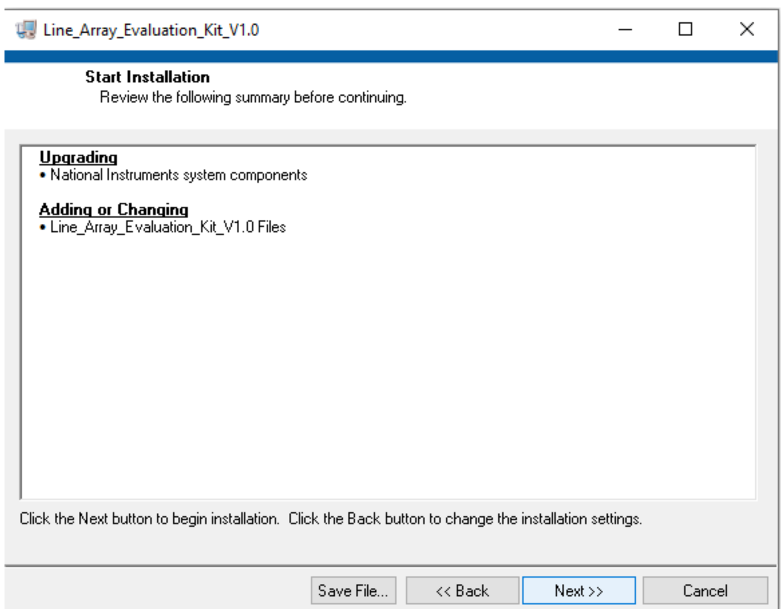


Figure 13: Installation wizard summary window

With pressing the “Next” button again the installation process will be started. This might take a few minutes depending on the Hardware it is installed.

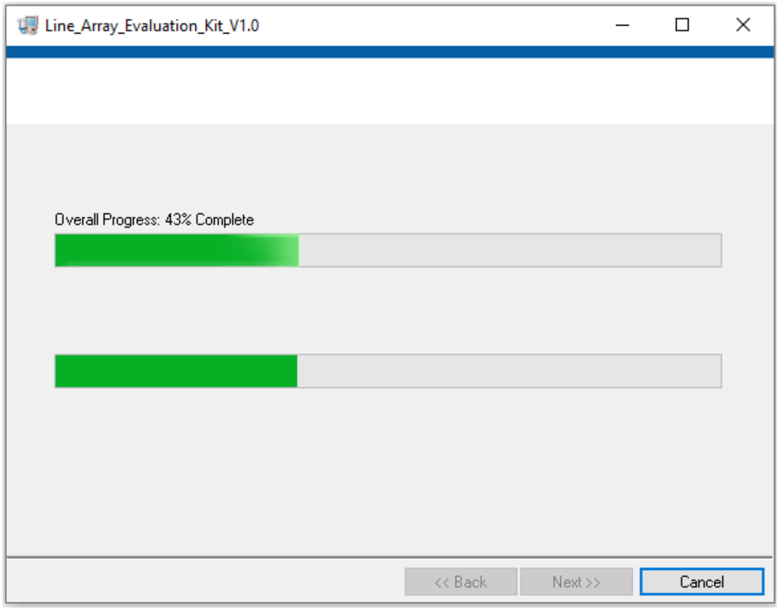


Figure 14: Installation wizard progress window

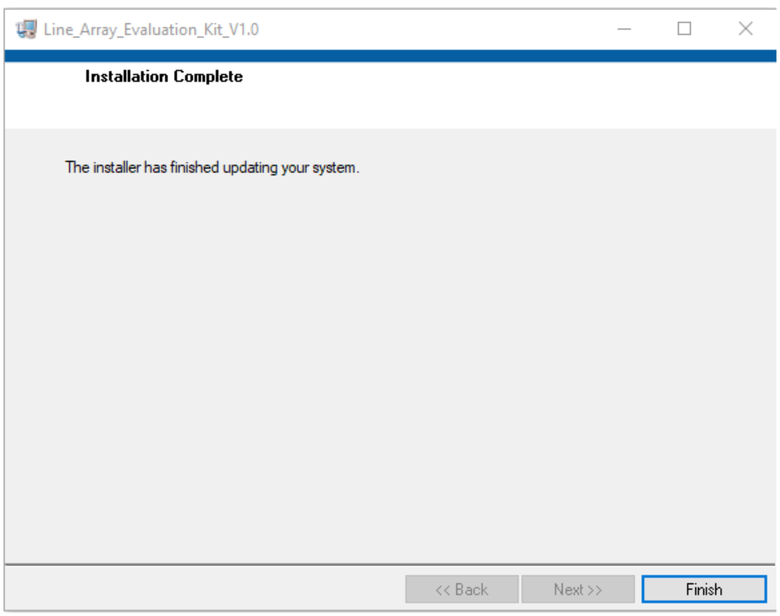


Figure 15: Installation wizard finished window

After the installation is finished the Hardware can be connected as described in Chapter 3.1. and the software can be started.

When powering the Evaluation Kit with the AC/DC converter the Evaluation board should be found in the device manager on your computer. The COM Port number can differ depending on the USB slot used for the connection.

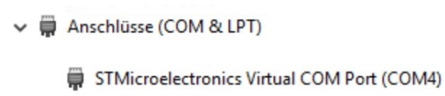


Figure 16: Device Manager Screenshot of the COM Port section

Now the ArrayEvalBoardGUI.exe can be executed. The Screen should look as seen in Figure 17.

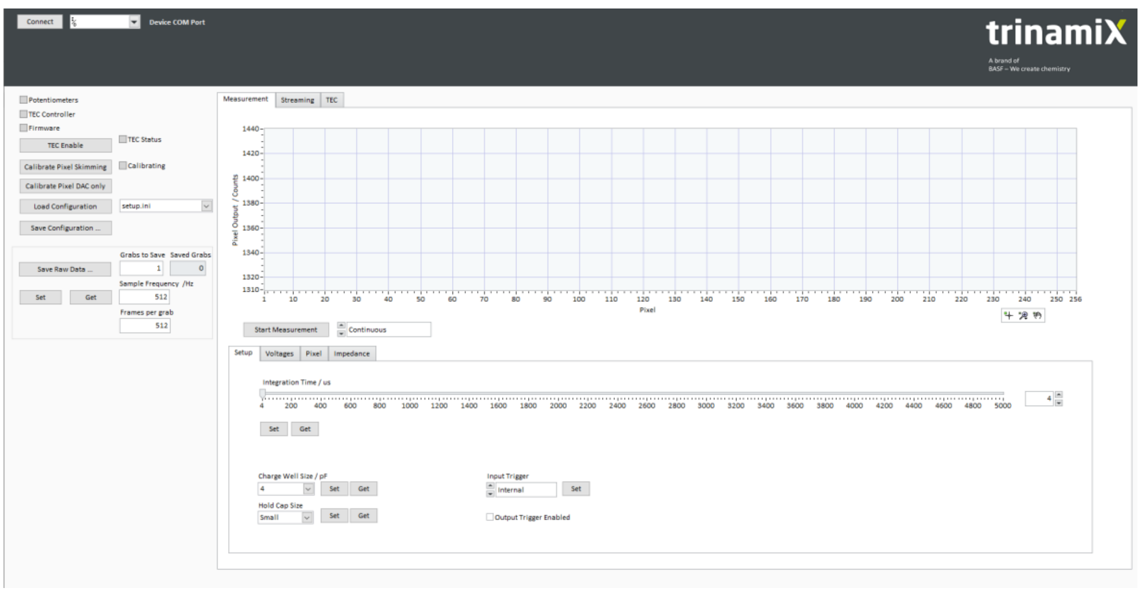
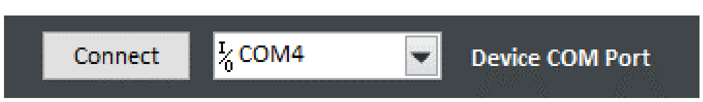


Figure 17: Main screen after starting the ArrayEvlaBoardGUI.exe

In the upper left corner, the Connection dialog is displayed. Choose here the COM Port to which the PbS Array Evaluation Board is connected and press Connect. If no COM port is listed, the port number can also be entered manually. Please refer to the device manager for the correct number.

1.

2.



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3. 

Figure 18: COM Port Connection dialogue

The status indicators for the “Potentiometers”, ”TEC Controller” and “Firmware” should light up in green on the left side of the GUI and the Evaluation Kit is ready to be used.

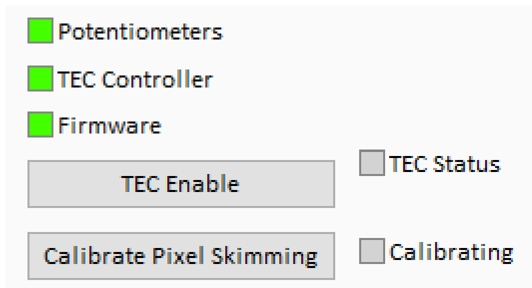


Figure 19: Status Flags for Potentiometers, TEC Controller, Firmware, TEC and calibration

3.2.2. ArrayEvalBoardGUI description

In this chapter the different tabs and dialogues are described to understand the possibilities the Software offers.

The Screen is divided into four sections. Figure 20 shows what section covers which part of the interface.

Section 1 is the connection interface. This part is used to connect the hardware vie the USB port with the Interface as mentioned in 3.2.1Install Drivers and Software.

Section 2 is the initialization interface. In this section all presetting parameter can be loaded. Before starting a Measurement the steps mentioned in 3.3should be followed to provide comparable results.

Section 3 is the save and sample interface. This controls how many samples per second are generated, how many frames a grab contains and how many grabs are saved when pressing the “Save Raw Data”-Button. -Hint: The sample frequency must obey the formula $SF < \frac{1}{t_{int}}$ where SF is the sample frequency and t_{int} the integration time set in the “Setup” tab in the Measurement Window and should not exceed 1024 frames due to timing instabilities.

Section 4 is the data interface. In summary this section shows the information gathered with each frame in some different ways and provides an interface for changing settings during the measurement. A more detailed description is found in the Section: 3.2.2.2 Data interface

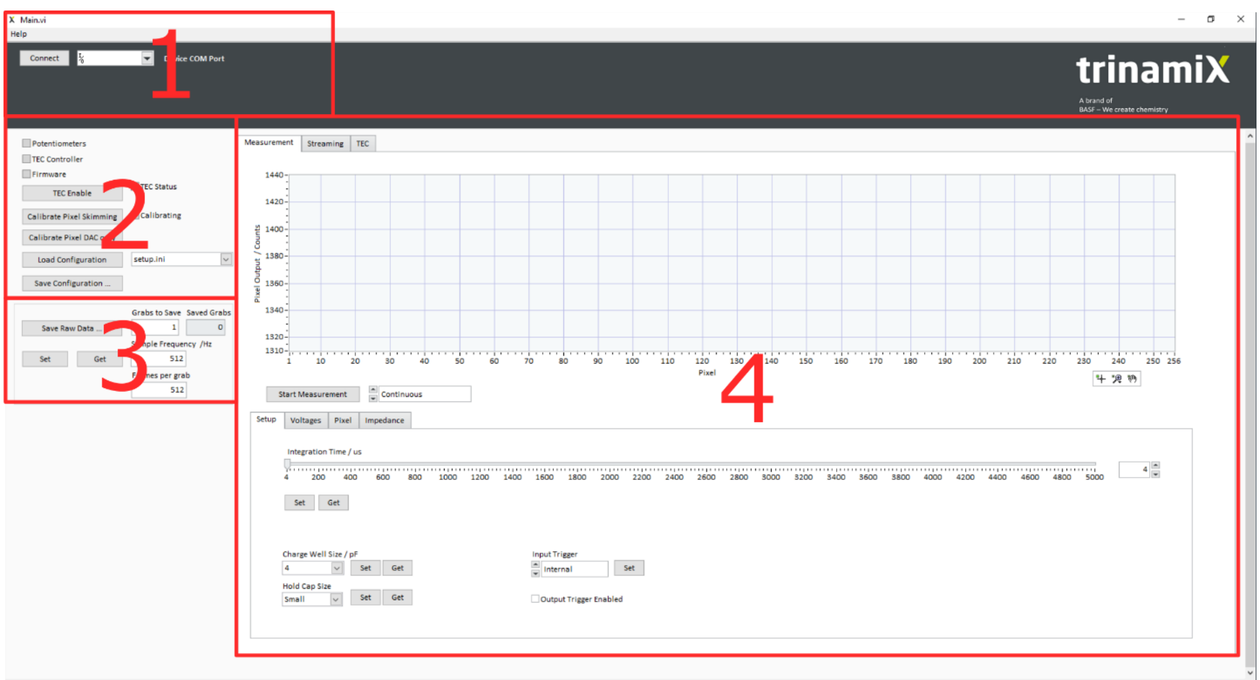


Figure 20: Section View of the Evaluation Board Software

3.2.2.1. Initialization interface

The initialization interface allows you to observe the status of the potentiometers, the firmware and the TEC controller, load some presetting parameters, enable and disable the TEC controller for thermal stabilization of the detector array and gives you the possibility to calibrate the pixels to a target number of counts. After a successful connection with the Evaluation Board the section should look like the left side of Figure 21.

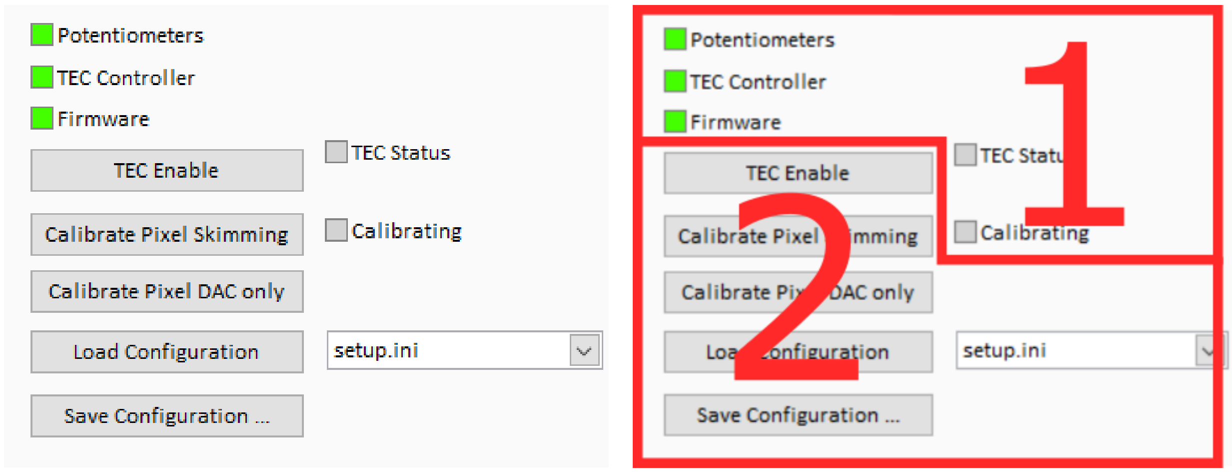


Figure 21: Section: Initialization interface after connecting the Board (left). Section view (right)

In the Section view of Figure 21 the initialization interface can be divided into 2 subsections:

Section 1: Status Flags:

Gray: Status bit is not set

Green: Status is set to "OK"

Red: Status is set to "Failure"

Yellow: Status is set to "Busy"

Section 2: Buttons:

TEC Enable/Disable Button: This button switches the TEC controller ON/OFF indicated with the TEC Status Flag and the Text on the Button. – Hint: The Text on the Button shows the status the Controller reaches when pushing the Button this means if the text displays "TEC Enable" the TEC is disabled.

Calibrate Pixel Skimming: This button performs a per pixel skimming which means that the Digital Potentiometer values which provide the DAC VH and DAC VL voltage are set, so that the minimum and maximum dark current can be subtracted. After this the current of each individual pixel is set via the pixel digital-analog-converter (DAC). This should result in a flat line on the "Pixel Output" at the desired "Skim Target" value. If some pixels cannot be pulled to the desired value, the algorithm marks the pixel as dead. During a calibration the "Calibration" status flag changes to yellow to indicate that the process is running.

Calibrate Pixel DAC only: This button does mainly the same as the Calibrate Pixel Skimming button except it leaves the DAC VH and DAC VL values untouched.

Load/Save Configuration: These buttons are used for the preset setup dialog. It loads/saves the settings for the parameters used to run the detector in/from the folder C:\Program Files\Array_Evaluation_Kit_V1.0\Files. The setup file that is loaded can be selected via the drop-down menu on the right side. This menu searches the mentioned folder for *.ini files and displays them.

3.2.2.2. Data interface

The Data interface is divided into 3 sub windows as seen in Figure 22. Each sub window shows another aspect of the data that can be generated with this evaluation software to understand how the detector array is working and what it is capable of.

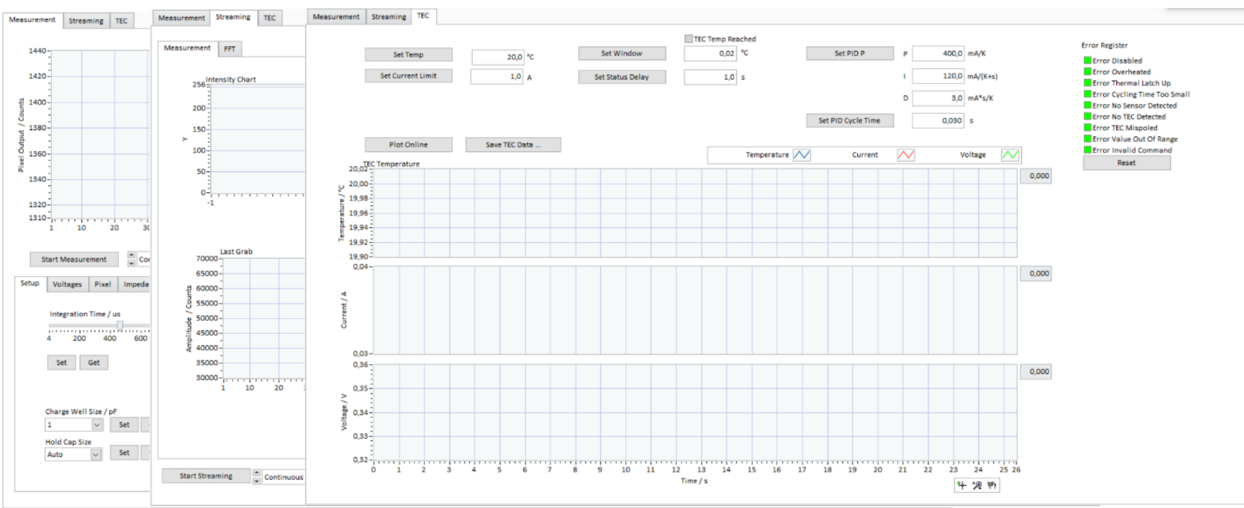


Figure 22: 3 Subwindows in the Data interface overlapped over each other

The measurement sub window can be divided into the sections as seen in Figure 23. The first section is mainly a graph that displays the raw data values of a frame. This can be done continuously or by collecting a single frame. By pressing the “Start Measurement” button the Software collects either one frame (Single Frame mode) and stops or collects 1 frame every second (Continuous mode). The Graph can be saved by right-clicking into the graph and choosing “Export” and a preferred export functionality (clipboard/excel/image).

Figure 23: Measurement sub window, divided into 2 sections

The second section shown in Figure 23 is the settings section used for changing settings by the firmware. This section has 4 Tabs. The first tab is the "Setup" tab shown in Figure 24. In this tab the main amplification Settings of the ASIC can be changed. The integration time and the charge well. A formula to calculate the amplification is provided in the chapter 4 Physics and algorithms.

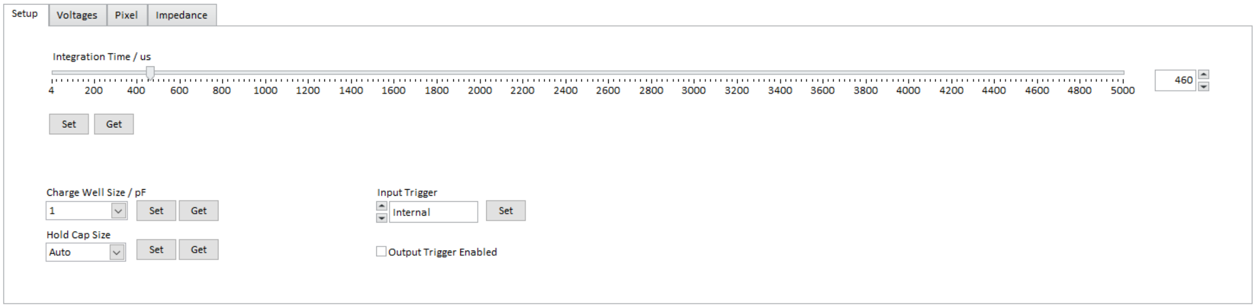


Figure 24: Setup tab in the Measurement Window

The next tab in the settings section is the "Voltages" tab. The tab is shown in Figure 25: Voltages tab in the Measurement Window This tab allows to adjust all voltages that are generated on the Evaluation Board and used for the detector array.

The Bias Voltage allows to change the relative signal on the output but after changing this value a new calibration is needed.

The G Skim Voltage is used to reduce the current on the input off the readout IC that reads the detector array. This value should only be used if the detector array is expected to have low impedance (maybe due to thermal reasons) or a large amount of incident light.

The Skim Target value is the value that sets the target for the calibration algorithm. Depending on the working parameters the value should be chosen between 15 000 and 25 000. The number of counts can be converted to the respective ADC (Analog-Digital-Converter) value with the conversion factor of 16 000 Counts/V.

DAC VH/DAC VL voltages are values which are adapted via the calibration algorithm to provide the optimal range of the pixel DACs inside the detector array. These values depend on the impedance and the temperature of the detector array, the incident light during calibration, the bias voltage, integration time and charge well. They normally should not be changed manually.

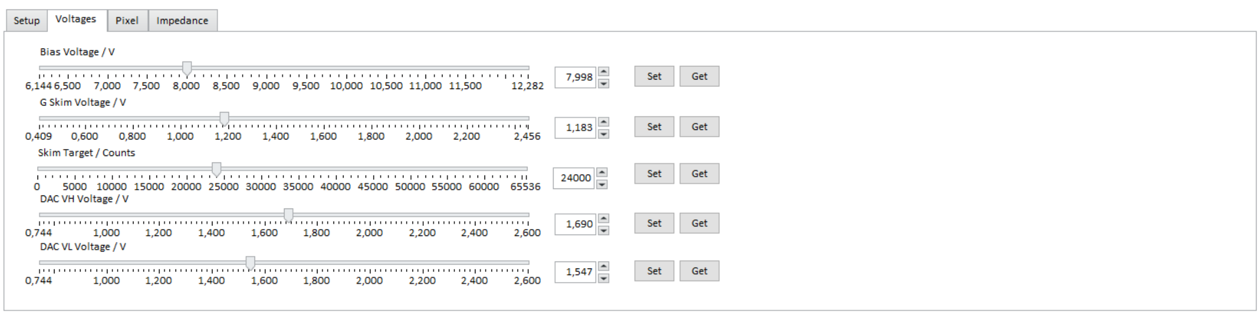


Figure 25: Voltages tab in the Measurement Window

The Pixel Tab Figure 26 is used to see how many pixels are marked as “dead”, and the bad pixel map that saves the current state of dead pixel flags for every pixel. The checkbox for “Activate Dead Pixel Averaging” is used to control then handling of bad pixels by the firmware. If the checkbox is active, the mean value of the neighbouring pixels that are marked as alive will be used to interpolate the value for the dead pixel. If it is unchecked the value will be the measured (and likely erroneous) value of the pixel.

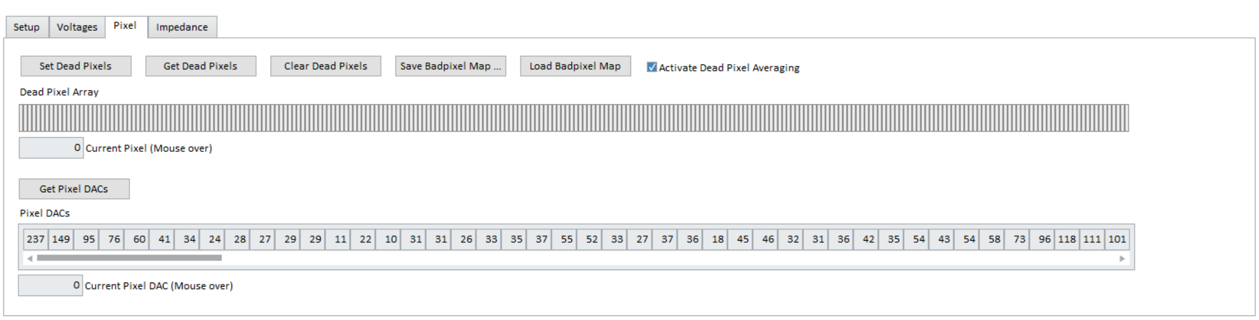


Figure 26: Pixel tab in the Measurement Window

In Figure 26 also a table with the name “Pixel DACs” is shown. This table shows the values of the DACs on the read out IC in the detector Array that where set by the firmware after calibration. When the IC is powered the DAC values are in an arbitrary state and need to be filled with values to get reasonable results out of the detector array. The information which DAC value was last send to the IC can be retrieved with the button “Get Pixel DACs”.

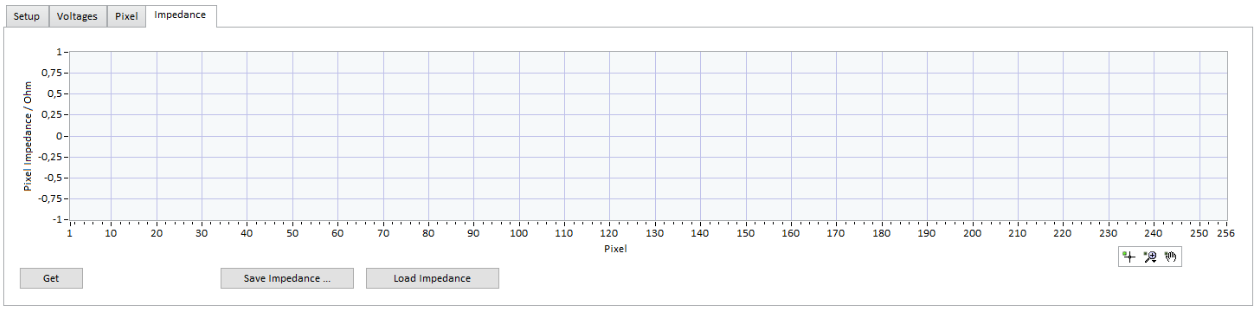


Figure 27: Impedance tab in the Measurement Window

The Impedance tab as shown in Figure 27 can be used to estimate the impedance of each pixel. To get the impedance the button “Get” can be used. Values generated with this estimation can be saved with the “Save impedance” button. Previous measurements can be loaded with the “Load Impedance” button.

The next part describes the “Streaming” window.

The “Streaming” window is divided into 2 tabs. The first tab can be seen in Figure 28, the measurement tab. This tab is divided into 2 charts. The chart labeled with “intensity Chart” shows a false color intensity chart which plots pixel intensity versus frame number. The chart labeled with “Last Grab” shows a graph which shows the last frame of a grabbed package and the calculated minimum, maximum and mean value and standard deviation of the whole data package. In the bottom left corner the button “start streaming” can be used to perform a measurement. This measurement can be performed as continuous or single grab. The single grab takes one package as defined in Section 3 of Figure 20. With the continuous streaming the software will perform indefinite grabbing and plotting of live data.

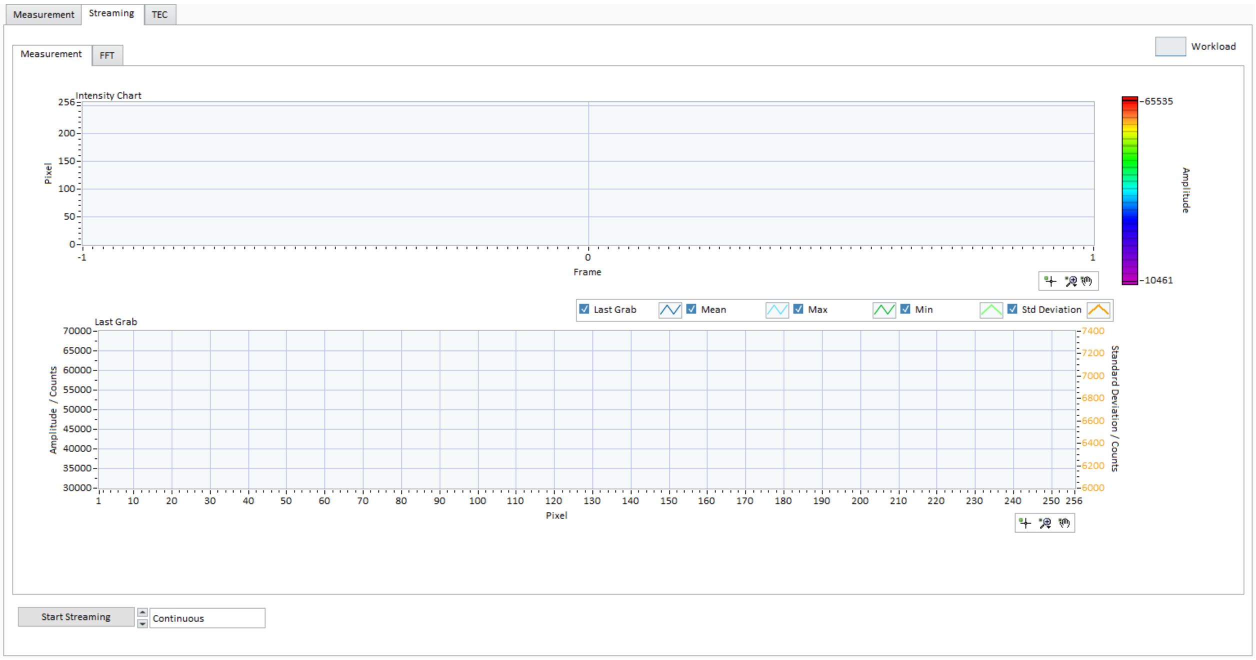


Figure 28: Streaming window

This tab shows two graphs and various settings. The tab Figure 29 is mainly for calculation purposes and shows now longer raw data. Here the grab will be processed with a fast Fourier transformation algorithm and its respective settings. The graph with the title "Amplitude (rms) – Frequency of one selected Pixel" shows a Fourier transformation graph of the grabbed frame block, i.e. the amplitudes (root mean square) of each frequency to reconstruct the signal gathered during the grabbed block.

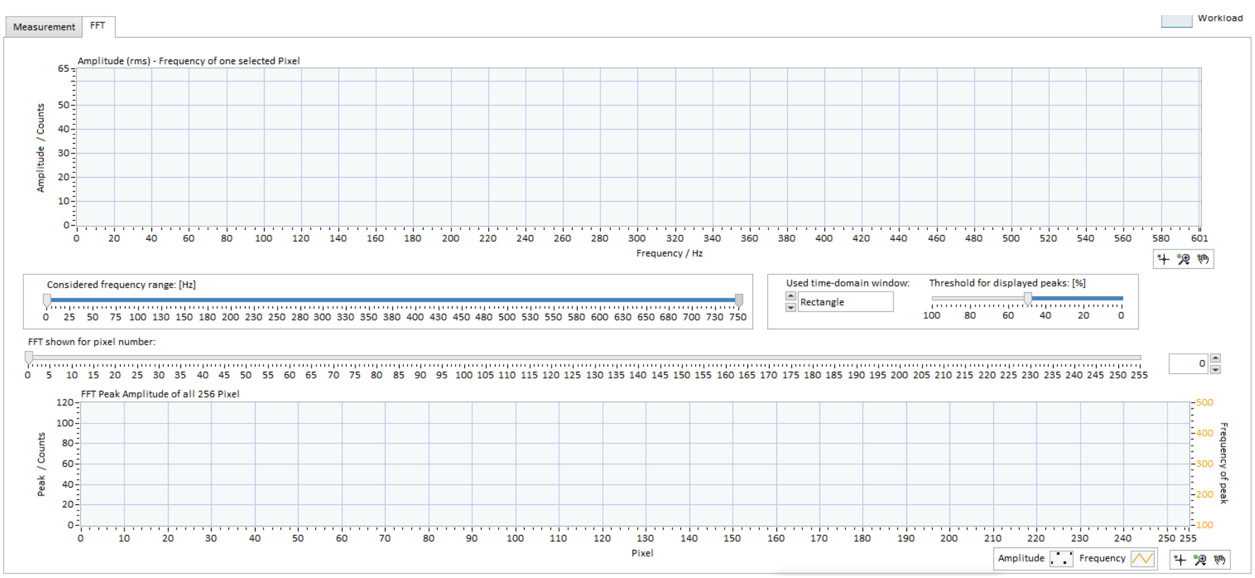


Figure 29: FFT Tab in the Streaming window

The Graph with the label “FFT Peak Amplitude of all 256 Pixel” shows the highest amplitude value of each pixel of the most significant peak below the threshold value. This is used to get a more detailed view without the high values caused by the DC component of the signal at 0 Hz. Why this is used will be explained in the section 4 Physics and algorithms. The slider with the title “Considered frequency range” is used to fit the Frequency axis in the “Amplitude (rms)” graph to the desired frequency range that might be observed. The dropdown menu with the title “Used time-domain window” is a preselection of windows used for signal processing. The description of these windows and when to use is not a topic of this manual.

The Slider with the title “Threshold for displayed peaks” defines a threshold for the peak that is displayed in the “FFT Peak Amplitude of all 256” Graph.

With the slider with the title “ FFT shown for pixel number” a pixel for the “Amplitude (rms)” graph can be selected.

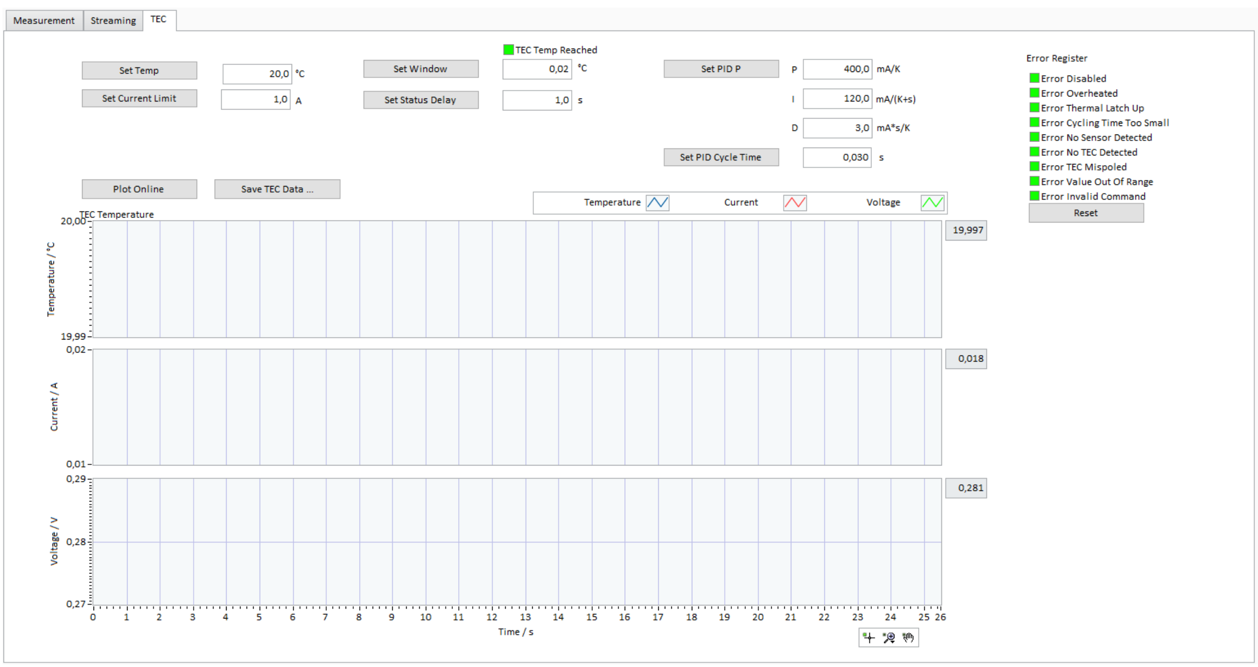


Figure 30: TEC Window

The TEC window supplies all information the TEC controller needs and sends back to the interface.

In the upper third the various parameters can be set to control the TEC.

The “Set Temp” button sets the temperature the controller tries to reach. Allowed values are between 5°C and 40°C. (Hint: If the Controller should stabilize to a value other than room temperature it is recommended to provide a sufficient heatsink for the array. Otherwise the controller will go into error state since if it cannot stabilize at the desired target temperature.)

The Current Limit can be set from 0.2 to 1.5A

The Temperature window can be set from 0.001 to 32 K

The status delay can be set from 1 to 32000 s

The P Value of the PID loop can be set from 0 to 100 000 mA/K

The I Value of the PID loop can be set from 0 to 100 000 mA/(K+sec)

The D Value of the PID loop can be set from 0 to 100 000 mA*s/K

The cycle time Value of the PID loop can be set from 0.001 to 1s

On the right hand side the status bits for the Error register of the TEC Controller are shown. These error bits should provide a fault indication, for example if the heatsink is insufficient and the TEC goes into a thermal latch up. These registers must be reset if an error occurred and the controller should start up again

The three plots in the lower part provide an overview of the parameters that the controller measures. The first graph shows the actual measured temperature.

The second plot is showing the current that the controller sources to the TEC Element. This information together with the third Graph (applied voltage to the TEC Element) can be used to monitor if the PID values are set good enough for the test or if there are problems getting the heat away (e.g. heatsink is warming up, no stabilization, large over- and undershoots).

For a first trim of the PID parameters the Ziegler-Nichols method can be applied.

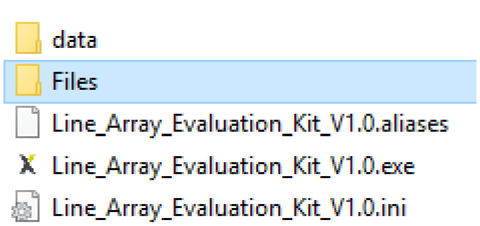
3.3. Getting started

This chapter gives a short description on what to do when starting the Software for the first time.

It is recommended to first read the information provided in Chapter 4 Physics and algorithms before proceeding further.

3.3.1. Configuration

Before starting any kind of measurement a configuration must be loaded. The software loads, after connecting with the hardware, the parameters stored in the setup.ini file.



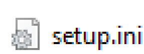


Figure 31: File structure of the Array_Evaluation_Kit folder.

This file is prefilled with reasonable start parameters. When optimizing any value for the TEC or the measurement these can be stored with the “Save Configuration” button.

When loading a configuration, the file must be preselected via the dropdown menu. This dropdown menu shows only the *.ini files that are stored in the folder “Files”.

After pressing Load Configuration the settings are written in all registers an send to the detector array

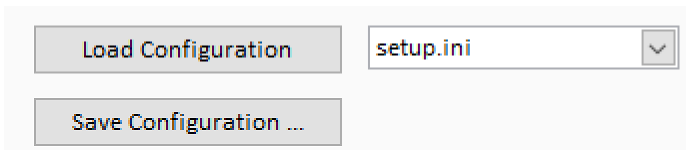
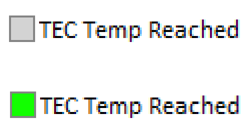


Figure 32: Load/Save Configuration dialog

3.3.2. Temperature management

This chapter describes how the detector array can be thermally stabilized with the supplied components.

First the TEC must be enabled by pressing the button “TEC Enable” as shown in Figure 21. After the TEC status indicator changed to green the TEC controller tries to reach the temperature set in the TEC window Figure 30. When switching to this window the TEC Temperature, current and voltage can be observed to see whether the controller settings work properly or the PID Values or the heat sink should be optimized. By pressing the “Plot Online” button the values can be observed as shown in Figure 33. The status indicator “TEC Temp Reached” will change to green when reached the temperature window set by the “Set Window “ button for at least 5 seconds (Figure 34).



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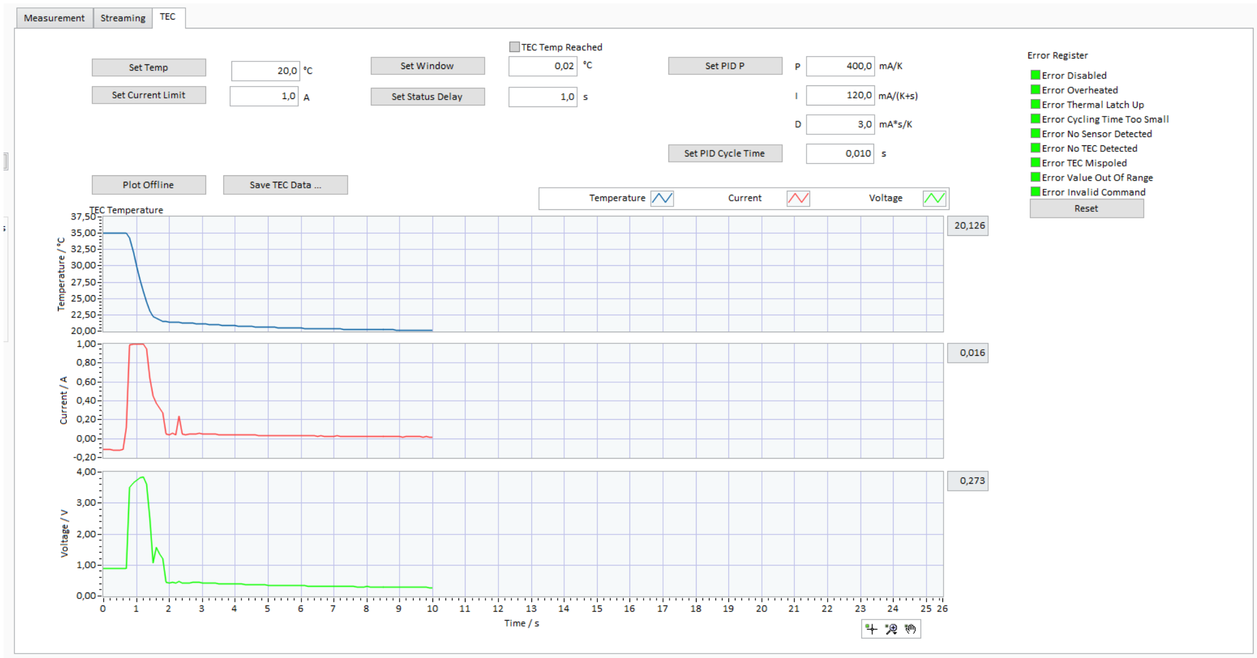

Figure 33: TEC window after pressing "Plot Online" and enabling TEC

Thermal stabilization is necessary to avoid signal drifts induced by temperature changes during the measurement. Therefore the parameters for the PID Controller should be optimised to provide a stable operation in the desired temperature regime.

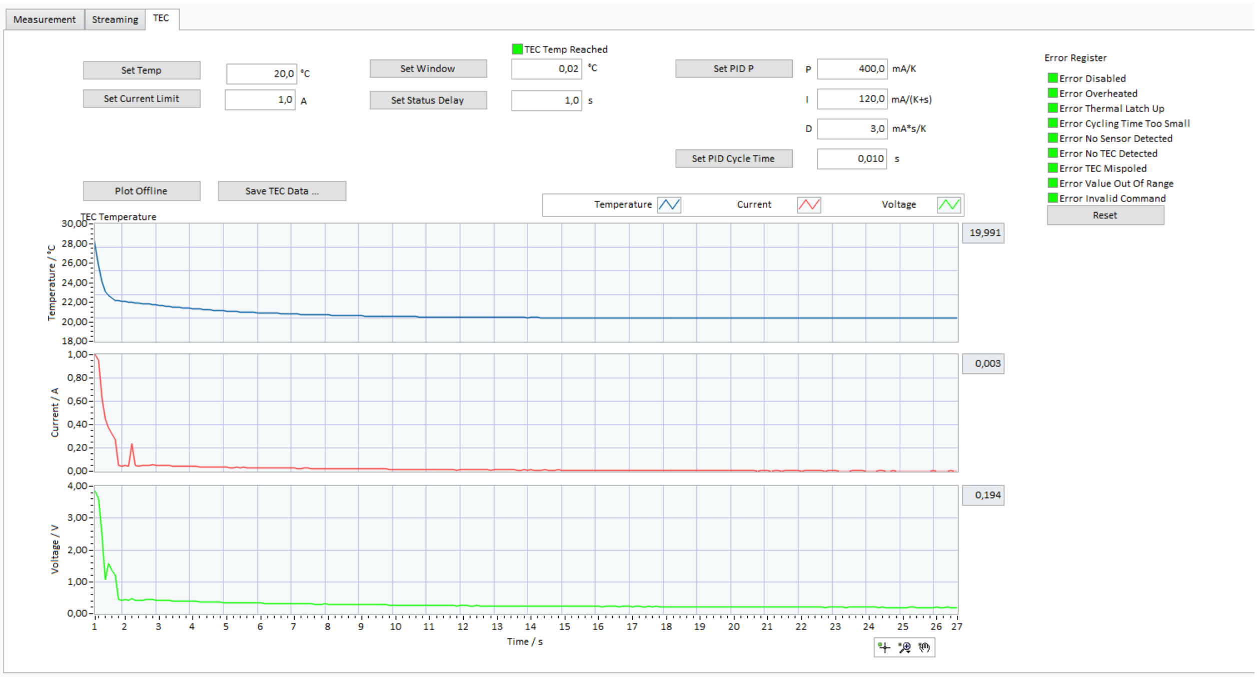

Figure 34: TEC window after TEC has stabilized

When the status bit of the "TEC Temp reached" lights green, the next steps can be followed to start a measurement.

3.3.3. Calibration

The calibration is necessary to establish a baseline as starting point before any measurement. If a measurement is performed without calibration the results can be seen in Figure 35: Measurement after startup without calibration. The Pixel values are all pinned to the maximum Value of the ADC, even without any incident light.

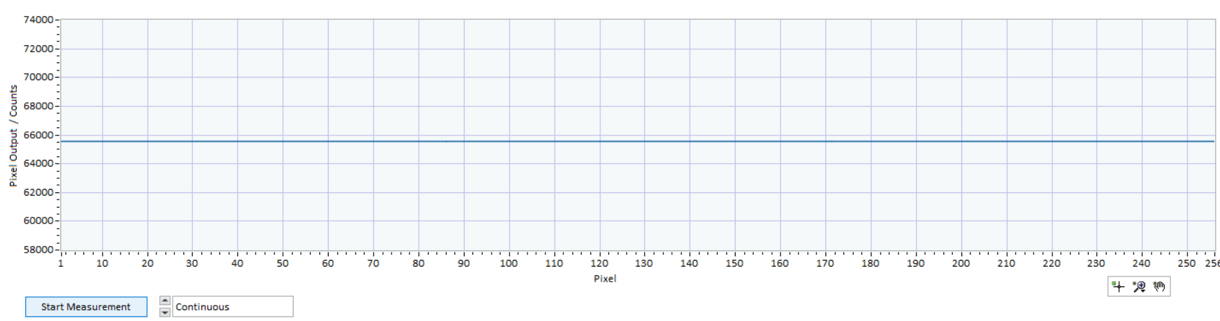

Figure 35: Measurement after startup without calibration

Before calibrating the pixel skimming the detector should covered to block any incident light. Otherwise the skimming might fail or an unwanted offset is calibrated into the skimming.

Then the “Calibrate Pixel Skimming” Button can be pressed. After pressing the button, the “Calibrating” status flag changes to yellow during the calibration cycle and turns off when finished.

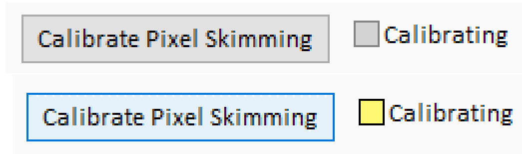

Figure 36: Calibrate Pixel Skimming

When a Calibration ended successfully a measurement should look like Figure 37. The mean value of a measurement after skimming should be around the “Skim Target” Value (Figure 25).

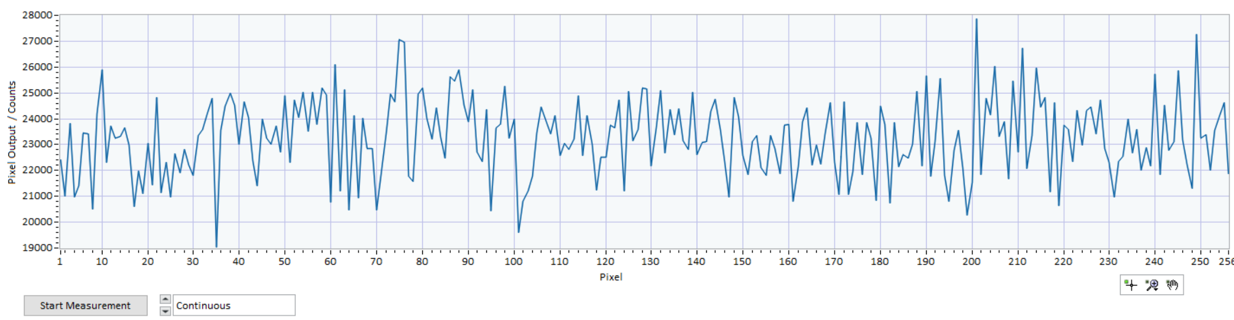

Figure 37: Measurement after successful calibration of the pixel skimming

3.3.4. Measurement

This chapter explains how a measurement can be performed and what the different Graphs in the software show at different situations.

After Pressing the “Start Measurement” button in the Measurement window the graph will show the values collected by the firmware as seen in Figure 37. This Measurement can be switched to be “continuous” or “single frame”. The Continuous measurement shows measurements with a framerate of about 10 Frames every second until stopped.

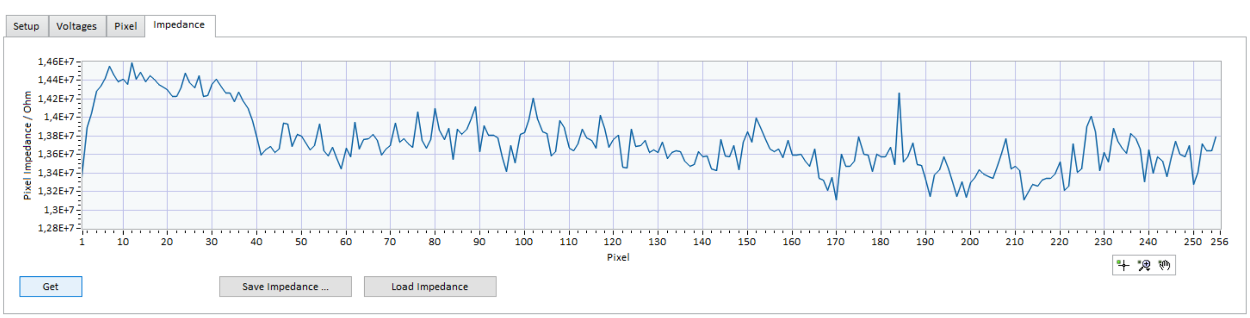

Figure 38: Impedance tab with an example impedance measurement

Figure 38 shows an impedance measurement performed by pressing the “Get” button in the impedance tab in the measurement window. The Impedance is calculated internally by the firmware and can be saved with the “Save Impedance…” button. This measurement helps to calculate the amount of current the read out IC collects during a measurement. The current can be used to determine the best amplification for a given operation point as described in Equation 3 in Chapter 4. Physics and algorithms

Figure 39: Streaming measurement in the measurement tab with example measurement

Figure 39 and Figure 40 show measurements performed in the streaming window. The collected samples are shown in the Intensity Chart and the last frame together with the min, max, mean and standard deviation values of all frames and pixels are shown in the Last Grab chart. The FFT Graph shows more or less the noise of the detector array and the readout system if no or unmodulated light falls onto the detector.

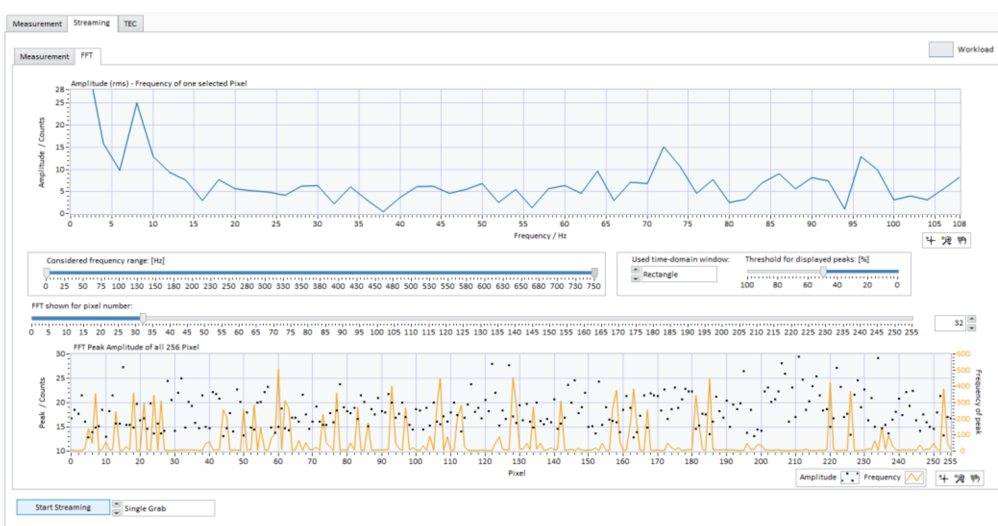

Figure 40: Streaming measurement in the FFT tab with example measurement

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When applying a modulated infrared light source, such as an incandescent lamp modulated with the AC voltage of the mains power socket, the variation of intensity will become visible. In Figure 41 the Intensity chart shows a periodical change in color and the Last Grab chart shows a change in the min, max, mean and standard deviation values.

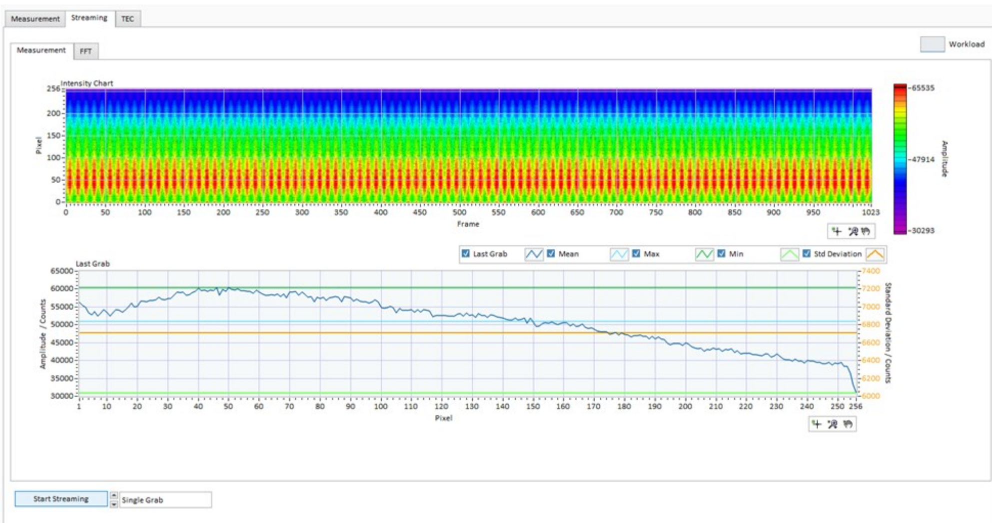

Figure 41:Streaming Measurement with modulated light source

When looking at the FFT the modulated frequency can be seen. In this case the light source was modulated with 100Hz as the peak in the Amplitude(rms) graph indicates and this can be seen on every pixel as indicated by the FFT Peak graph. Every Pixel has its detected peak at the frequency 100Hz.

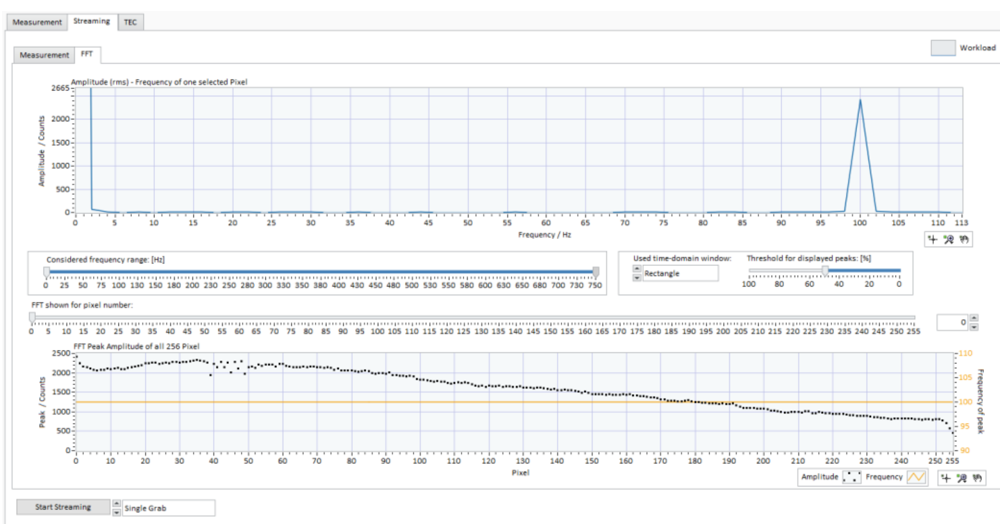

Figure 42: Streaming measurement in the FFT tab with modulated light source

4. Physics and algorithms

4.1. Photoconductor Theory

A photoconductive detector is a detector that reduces its resistance when illuminated. In case of a PbS Photo resistor the resistance changes when illuminated with infrared radiation. This response is variable with the wavelength, the frequency of light modulation, detector temperature and applied voltage (bias voltage).

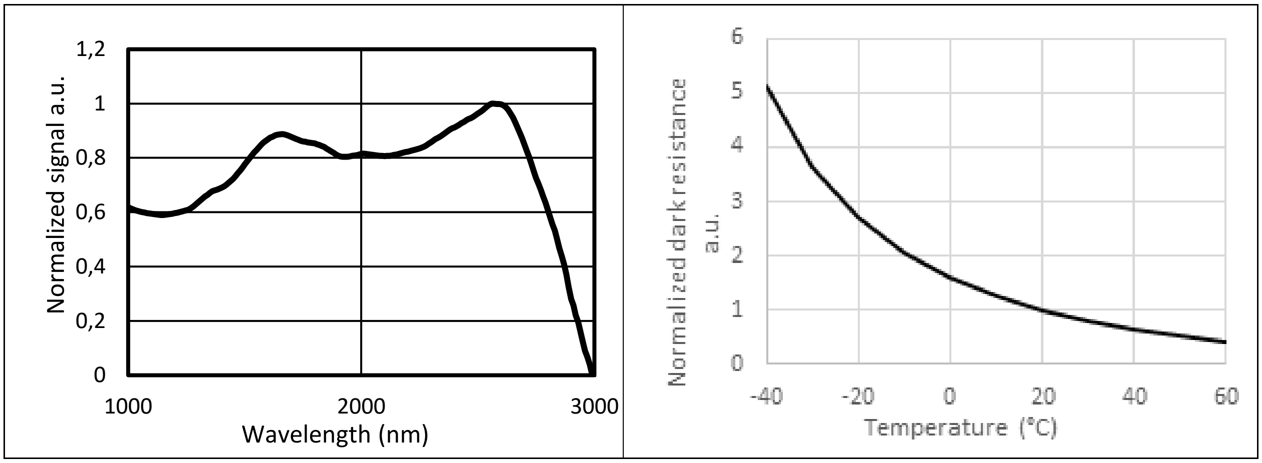

Figure 43: Dependency of photoresponse vs. wavelength and dark resistance vs. temperature (PbS)

In other words, the current flowing through the photoresistor changes with bias voltage, illumination and sensor temperature.

The noise of this type of sensor is mostly limited by the 1/f noise. This means at low frequencies the noise increases and therefore it is suggested to use this sensor with modulated light sources. Depending on the detector material, the frequency cutoff of the photoresponse occurs at several 100 Hz. One needs to bear in mind that the frequency of the full system (detector, read-out-electronics, ADC converter) needs to be considered when choosing a suitable modulation frequency. In the case of the array module, modulation frequencies between 10 and 100 Hz are recommended.

The most common circuit in which photoresistors are used is the voltage divider (Figure 44) that is AC coupled with a voltage amplifier. This circuit requires a modulated light source because only the AC component of the signal can be monitored at the input of the amplifier.

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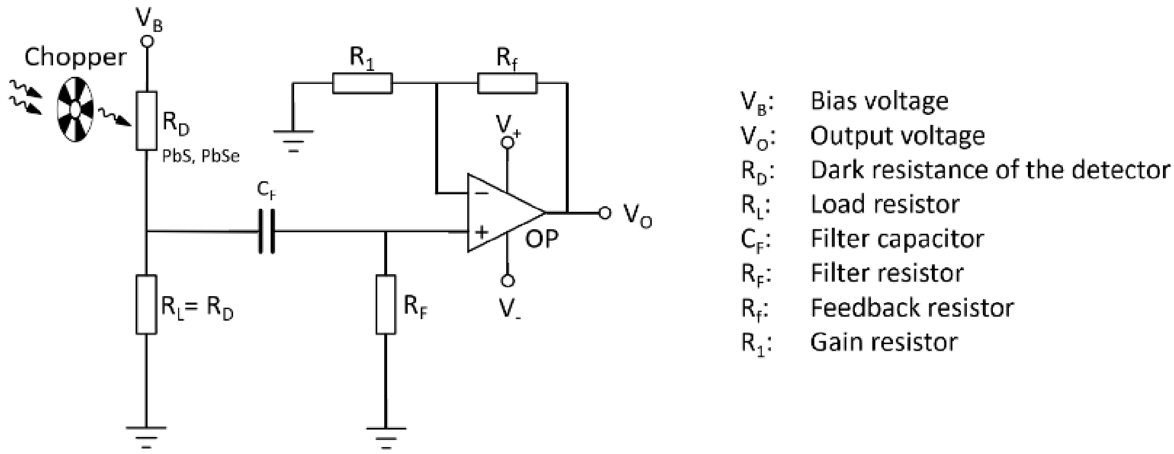

Figure 44: Exemplary circuit for PbS detectors

$$I_D = \frac{U_B}{R_D} \qquad \text{Equation 1}$$

In this circuit it is necessary to AC couple the amplifier because the signal current compared to the dark current is different by a factor of several magnitudes. AC coupling ignores the DC dark current and therefore increases the Signal to Noise ratio of the measurement.

However, this is not the preferred mode of operation for line arrays due to their inherent pixel-to-pixel impedance variations.

The readout IC for the detector array is a buffered direct injection circuit that compensates the dark current coupled with a current integrating circuit and a buffer. This allows the compensation of the dark current for every individual pixel and integrates the signal current over a specified time. More specific details are described in the next subchapter

4.2. Read Out model

The read-out IC used in the detector array is an analog multiplexing current integrator. A schematic of one channel can be seen in Figure 45. This circuit has a part that compensates the dark current of the pixel using global and/or per pixel skimming. The remaining signal current is fed into a integration circuit that integrates the current for the time defined by the integration clock. This signal is transferred to a hold capacitor and fed into a buffer cell that holds the value till the read out is performed.

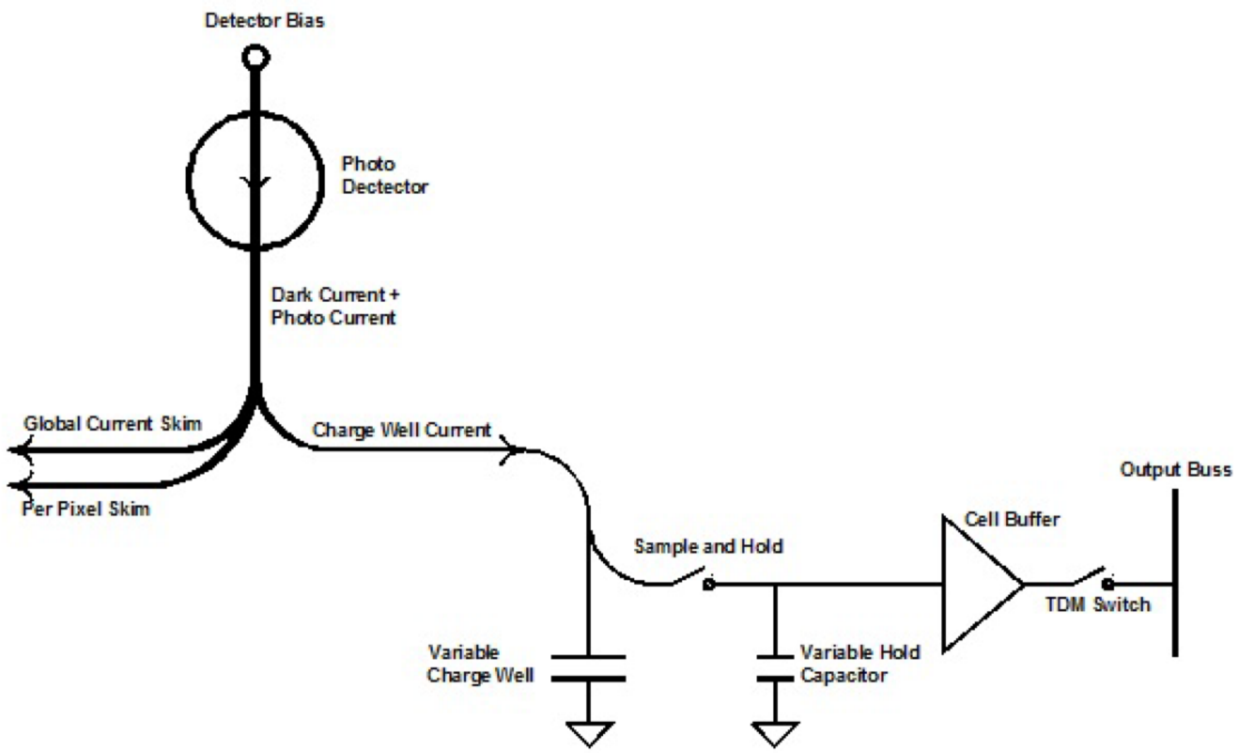

Figure 45 Schematic of one channel of the read-out IC

4.3. Skimming algorithm

With the skimming algorithm the different dark resistances can be accounted for by subtracting the individual pixel dark currents.

The skimming algorithm tries to find DAC VH and DAC VL values in which the detector array can be operated. Then it performs a pixel DAC skimming with an iterative I-Controller so that all pixel output values are within an accepted window of the configured target value. The pixel current and its components are described in Equation 2.

$$i(pixel) = \frac{DAC(pixel)}{255} * (\mathrm{DAC_{VH}} - \mathrm{DAC_{VL}})$$ *Equation 2*

After a successfully performed skimming the values of a measurement without signal should be around the target voltage otherwise the array might not be thermally stable, or the illumination has changed during or after the skimming.

4.4. Amplification

The amplification of the circuit can be calculated via Equation 3.

$$A = \frac{t_{int}}{C_{well}}$$ *Equation 3*

Where t_{int} is the integration time and C_{well} is the charge well capacitor value. This implies that the output signal can be improved by changing these parameters.

The output voltage can be calculated via the formula Equation 4 and converted to ADC counts via the factor $16\ 000\ \frac{Counts}{V}$

$$V_{ADC} = \frac{t_{int}}{C_{well}} * i_{signal} * \frac{C_{well}}{C_{well} + C_{Hold}}$$ *Equation 4*

5. Application example

The detector array is built to detect infrared radiation and provides spatial resolution. This can be used for example in spectrometric applications, where the incoming radiation is split into its components and spatially separated.

Figure 46 shows an exemplary setup of a spectrometer. The light source (1.) might be an incandescent lamp, between is a wavelength sorting element (2.), e.g. a transmission grating or some kind of filter, and after that a detector array.

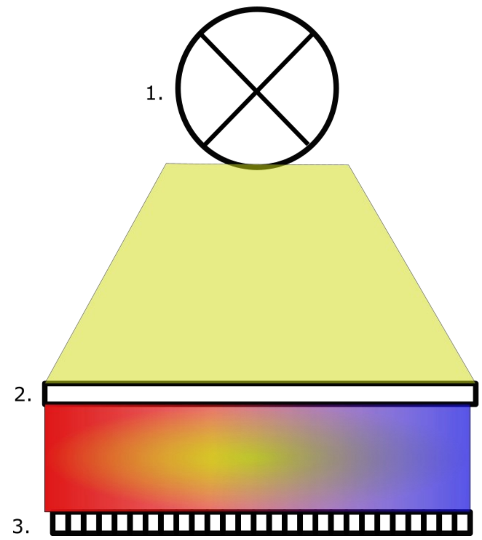

Figure 46: Exemplary setup of a spectrometer

In Figure 47 a measurement of such a setup can be seen. The light source was modulated with 100Hz and the detector response shows a continuous signal like expected by a black body radiator.

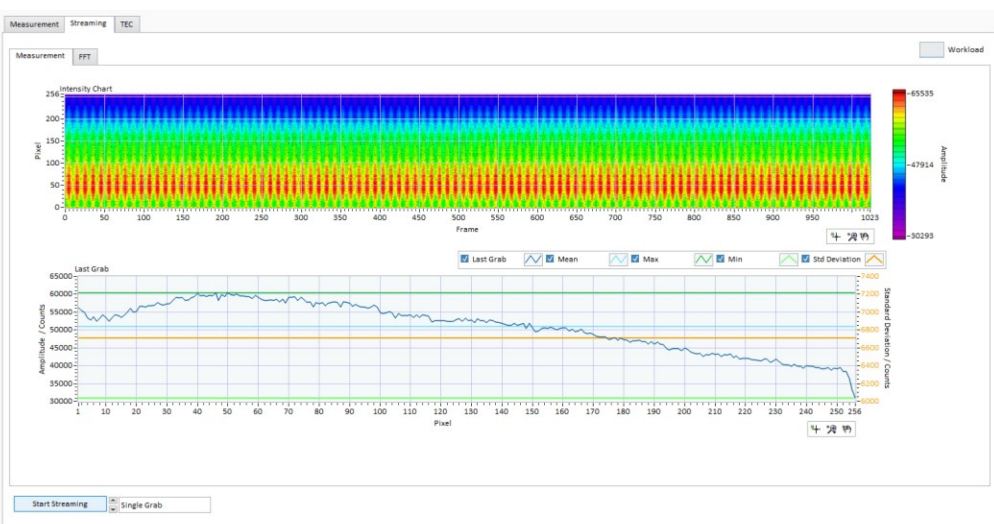

Figure 47: Measurement of incandescent Lamp with wavelength splitter in between.

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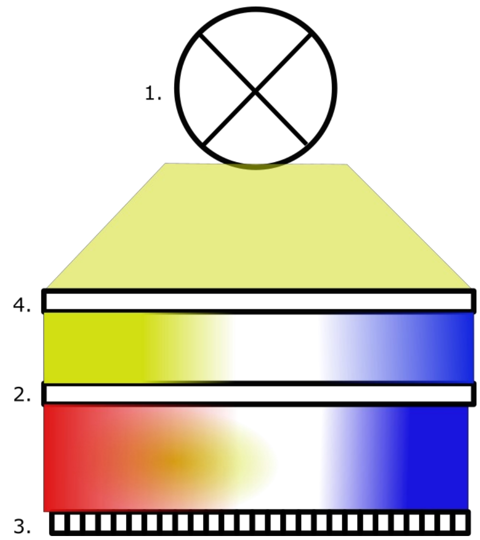

Figure 48: Exemplary setup of a spectrometer with sample in between

Figure 48 shows the same setup but with a sample (4.) in between. If a measurement is performed with this settings, a difference in the detector response can be observed. This time the signal shows spectral information relating to the absorption characteristics of the sample.

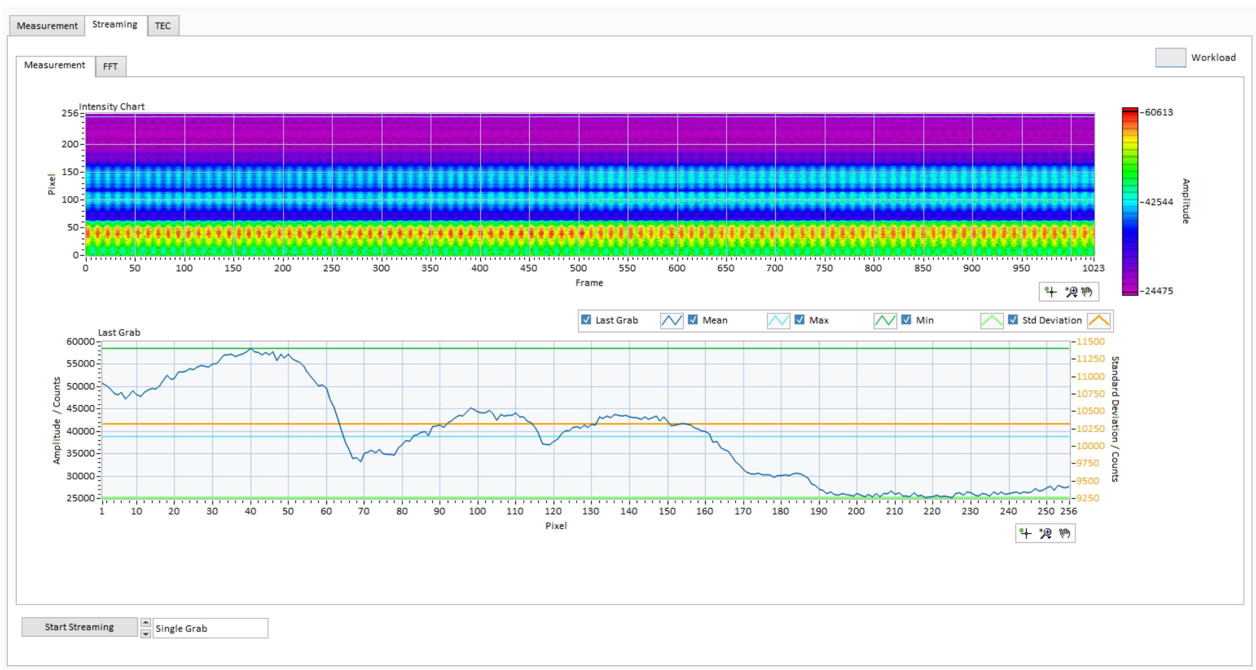

Figure 49 Measurement of incandescent Lamp with wavelength splitter and sample in between

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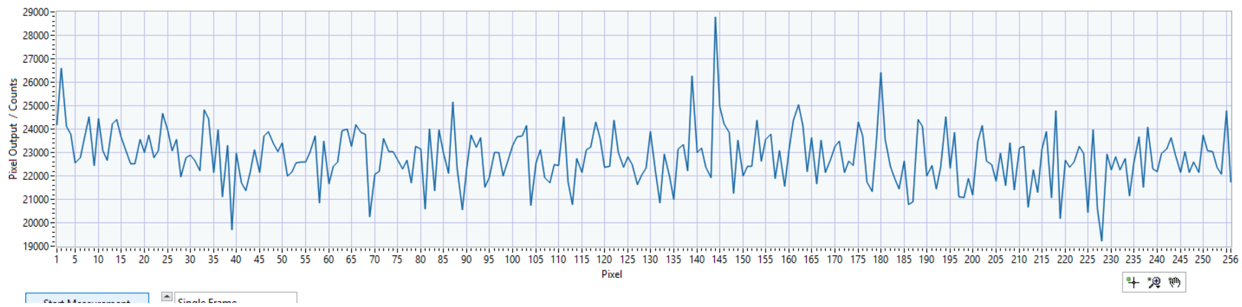
6. Appendix

6.1. Error Register

6.1.1. Skimming

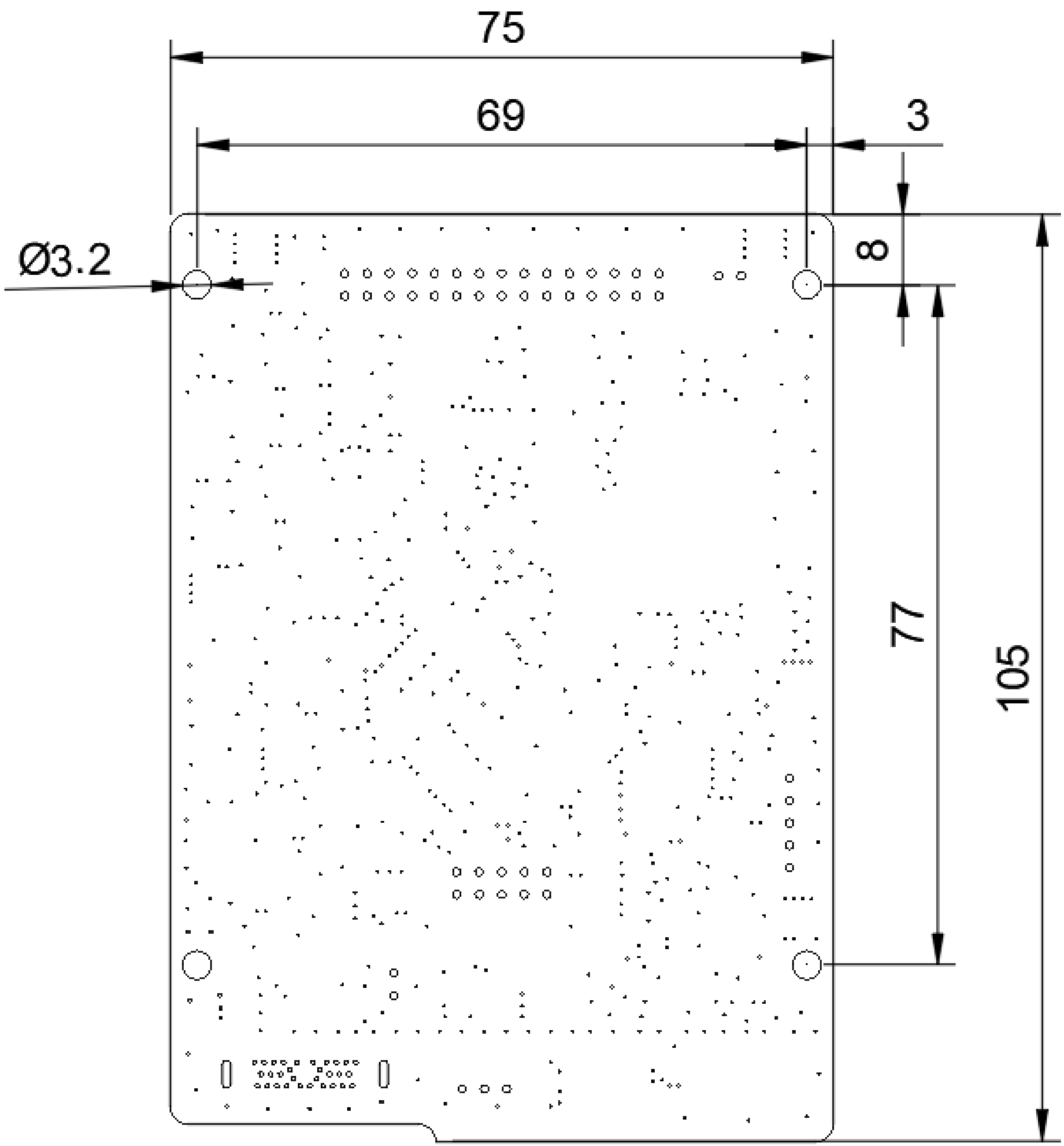
After skimming is performed the Software output of the should look like this:



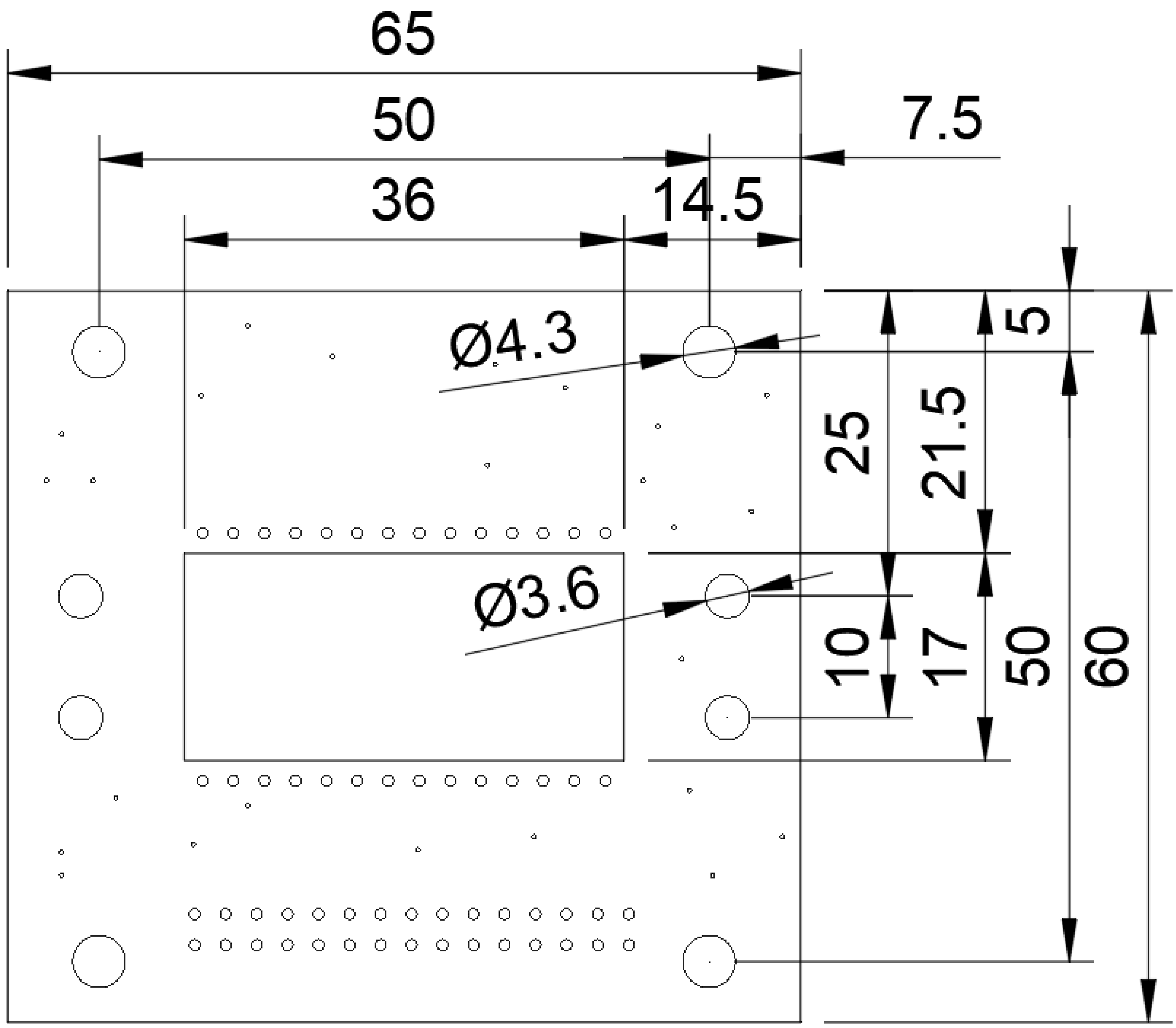
The variation from the minimum pixel output to the maximum pixel output depends on the amplification, the skim target value and the Impedance of the Module.

6.2. Dimensional schematics

6.2.1. Main board



6.2.2. Adapter Board



6.3. Circuit schematics

6.3.1. Main board

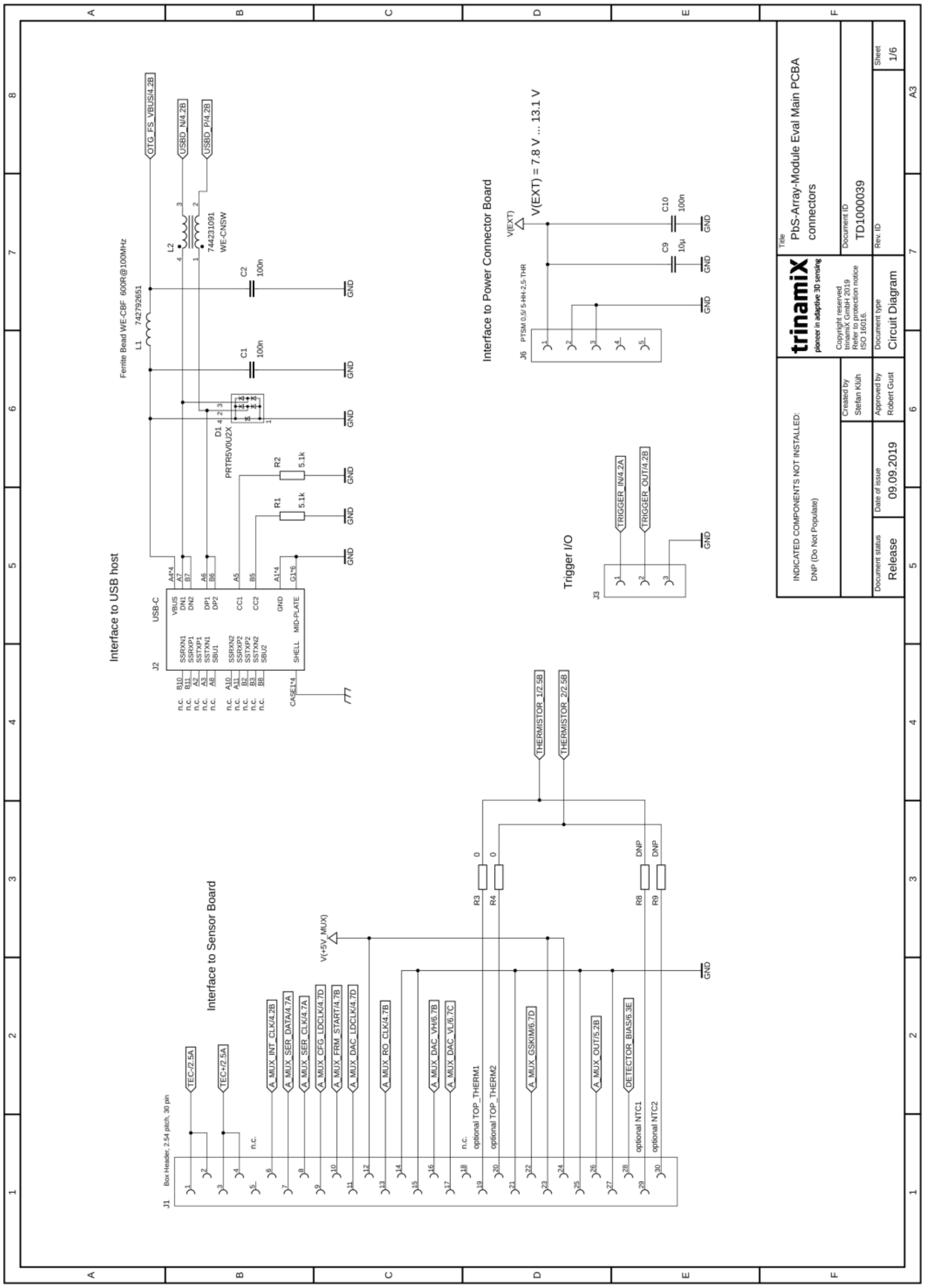


Figure 50: Schematic of the Evaluation Board Part 1

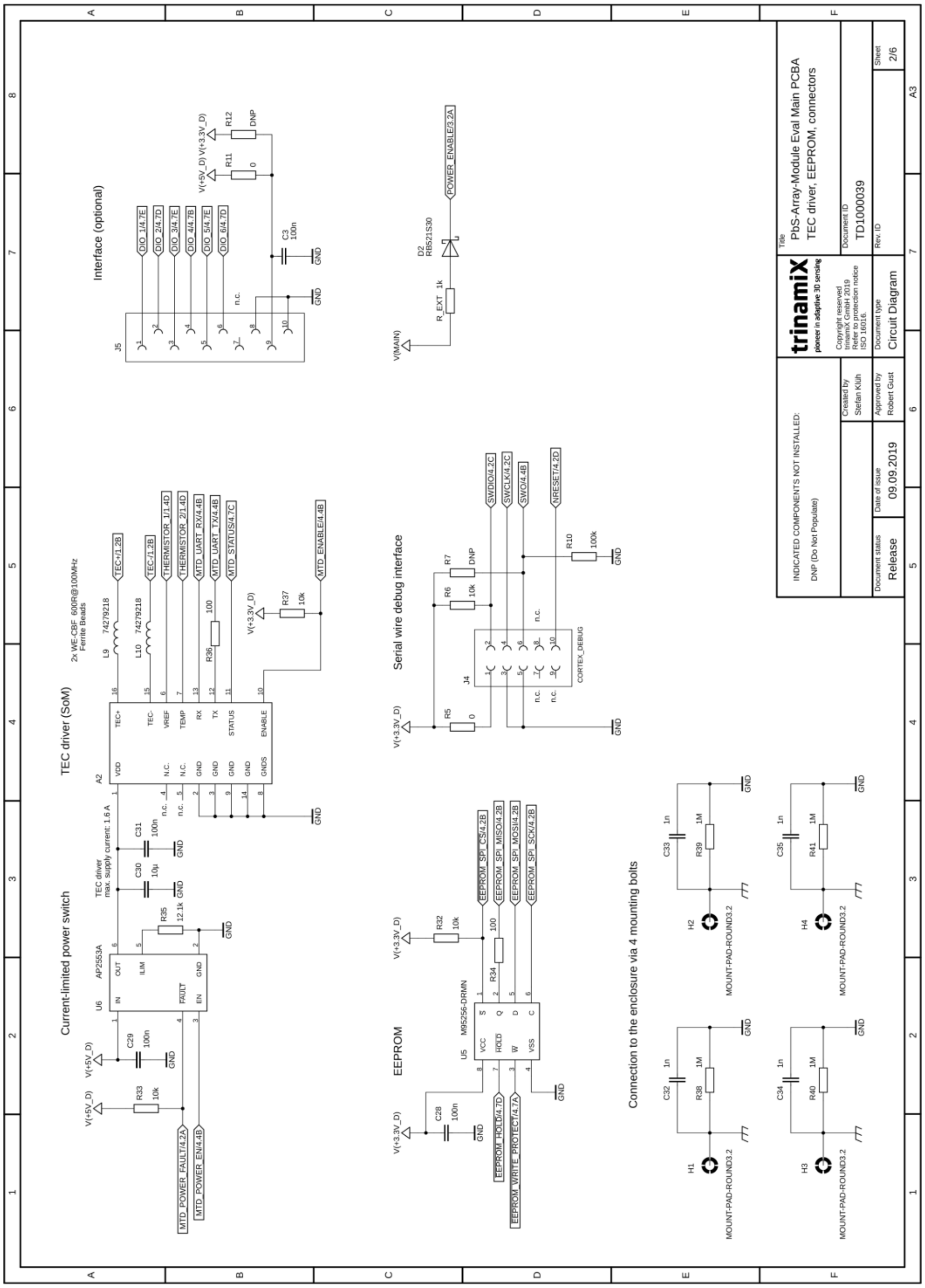


Figure 51: Schematic of the Evaluation Board Part 2

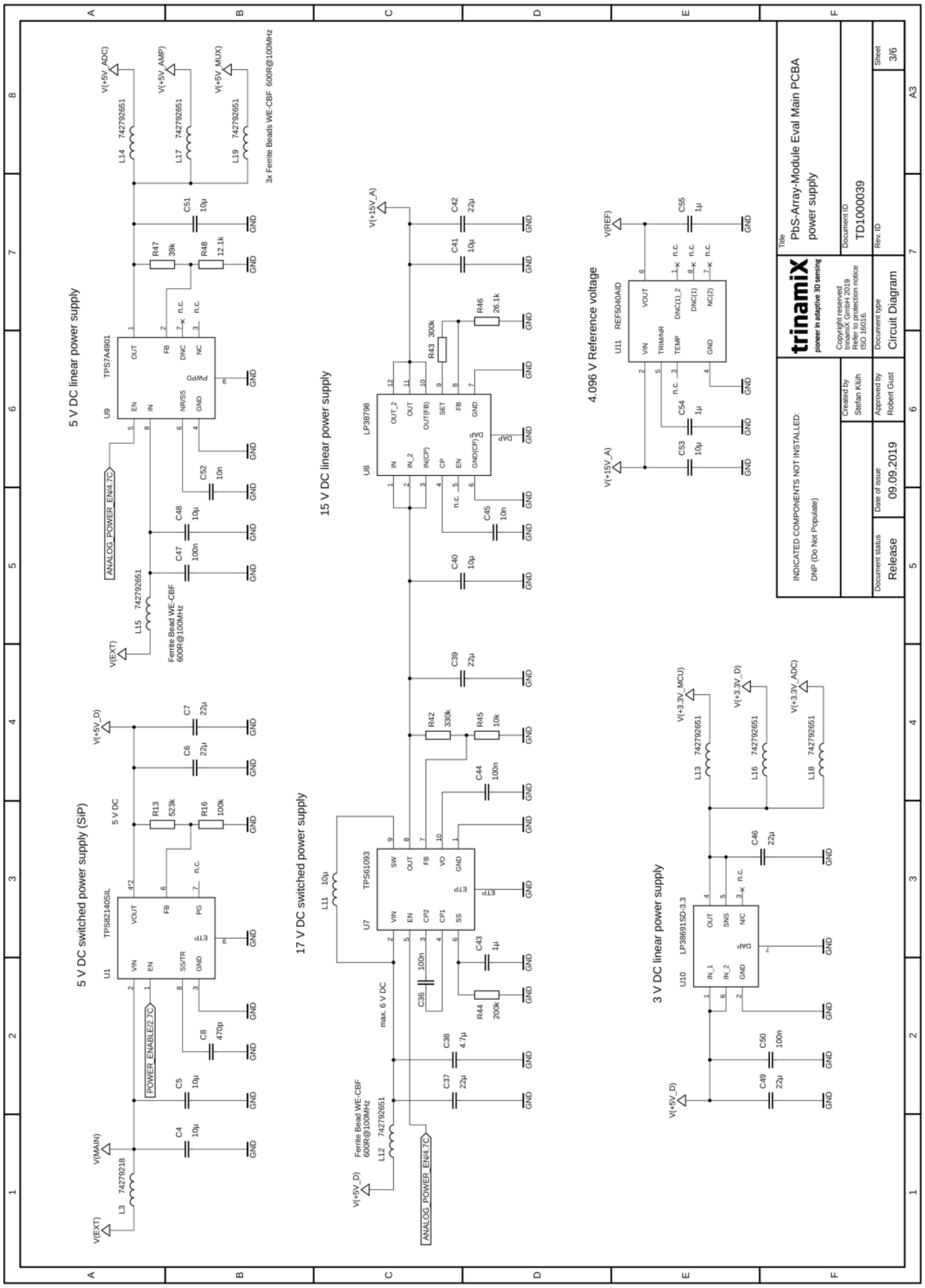


Figure 52: Schematic of the Evaluation Board Part 3

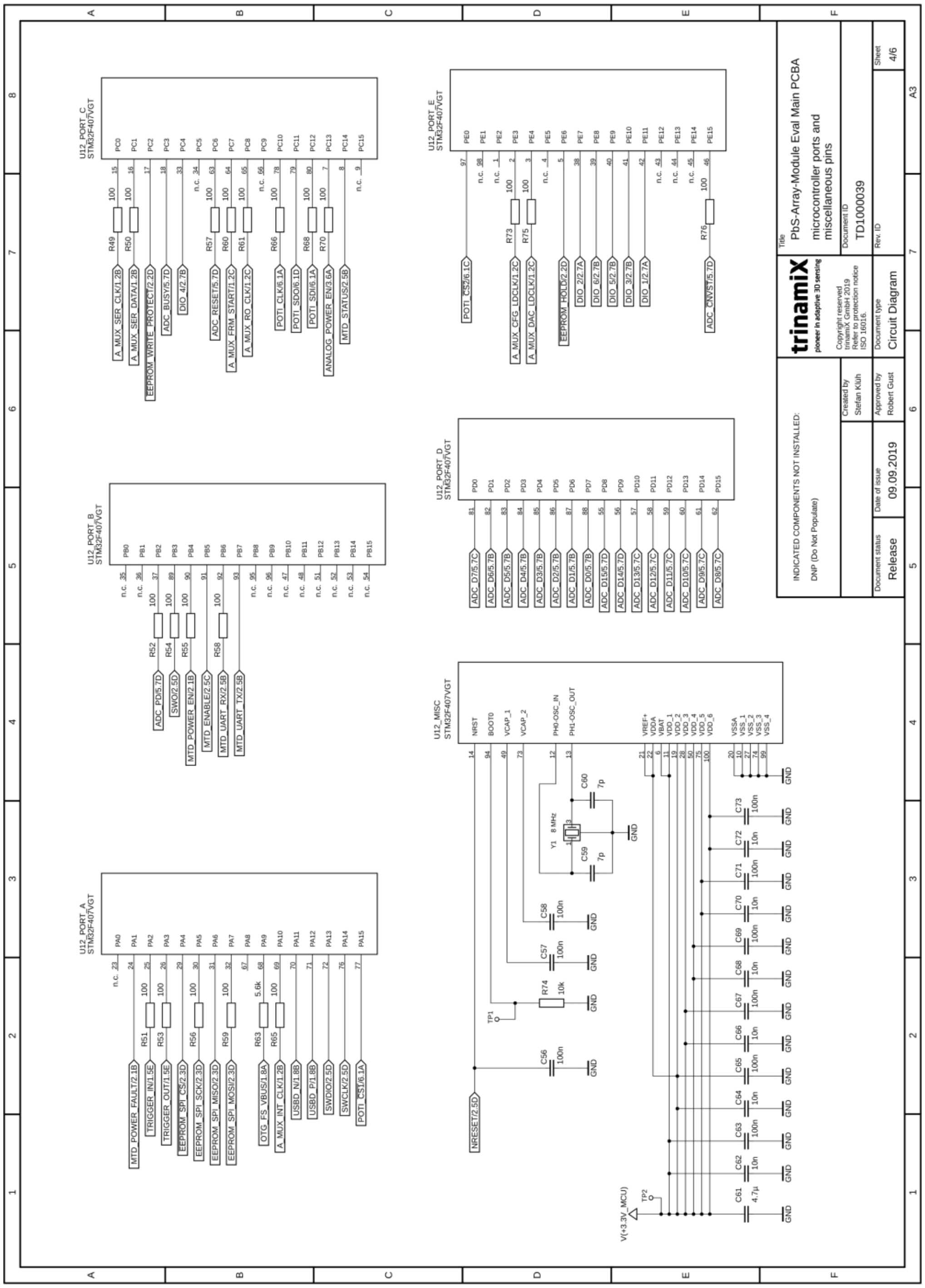


Figure 53: Schematic of the Evaluation Board Part 4

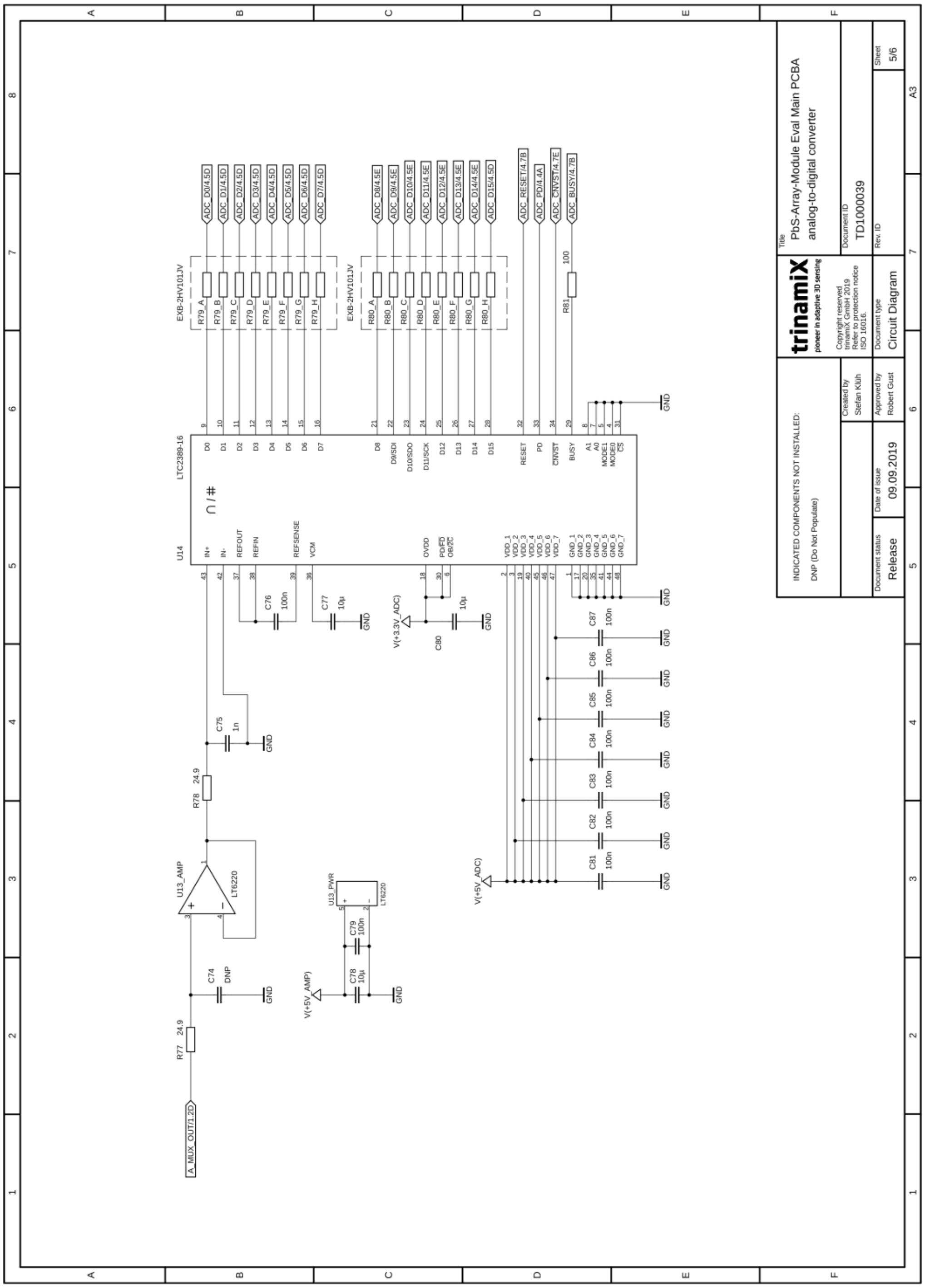


Figure 54: Schematic of the Evaluation Board Part 5

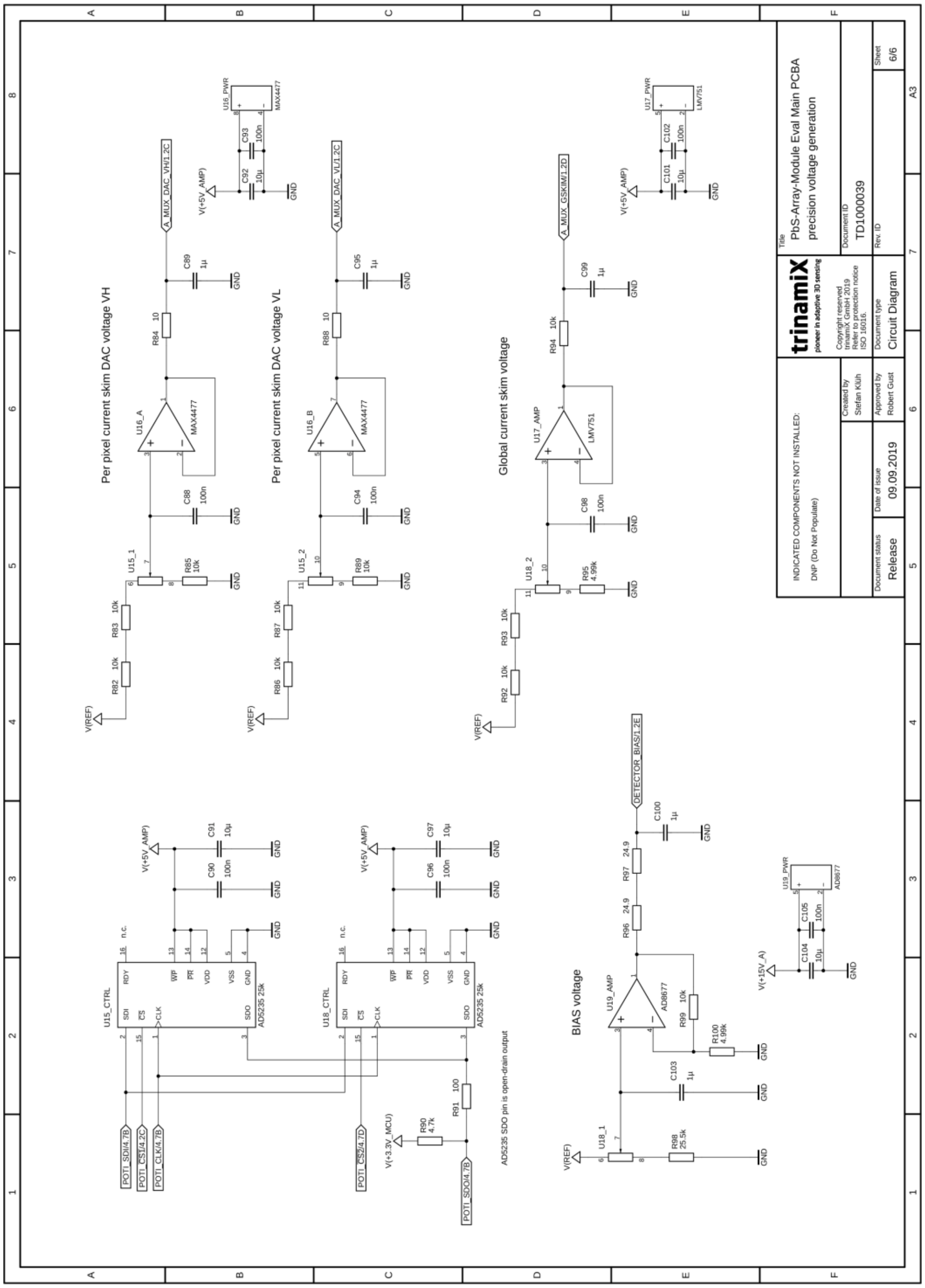


Figure 55: Schematic of the Evaluation Board Part 6

6.3.2. Adapter Board

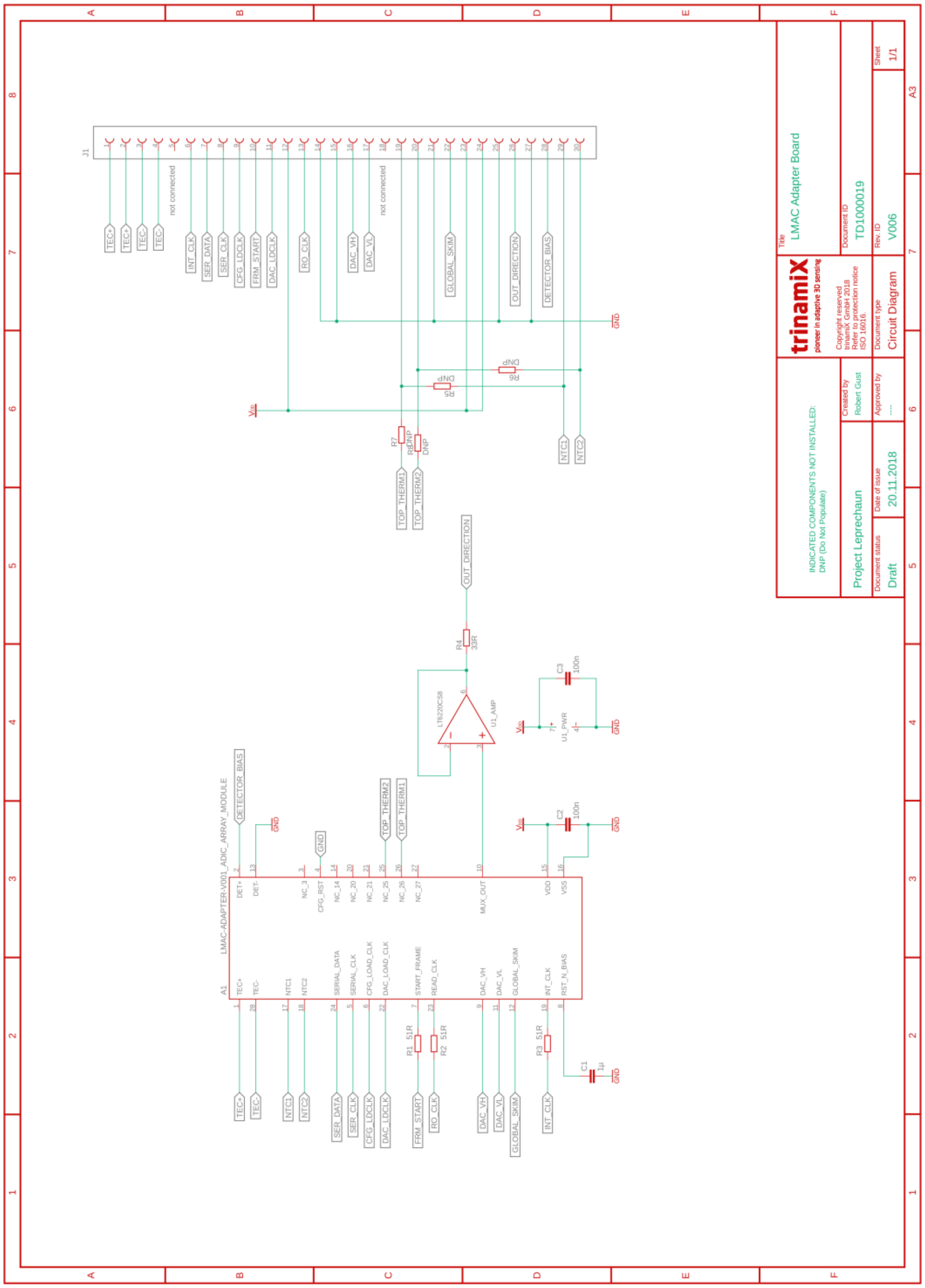
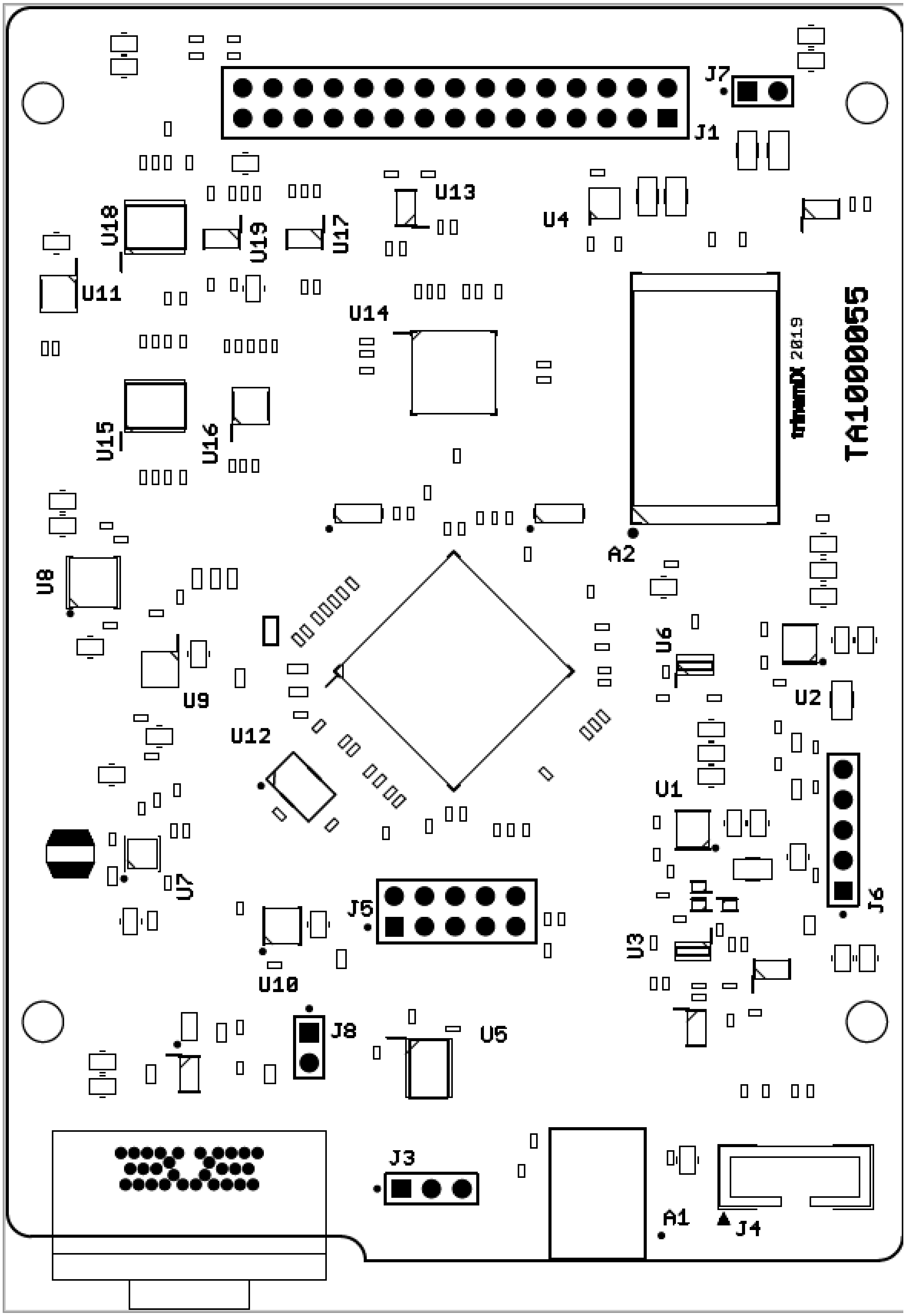


Figure 56: Schematic of the Adapter Board



J7
J1
U13
U4
U18
U19
U17
U11
U14
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U15
U16
A2
U8
U6
U9
U12
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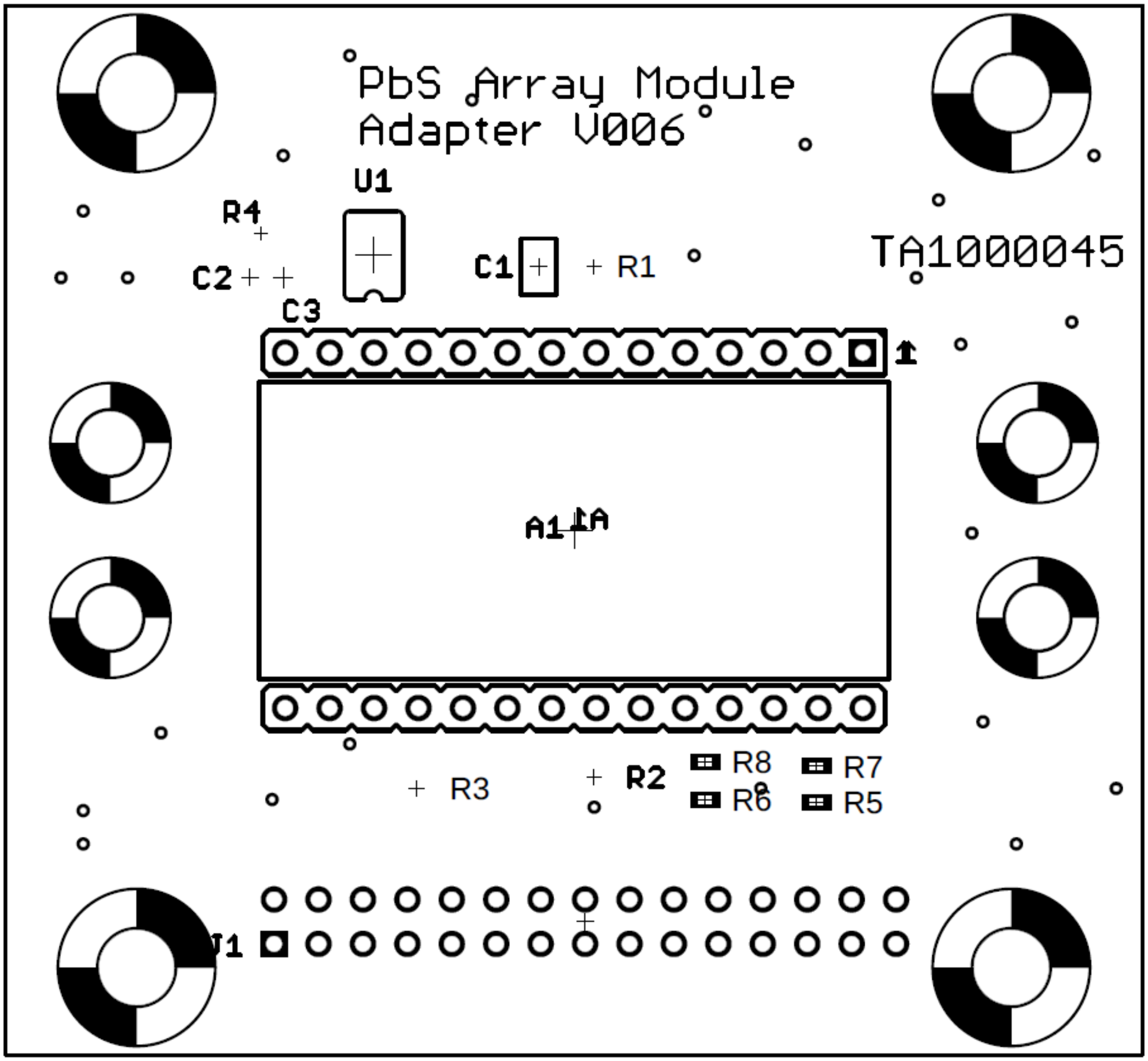
U5
J3
A1
J4

6.3.3. Adapter Board



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6.4. Documentation of .NET dll

6.4.1. General

The PbsEvalBoardDll.dll is a .NET dll that can be found in the subfolder “data” and can be used with your own application. It allows to configure the evaluation board, perform measurements and read the captured data.

6.4.2. Constructor

The Constructor is used to establish a serial connection to the evaluation board. The constructor takes the parameters for the serial connection as input.

Name	Type	Direction	Description
comPortNumber	I32	Input	COM port number
baudRate	I32	Input	Baud rate
timeout	I32	Input	Timeout in ms
error	I32	Output	Error ID (0 = no error)

6.4.3. Functions

6.4.3.1. CommandPerformMeasurement

Perform a measurement

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
numberOfSamples	U16	Input	Number of measurements to be captured (0-65535) If 0, measurement will run continuously until stopped
timeout	I32	Input	Timeout in ms

6.4.3.2. CommandEndMeasurement

Stop an ongoing measurement

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
timeout	I32	Input	Timeout in ms

6.4.3.3. CheckMeasurementdDataAvailable

Check for measurement data in buffer

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
countSets	I32	Output	Number of captured measurements
countElements	I32	Output	Number of values per measurement

6.4.3.4. GetMeasurementData

Read measurement data from buffer as frames. Each frame contains a measured value for each pixel and the sequence number.

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
data	U16[]	Output	Data from buffer formatted as continuous array
countSets	I32	Input	Number of measurements to be read
sequenceError	Bool	Output	Error in sequence

6.4.3.5. CommandGetVersion

Read product name and firmware version

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
version	String	Output	Version
timeout	I32	Input	Timeout in ms

6.4.3.6. CommandGetAsicConfiguration

Read ASIC configuration

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
asicId	U8	Input	ASIC ID (0)
IntegrationTime	U16	Output	Integration time in µs (4-1000 µs)
asicConfiguration	U32	Output	24 configuration bits
timeout	I32	Input	Timeout in ms

6.4.3.7. CommandSetAsicConfiguration

Set ASIC configuration

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
asicId	String	Input	ASIC ID (0 or 1)
IntegrationTime	U16	Input	Integration time in µs (4-1000 µs)
asicConfiguration	U32	Input	24 configuration bits
timeout	I32	Input	Timeout in ms

6.4.3.8. CommandGetAsicDac

Read ASIC DAC values

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
asicId	U8	Input	ASIC ID (0 or 1)
dacValues	U8[]	Output	256 DAC values formatted as array
timeout	I32	Input	Timeout in ms

6.4.3.9. CommandSetAsicDac

Set ASIC DAC values

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
asicId	U8	Input	ASIC ID (0 or 1)
dacValues	U8[]	Input	256 DAC values formatted as array
timeout	I32	Input	Timeout in ms

6.4.3.10. CommandGetBoardConfiguration

Read configuration of Evaluation Board

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
samplesPerSecond	U16	Output	Number of samples per second (1 – 512 Hz)
trigger	ENUM	Output	Trigger source (internal or external)
numberOfAsicChips	U8	Output	Number of ASICs (1)
timeout	I32	Input	Timeout in ms

6.4.3.11. CommandSetBoardConfiguration

Set configuration of Evaluation Board

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
samplesPerSecond	U16	Input	Number of samples per second (1 – 512 Hz)
trigger	ENUM	Input	Trigger source (internal or external)
numberOfAsicChips	U8	Input	Number of ASICs (1)
timeout	I32	Input	Timeout in ms

6.4.3.12. CommandGetPoti

Read potentiometer values (see Figure 1)

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
asicId	U8	Input	ASIC ID (0 or 1)
potiId	U8	Input	Potentiometer ID (0 or 1)
valuePoti0	U32	Output	Resistance of potentiometer 0 (30 – 25000 Ohm)
valuePoti1	U32	Output	Resistance of potentiometer 1 (30 – 25000 Ohm)
timeout	I32	Input	Timeout in ms

6.4.3.13. CommandSetPoti

Set potentiometer values (see Figure 1)

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
asicId	U8	Input	ASIC ID (0 or 1)
potiId	U8	Input	Potentiometer ID (0 0r 1)
valuePoti0	U32	Input	Resistance of potentiometer 0 (30 – 25000 Ohm)
valuePoti1	U32	Input	Resistance of potentiometer 1 (30 – 25000 Ohm)
timeout	I32	Input	Timeout in ms

6.4.3.14. CommandSaveSettings

Save potentiometer settings

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
timeout	I32	Input	Timeout in ms

6.4.3.15. CommandEnableTec

Activate or deactivate TEC (thermoelectric cooler) temperature control

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
Enable	Bool	Input	Activate or deactivate TEC temperature control
timeout	I32	Input	Timeout in ms

6.4.3.16. CommandGetTecStatus

Read status of TEC temperature control

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
Enable	Bool	Output	Status of TEC temperature control
timeout	I32	Input	Timeout in ms

6.4.3.17. CommandGetTecFirmwareVersion

Read firmware version of TEC controller

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
version	String	Output	TEC firmware version
timeout	I32	Input	Timeout in ms

6.4.3.18. CommandGetTecUuid

Read UUID (Universal Unique Identifier) of TEC controller

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
version	String	Output	UUID of TEC
timeout	I32	Input	Timeout in ms

6.4.3.19. CommandGetTecErrorRegister

Read error register of TEC controller

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
errorRegister	U16	Output	Output of error register
timeout	I32	Input	Timeout in ms

6.4.3.20. CommandResetTecErrorRegister

Reset error register of TEC controller

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
timeout	I32	Input	Timeout in ms

6.4.3.21. CommandSaveSettingsTec

Store setting of TEC controller in nonvolatile memory

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
timeout	I32	Input	Timeout in ms

6.4.3.22. CommandGetTecCurrentLimit

Read current limit for TEC

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
currentLimit	U16	Output	Current limit in mA (200 – 2000 mA)
timeout	I32	Input	Timeout in ms

6.4.3.23. CommandSetTecCurrentLimit

Set current limit for TEC

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
currentLimit	U16	Input	Current limit in mA (200 – 2000 mA)
timeout	I32	Input	Timeout in ms

6.4.3.24. CommandGetTecActualCurrent

Read current current of TEC

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
actualCurrent	U16	Output	Current in mA
timeout	I32	Input	Timeout in ms

6.4.3.25. CommandGetTecActualVoltage

Read current voltage of TEC

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
actualVoltage	U16	Output	Voltage in mV
timeout	I32	Input	Timeout in ms

6.4.3.26. CommandGetTecSetTemperature

Reads temperature setpoint of TEC

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
temperature	Float	Output	Temperature setpoint in °C
timeout	I32	Input	Timeout in ms

6.4.3.27. CommandSetTecSetTemperature

Set temperature setpoint of TEC

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
temperature	Float	Input	Temperature setpoint in °C
timeout	I32	Input	Timeout in ms

6.4.3.28. CommandGetTecActualTemperature

Read current TEC temperature

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
temperature	U16	Output	Temperature in °C
timeout	I32	Input	Timeout in ms

6.4.3.29. CommandGetTecCyclingTime

Read cycle time of TEC controller

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
cyclingTime	U16	Output	Cycle time in ms (1– 1000 ms)
timeout	I32	Input	Timeout in ms

6.4.3.30. CommandSetTecCyclingTime

Set cycle time of TEC controller

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
cyclingTime	U16	Output	Cycle time in ms (1– 1000 ms)
timeout	I32	Input	Timeout in ms

6.4.3.31. CommandGetTecPid

Read PID parameters of TEC controller

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
p	U32	Output	PID Parameter P (1-100000 mA/K)
i	U32	Output	PID Parameter P (1-100000 mA/(K+sec))
d	U32	Output	PID Parameter P (1-100000 (mA*s)/K)
timeout	I32	Input	Timeout in ms

6.4.3.32. CommandSetTecPid

Sets PID parameters of TEC controller

Name	Type	Direction	Description
Return value	I32	Output	Error ID (0 = no error)
p	U32	Input	PID Parameter P (1-100000 mA/K)
i	U32	Input	PID Parameter P (1-100000 mA/(K+sec))
d	U32	Input	PID Parameter P (1-100000 (mA*s)/K)
timeout	I32	Input	Timeout in ms

6.4.3.33. GetLastExceptionText

Read text of last .NET Exception

Name	Type	Direction	Description
Return value	String	Output	Exception text
errorNumber	I32	Input	Error ID

6.4.4. Error Handling

Error IDs are not passed as .NET Exception. Instead, each function call returns an integer error value. This implementation is intended to simplify the error handling in other programming languages, e.g. LabVIEW.

6.4.4.1. Utility Class ErrorStrings

The utility class ErrorStrings allows to read the corresponding text of an Error ID.

The Error ID 100 denotes a .NET Exception. The corresponding text can be read with the function call GetLastExceptionText.

6.4.4.2. Error IDs

Nummer	Description
0	No error
1	Timeout
2	Command could not be executed
3	Wrong input
100	.NET Exception

6.5. Warnings, restrictions and disclaimers

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6. During normal operation, some circuit components may have case temperatures greater than 60 °C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EK schematic located in the EK User manual. When placing measurement probes near this device during normal operation, please be aware that this device may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use this EK.

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