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Multi-Pixel Evaluation Kit by trinamiX

User guide

PCB V3, Firmware V1.7866

Key features

- 16 channels for up to 16-Pixel-Detectors
- 24-bit simultaneous sampling ADC with up to 128 kSPS
- Adjustable amplification via gain resistors or programmable gain
- I^2C temperature sensor
- Built in lamp driver for incandescent lamps (modulated at 10 Hz)
- 12 V power supply
- USB-C communication to PC
- Read out and data analysis with standalone software based on C#
- Plug & Play

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1. Introduction

The trinamiX Multi-Pixel Evaluation Kit is designed for a quick and cost-effective way to learn about the capabilities of trinamiX Multi-Pixel detectors. With no need to develop any code before carrying out own measurements, customers can perform a thorough evaluation of the Multi-Pixel detectors allowing to expedite their development process and make better informed decisions on hardware design and component requirements.

The Evaluation Kit is capable for simultaneous measurements of any conceivable Multi-Pixel line or matrix geometry with up to 16 pixels in total. Two different Multi-Pixel configurations can be evaluated using the Evaluation Kit: (1) Multi-Pixel detectors (Fig. 1a) and (2) Multi-Single-Pixel detectors which basically consist of Single-Pixel detectors arranged as Multi-Pixel array (Fig. 1b).

Figure 1: (a) Various trinamiX Multi-Pixel chips with up to 16 pixels (left) and (b) trinamiX Multi-Single-Pixel chips with eight Single-Pixel detectors and filter mount (right).

The Multi-Pixel evaluation kit consists of two Printed Circuit Boards (PCBs): (1) the main PCB and (2) an adapter PCB. The adapter PCB is plugged into the main PCB at the intended pin socket and can, for instance, be customized to directly fit into a prototype system of a customer.

The Evaluation Kit is designed to be powered externally by a 12V power supply. An USB-C port is employed to transfer the measurement data to a Windows-based software for visualization and data capture.

Basic principle of the electronics is that the mainboard provides a bias voltage of 10V to the detector board, amplifies the signals of each detector and digitalizes it via two analog-digital converters (ADC). A microcontroller processes the data and transfers it to a computer via the USB port.
The detector board also has an I^2C temperature sensor to provide a reading of the temperature near the detectors.

2. Specifications

Some important specifications of the Multi-Pixel Evaluation Kit are listed in Table 1:

Parameter	Description	Typ.	Unit
V_{IN}	Input voltage (USB)	12	V
V_{BIAS}	Bias voltage (detector)	10	V
f_s	ADC Sampling frequency	4	kHz

Table 1: Electrical specifications and ADC characteristics.

Figure 3 shows the pin layout of the adapter PCB socket including the applied voltages in Table 2.

SDA	SCL	NC	3.3V	VM	NC	GND	V_{BIAS}

CH 15	CH 13	CH 11	CH 9	CH 7	CH 5	CH 3	CH 1
CH 16	CH 14	CH 12	CH 10	CH 8	CH 6	CH 4	CH 2

Figure 2: Pin layout of the adapter PCB socket.

Pin	Description	V
SDA	Data line temperature sensor	Signal
SCL	Clock line temperature sensor	Signal
NC	Not connected	NC
3.3 V	Supply voltage temperature sensor	3.3
VM	High pass filter reference	5
NC	Not connected	NC
GND		GND
V_{BIAS}	Bias voltage detector	10
CH 1 -16	Signal detector	Signal

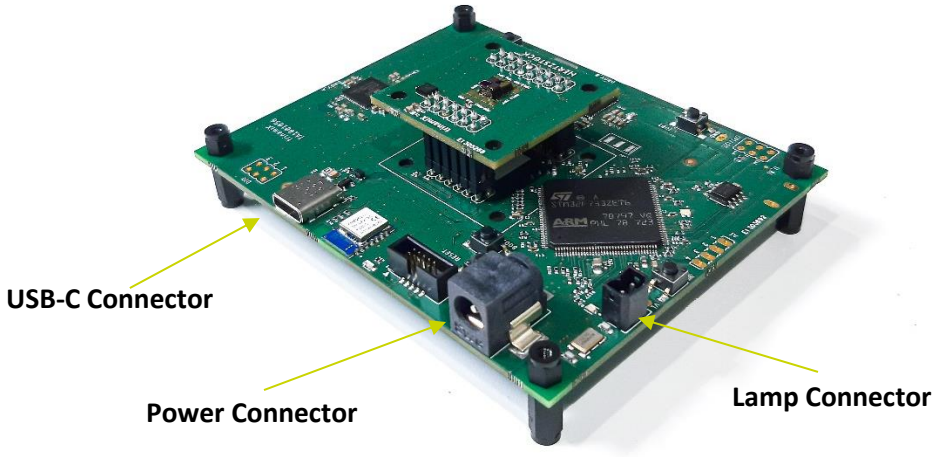
Table 2: Pin description of the adapter PCB socket.

3. Installation

The latest software to run the Multi-Pixel Evaluation Kit is provided with each Kit and can be alternatively downloaded from https://trinamix.de/eval-kit. It is highly recommended to install the software on a Windows 10, 64-bit system. For the installation, simply double-click the file "*Setup - trinamiX Multi-Pixel Evaluation Kit*" installer and follow the instructions.

4. Connections

As previously mentioned, the evaluation kit needs to be powered with 12V via a barrel jack. For data transfer and controls, the hardware has to be connected to a windows PC with an USB-C cable. The detector board can simply be connected via the 8+6 pin connector to the mainboard. If the detector board is configured with a thermoelectrical cooler (TEC) it will also be powered via the same connection.



Additionally, the mainboard provides a 2-pin PTSM connector that can deliver power for incandescent lamp sources. This is relevant in case the customer plans to use the board with a trinamiX reflection illumination head or plans to attach any other light source configuration.

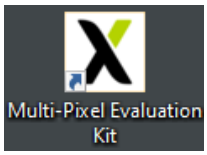
Aside from these wired connections, the board also provides wireless connection via Bluetooth. This is only relevant if the evaluation kit hardware is configured for a certain specific spectroscopy tasks where a chemometric model for material identification or classification has already been deployed in the trinamiX cloud system.

5. Data recording and analysis

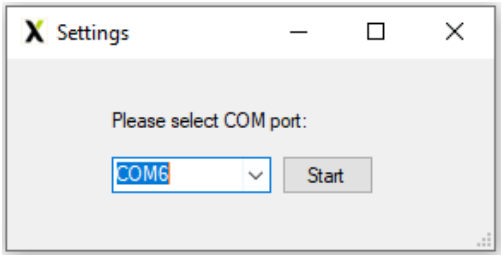
Please note that for working with the Multi-Pixel Evaluation Kit, an external modulated/chopped infrared radiation source is required. The allowed frequency range of the Evaluation Kit is 10 Hz to 2 kHz.

In order to record and analyze data using the Multi-Pixel Evaluation Kit, please follow the described steps:

1. Open the shortcut "*Multi-Pixel Evaluation Kit*" on your desktop to run the software:

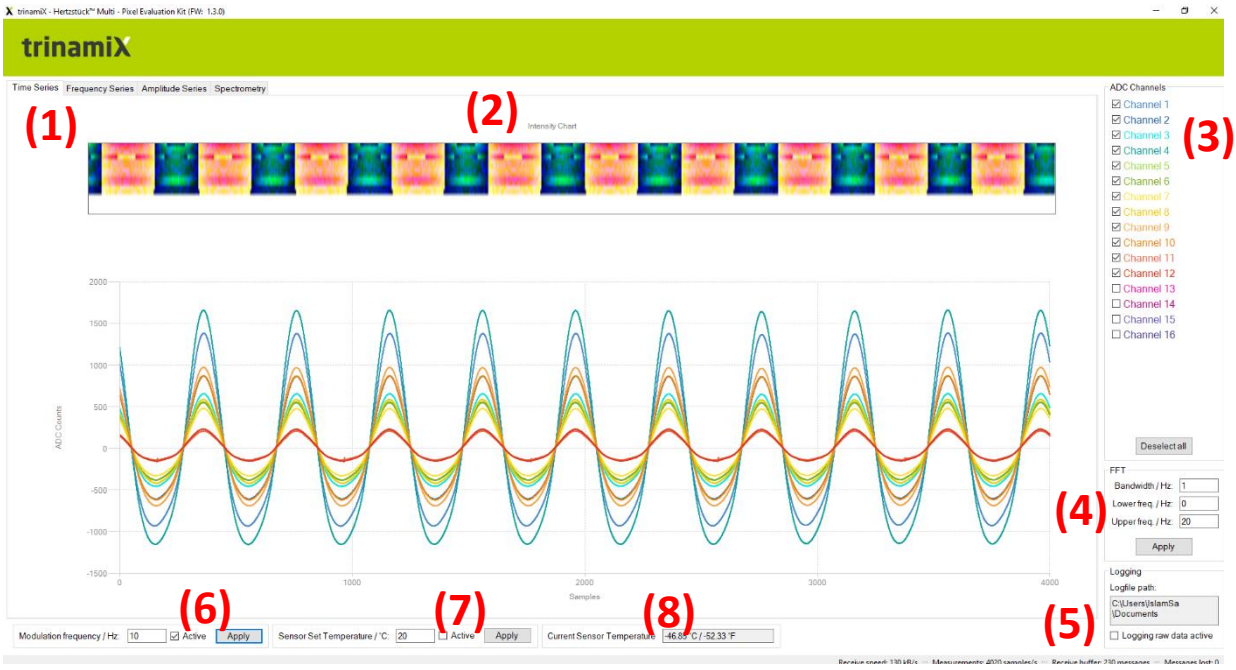


2. Select the COM port the Evaluation Kit is connected to and press "*Start*":

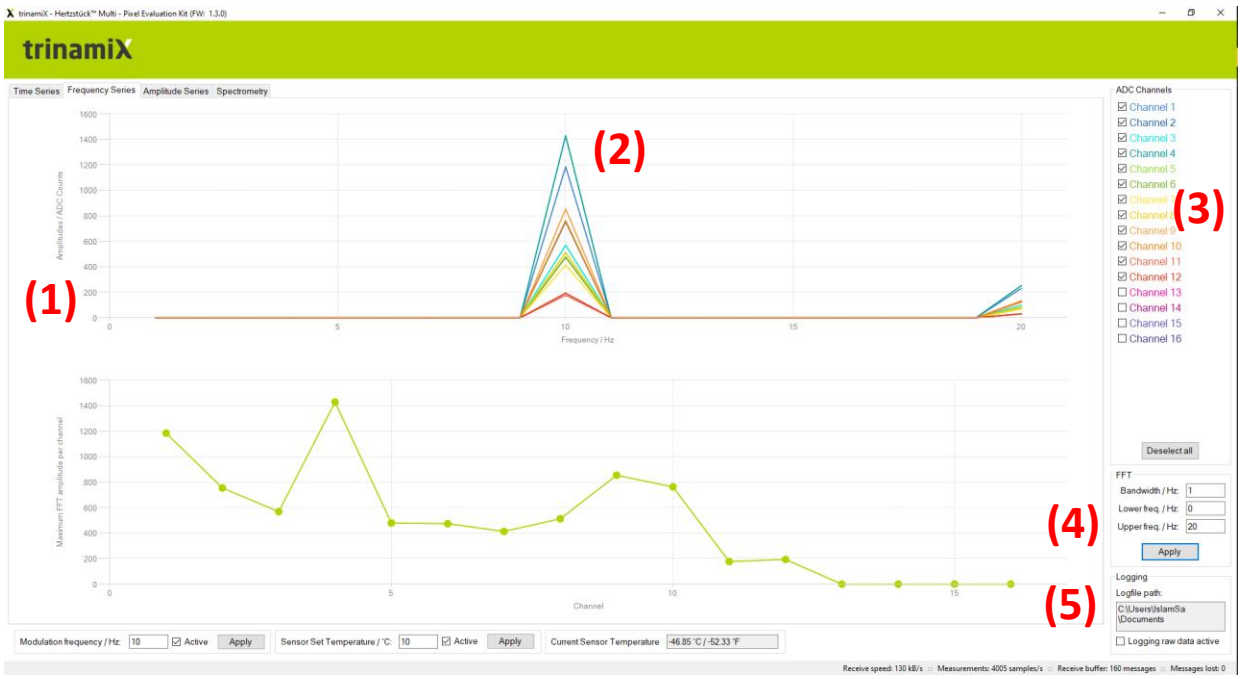


3. Tab "*Time series*":
   The time series tab provides the ADC signal counts over samples for all channels of the Evaluation Kit **(1)** including an intensity chart **(2)**. The channels to be displayed can be selected by the bar top right **(3)**. The number of samples shown on the x-axis can be varied by increasing or decreasing the bandwidth value **(4)**. In order to activate and save a Logfile, please tick the box down right **(5)** and select a file name and file path. The lamp modulation frequency and the target detector board temperature (if TEC is fitted) can be set up via appropriate fields/buttons seen in **(6)** and **(7)**. These 2 features are only available for Hardware Version 2. The value of the temperature sensor on the adapter PCB is displayed down left **(8)**.

   Note: On initial start-up of the software the first 12 channels are always active. Depending on the detector board configuration (e.g. only 6 detectors are actually connected) some channels can be disabled. Initial starting values for the lamp modulation frequency and TEC temperature is also set at 10Hz and 10°C respectively which can be changed after starting up the software.

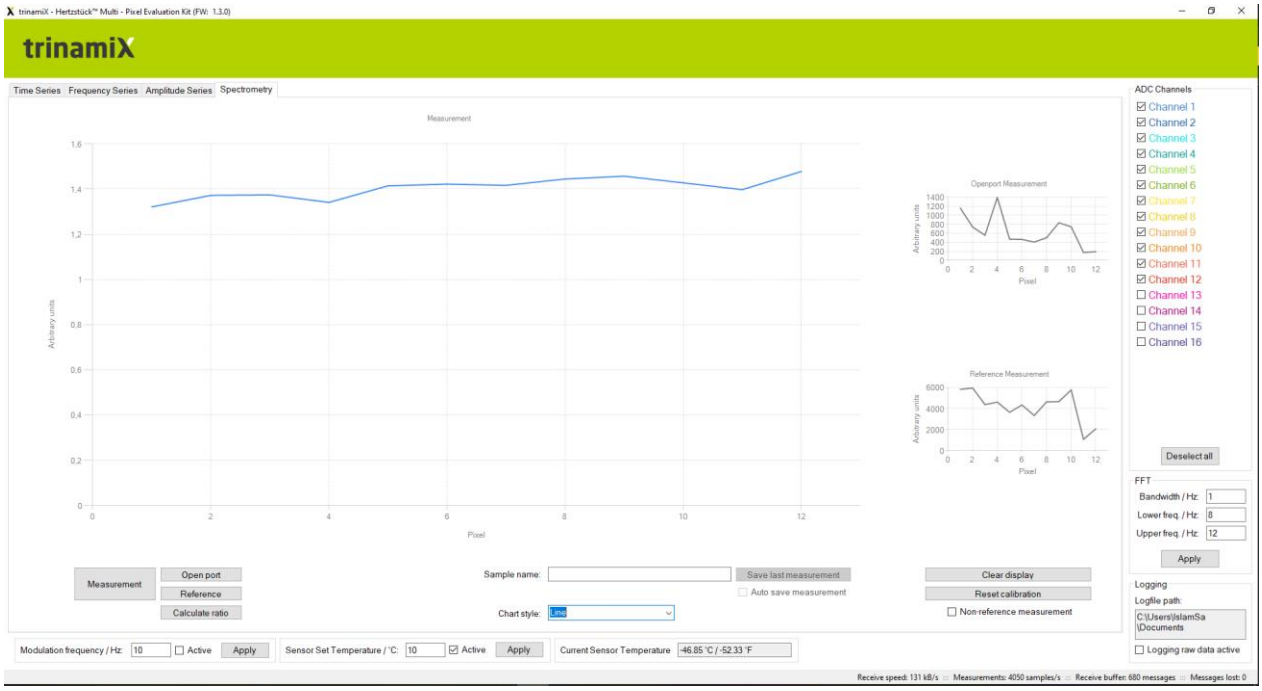


4. Tab “Frequency *series*”:
   This tab provides the FFT of the ADC signals **(1)** and the maximum FFT amplitude of each channel **(2)**. Again, the channels to be displayed can be selected by the bar top right **(3)**.
   The bandwidth of the displayed FFT as well as the lower and upper displayed value on the frequency-axis can be varied in the box down right **(4)**.
   Again, in order to activate and save a Logfile, please tick the box down right **(5)** and select a file name and file path.



5. Tab “Amplitude *series*”:
   This tab provides the peak of the FFT amplitude of each channel over the number of FFT calculations **(1)**. Again, the channels to be displayed can be selected by the bar top right.
   The bandwidth of the calculated FFT can be varied in the box down right.
   Again, in order to activate and save a Logfile, please tick the box down right and select a file name and file path.

6. Tab „Spectrometry“
   This tab allows for single shot reflection spectroscopy measurements if the board is pre-configured with a trinamiX optical head with a built-in illumination source. As it is specific to use cases, additional documents will be made available to the customer if requested.



6. Data output

The following section describes the output data structure of the Evaluation Kit for the case a customer is interested to create its own software for data analysis.

6.1. USB packages

The raw digital signal and temperature data is provided by the USB in packages of 971 bytes. The 4 first and last 4 bytes of each package represent a header [0x01, 0x02, 'e', 'v'] and footer ['a', 'l', 0x04, '\n'], respectively. After the header, a 1-byte package number is added which is repeatedly counted from 0 to 255. Bytes at indices 5 to 964 of each package represents 30 samples for every channel. Each sample is sent as a signed 16-bit binary number in 2's complement notation and big endianness. Bytes at indices 965 and 966 contain the temperature data, which is formatted as unsigned 16-bit and big endianness. Fig. 6 shows the Bit order of the data packages provided by the USB.

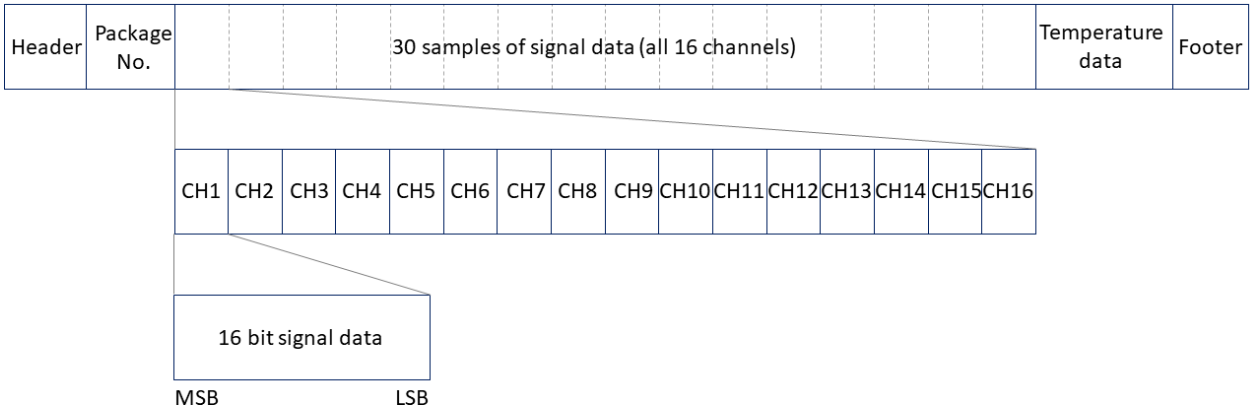


Figure 3: Bit order of data packages provided by USB.

The 16 adjacently packed samples, one for every channel, are captured simultaneously. The 30 samples are captured at a sample rate of 4 kHz.

The 16-bit signal data (Data_Code) is amplified by a factor of 11 for PbS and factor 101 for PbSe detctors and can be converted into a voltage value by using the following expression:

$$\text{Voltage (V)} = \frac{\text{Data\_Code} \cdot \frac{5\text{V}}{2^{16}}}{11\ (\text{PbS})} \qquad \text{Voltage (V)} = \frac{\text{Data\_Code} \cdot \frac{5\text{V}}{2^{16}}}{101\ (\text{PbSe})}$$

To convert the 16-bit temperature data (Temp_Code) to a temperature in degree Celsius (°C), please use the following expression:

$$\text{Temperature } (°\text{C}) = \frac{175.72 \cdot \text{Temp\_Code}}{65536} - 46.85$$

The temperature is measured by the ADC with a frequency of 1 SPS.

6.2. Frequency Analysis

When displaying the detector signals using a Fast-Fourier-Transformation (FFT), please use a bandwidth of Δf = 1 Hz and multiply each period with the Hanning-Window to weight it.

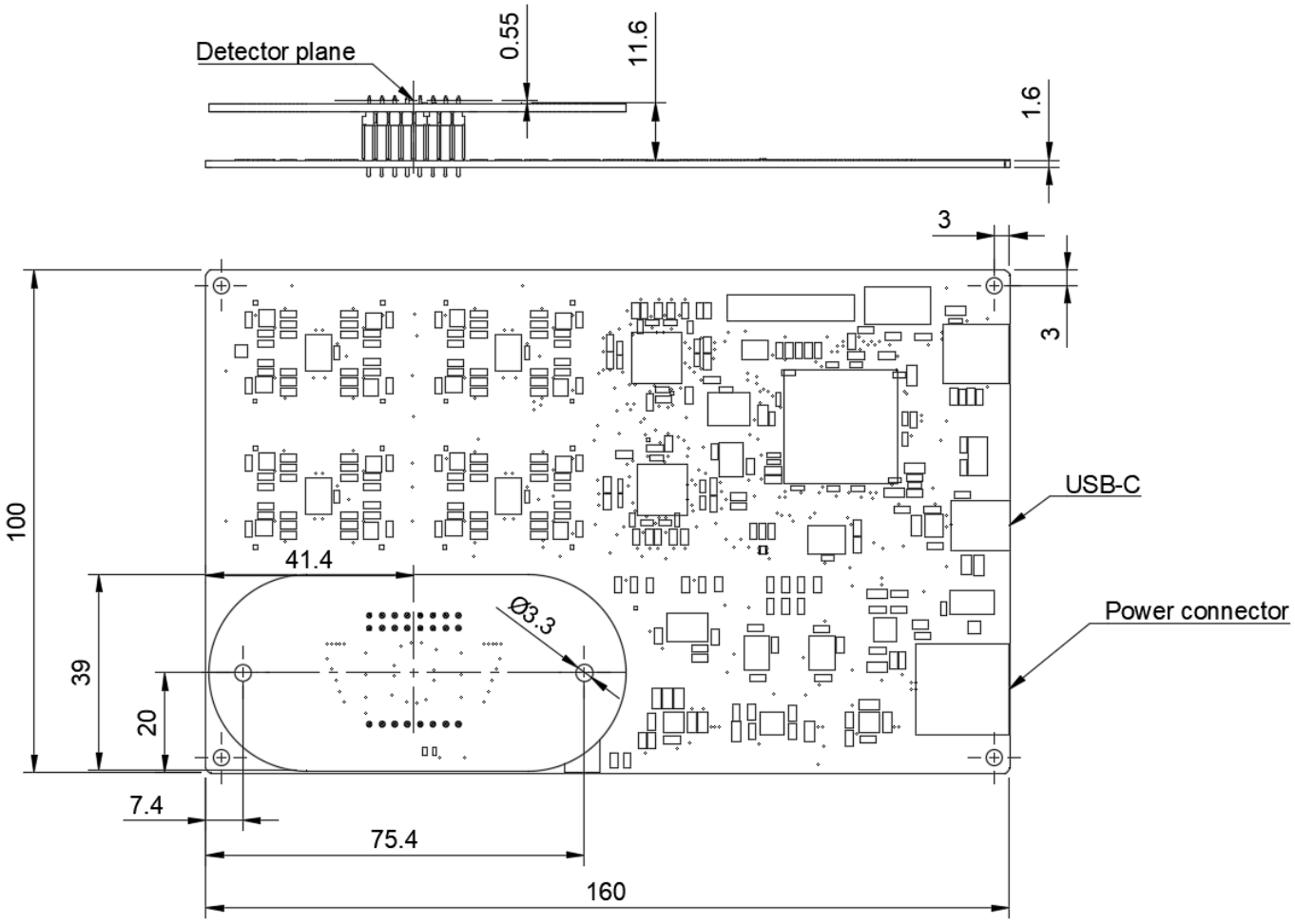
For the correct voltage value representation in a Root Mean Square value (RMS), please use the following expression:

$$\text{RMS} = \frac{\text{Amplitude}}{\sqrt{2}}$$

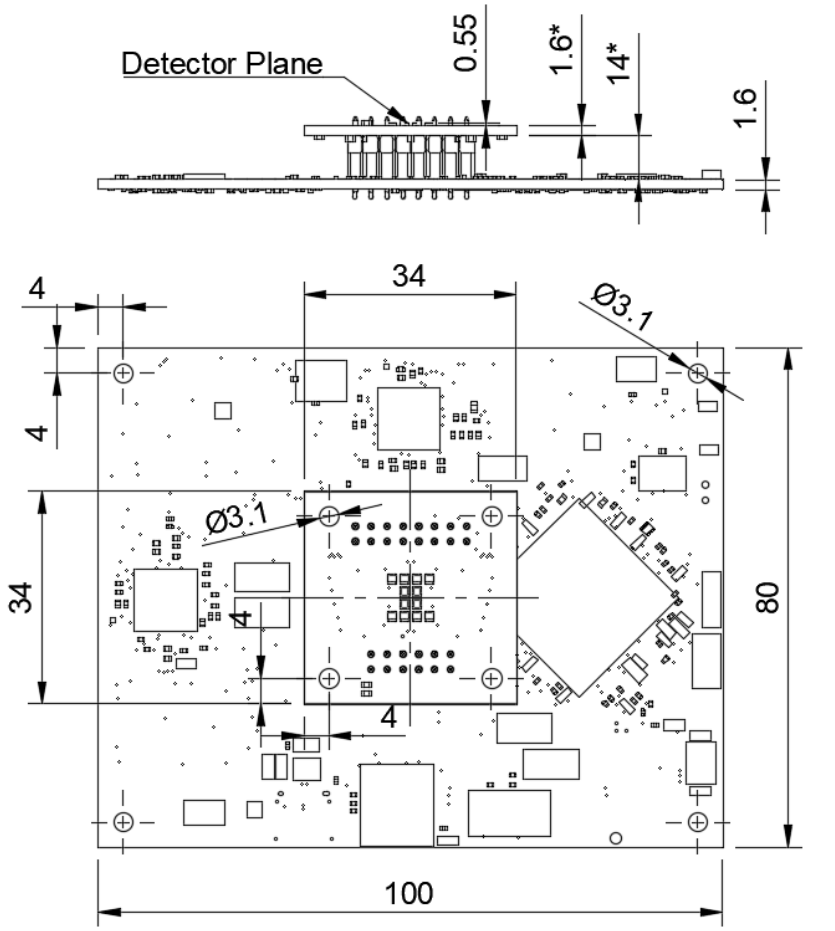
Then create the mean value of all FFT. To determine the noise, the standard deviation must be calculated.

7. Appendix

7.1. Technical drawing hardware rev. 1



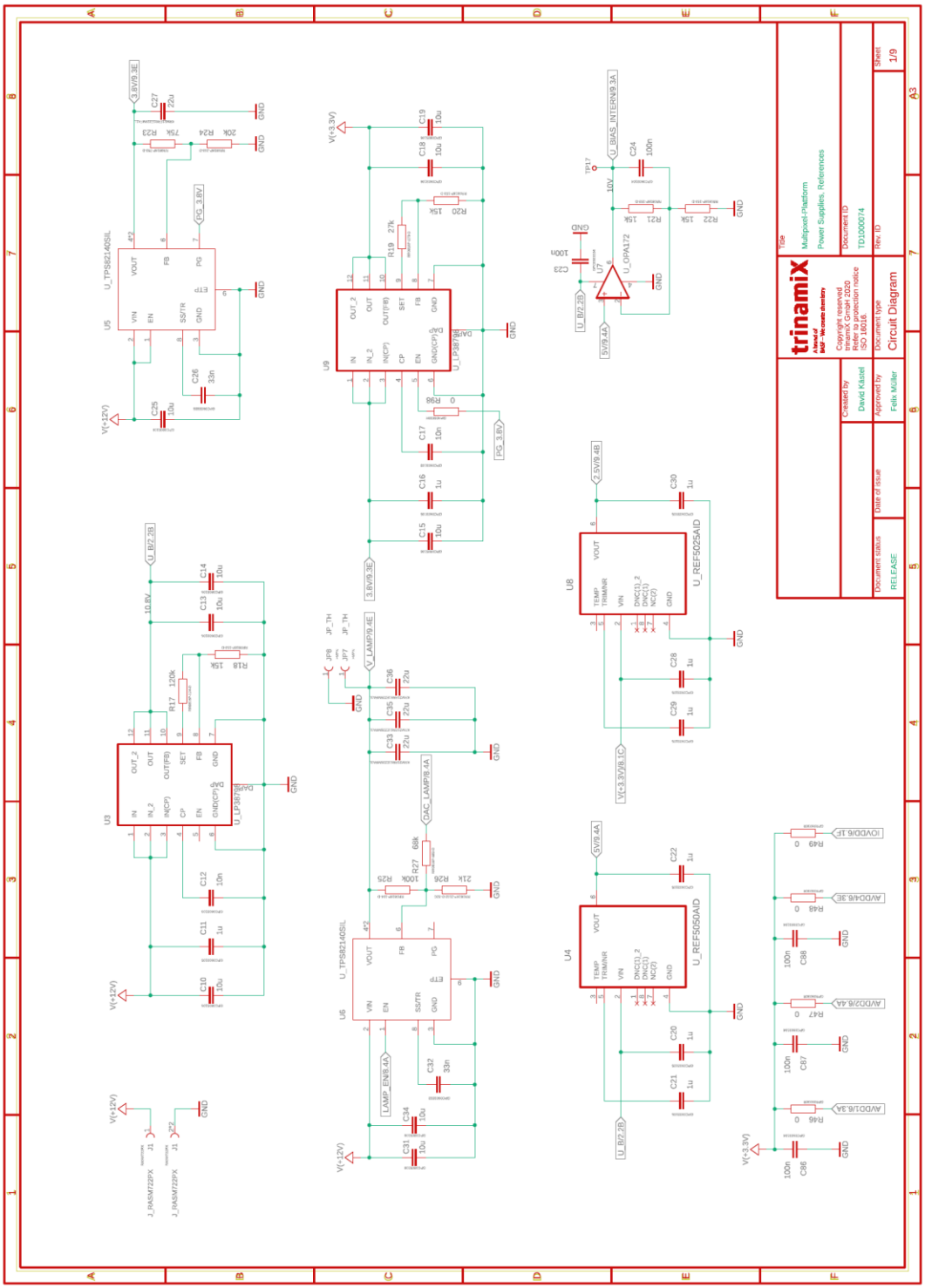
7.2. Technical drawing hardware rev. 2

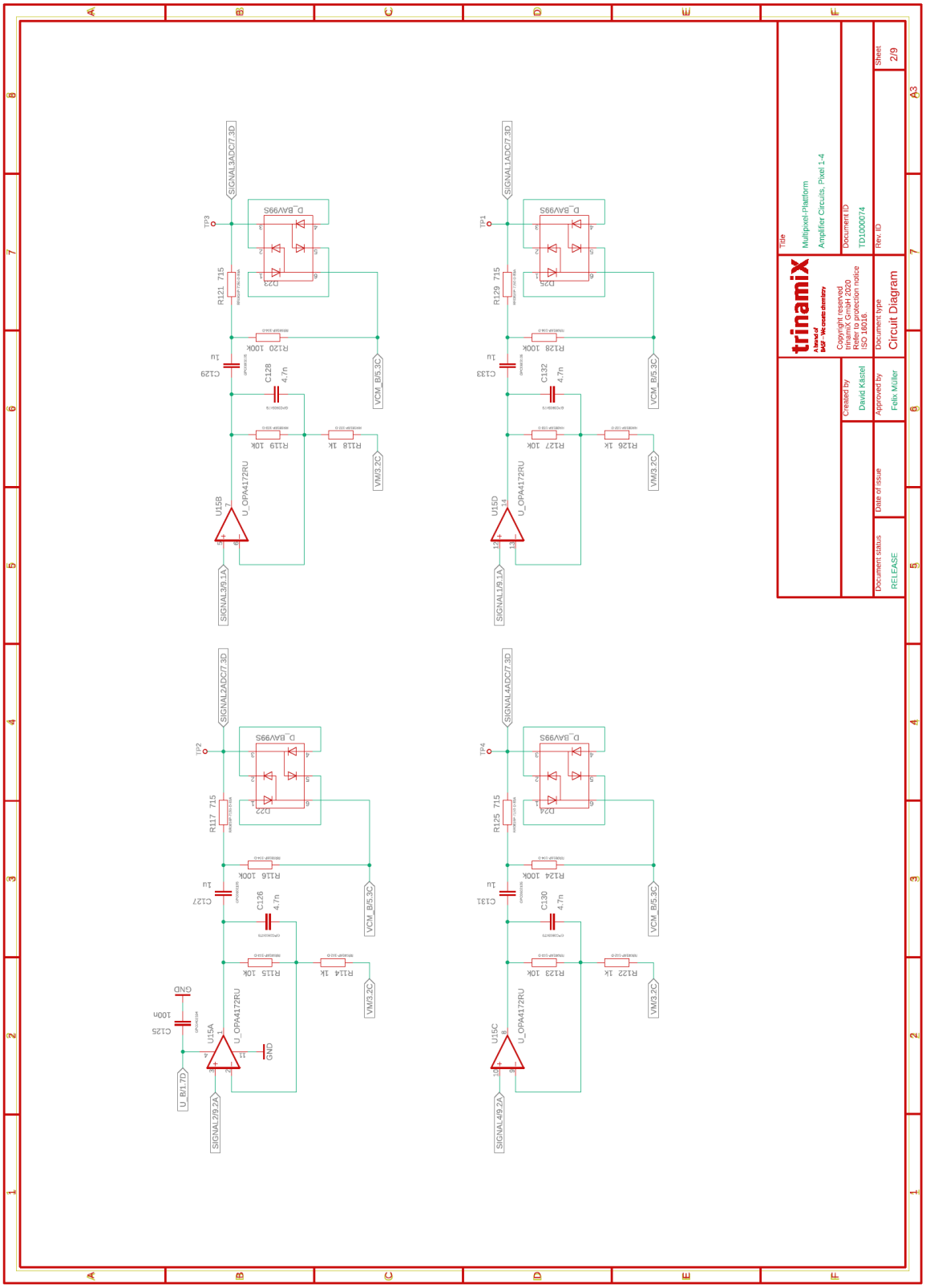


* Varies if TEC is installed

7.3. Circuit schematics

7.3.1. Main PCB





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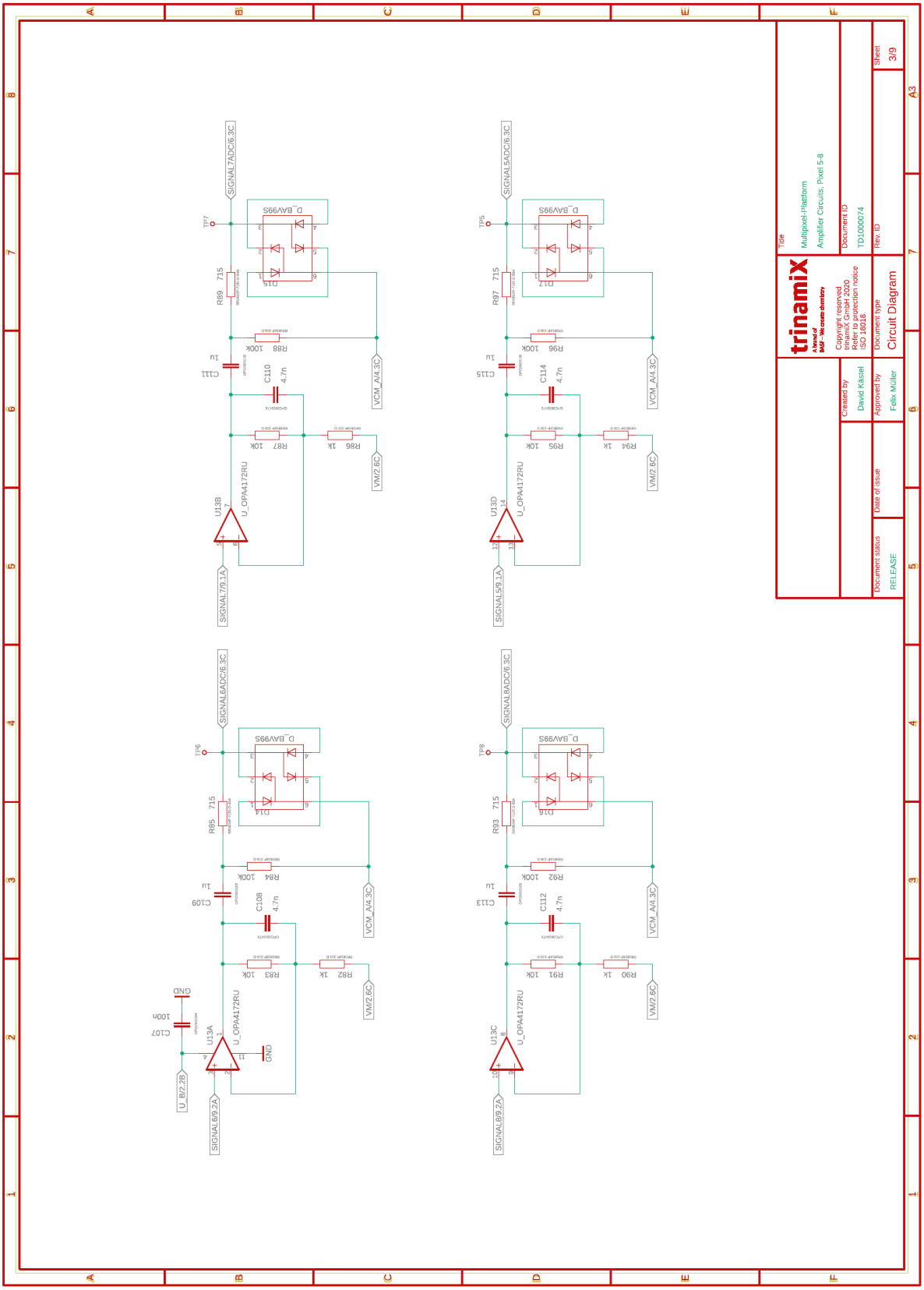

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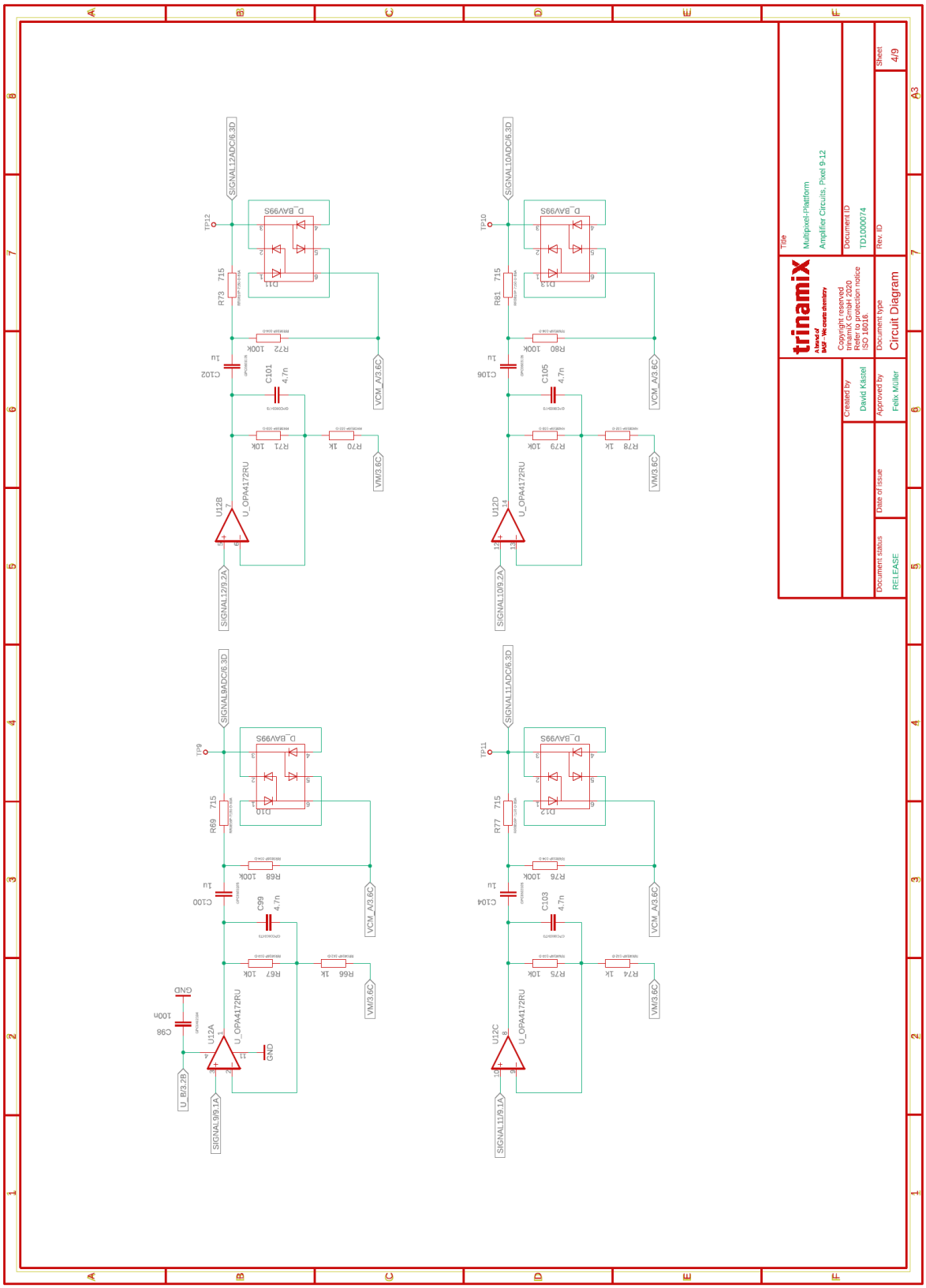
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Document type
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Created by
David Kästel
Approved by
Felix Müller
Date of issue
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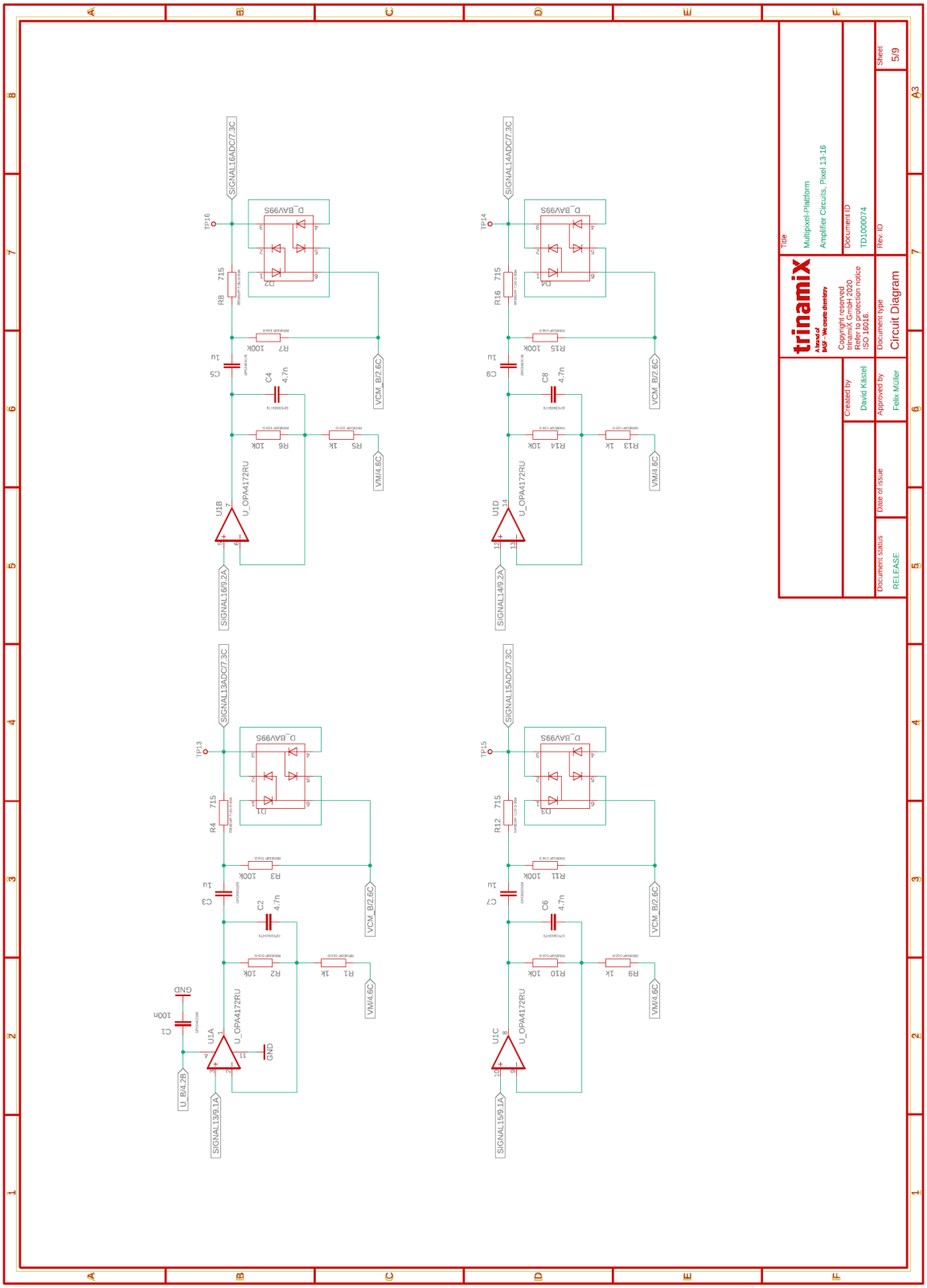
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Created by
David Kästel
Approved by
Felix Müller
Date of issue
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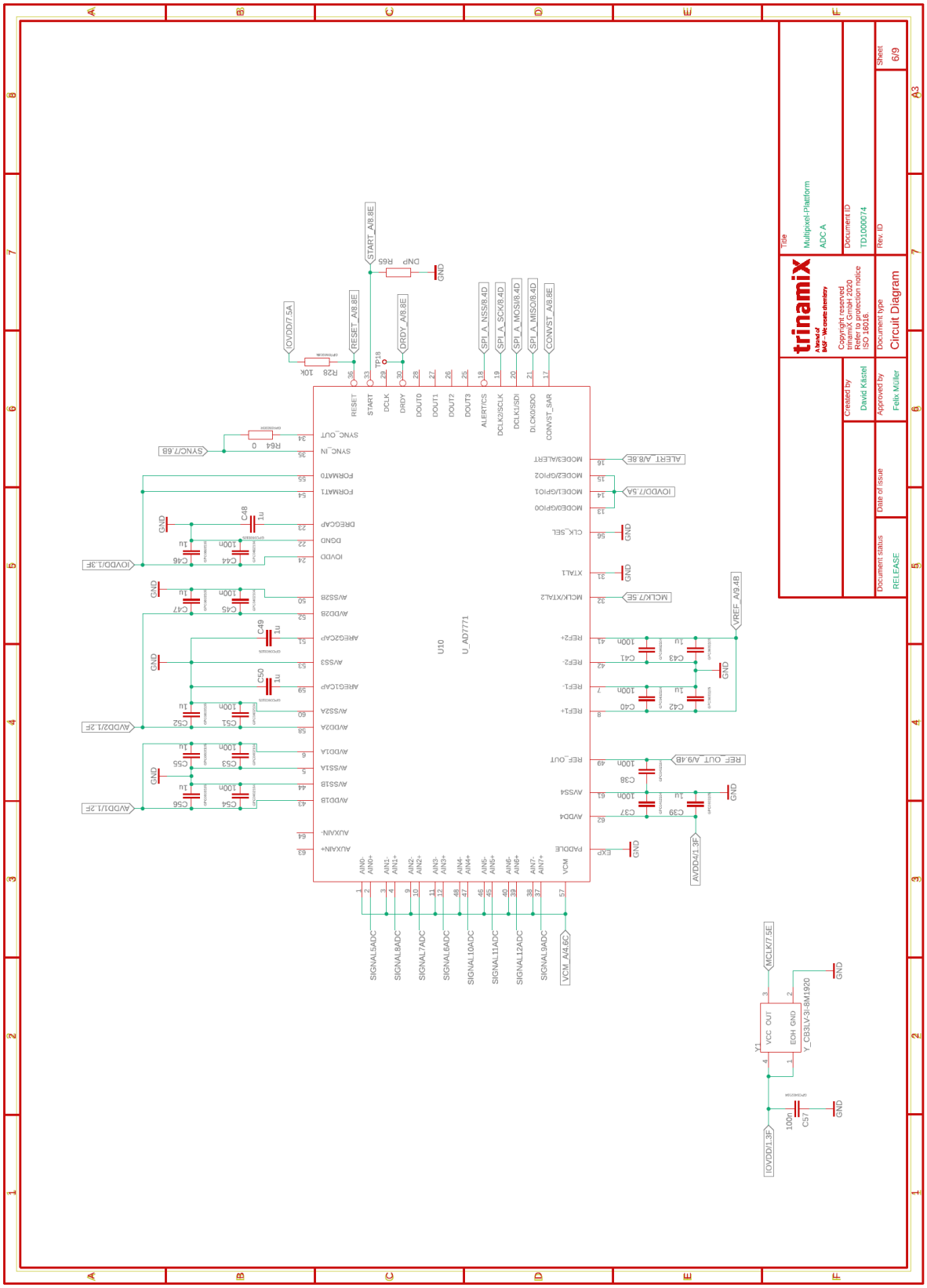

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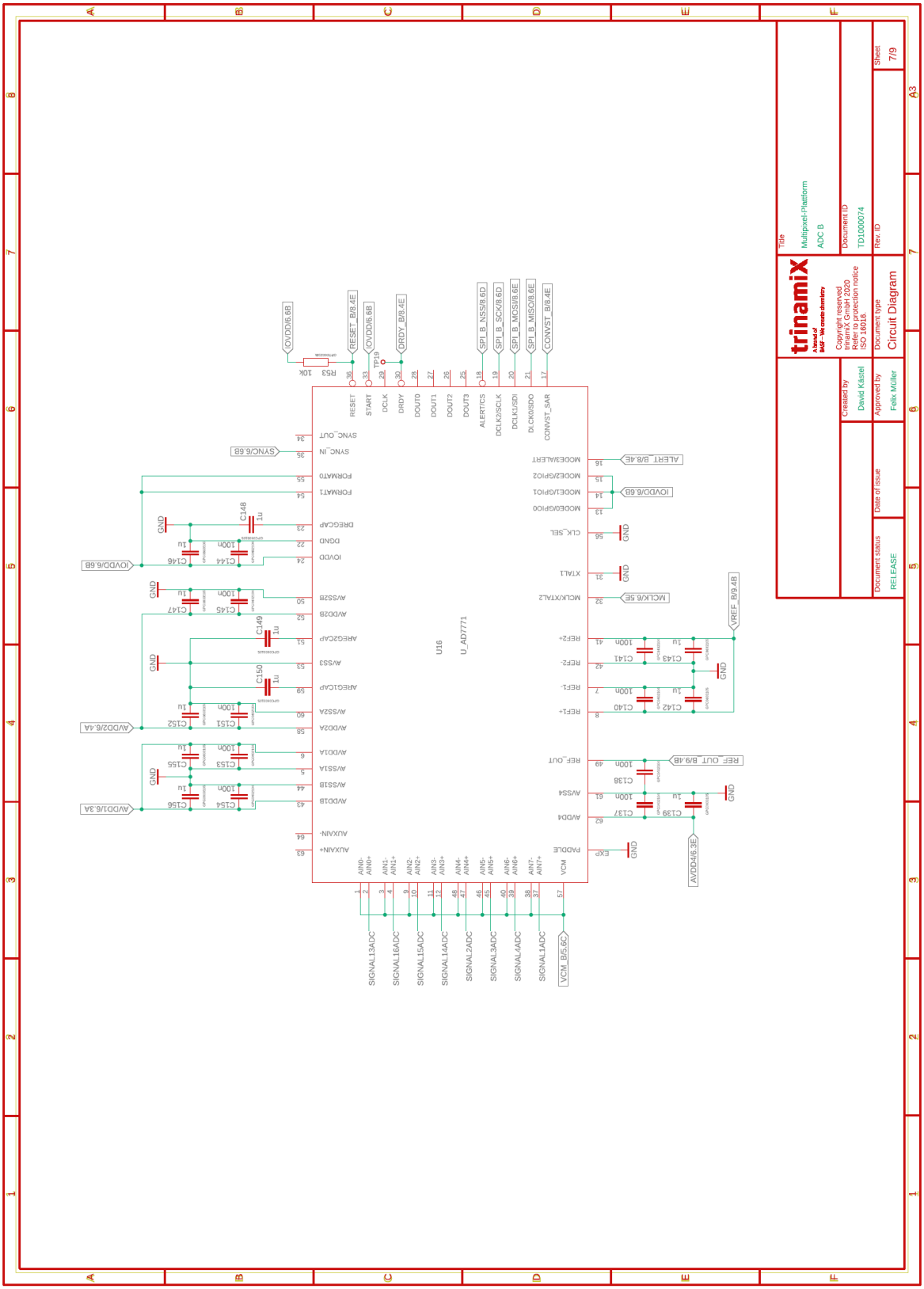

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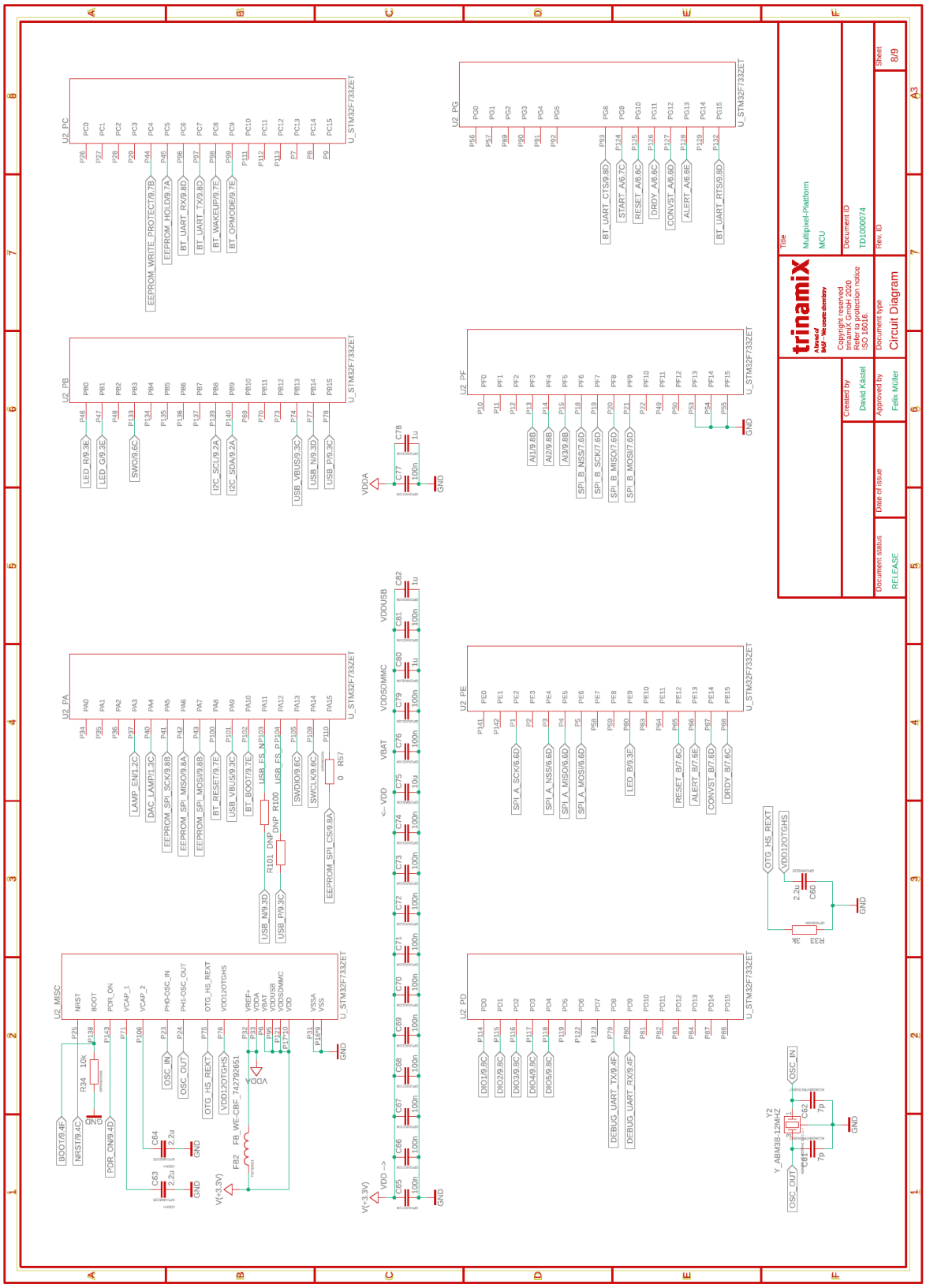
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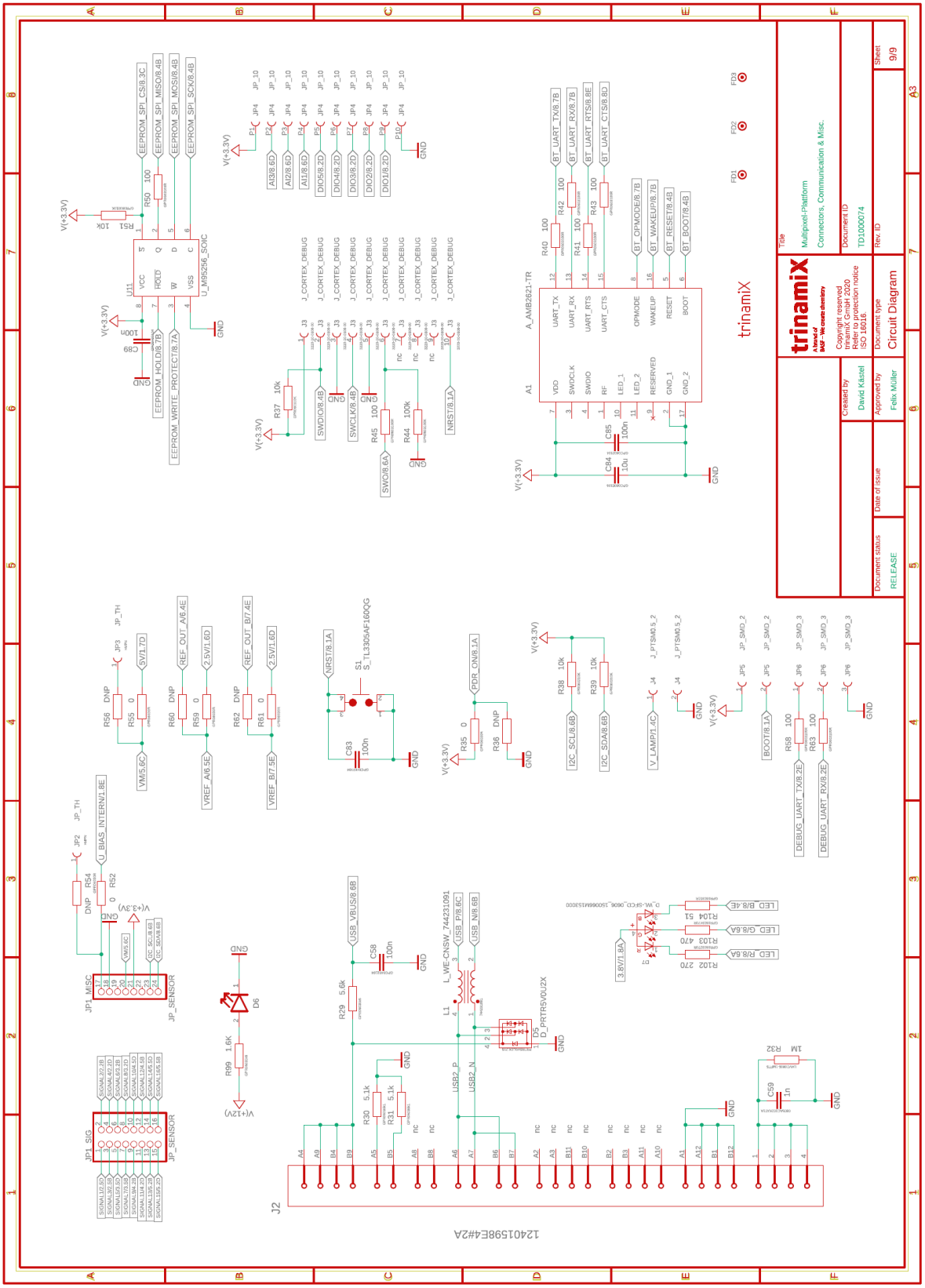

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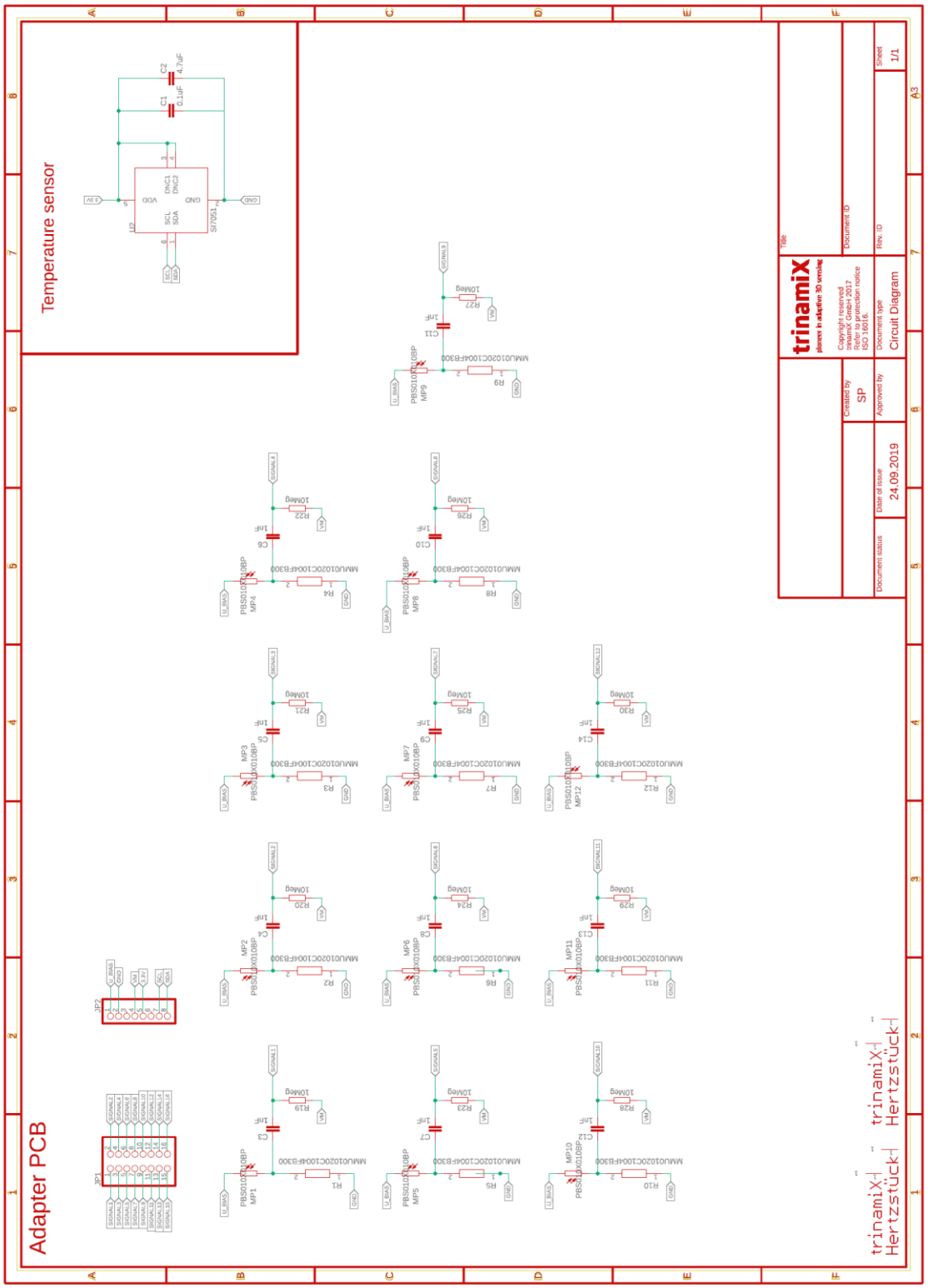
7.3.2. Adapter PCB



8. Disclaimer

Multi-Pixel Evaluation Kit (EK) by trinamiX

WARNINGS, RESTRICTIONS AND DISCLAIMERS

This EK with electrical accessories is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY and is not considered by trinamiX to be a finished end product fit for general consumer use. Persons handling the EK must have electronics training and observe good engineering practice standards. As such, the EK being provided is not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards.

This EK does not fall within the scope of the European Union directives regarding restricted substances (RoHS), recycling (WEEE), FCC, or UL, and therefore may not meet the technical requirements of these directives or other related directives. It should not be used at all or be part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EK for evaluation, testing and other purposes.

2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EK. Further, you are responsible to assure that any interfaces (electronic and/or mechanical) between the EK and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard.

3. You will employ reasonable safeguards to ensure that your use of the EK will not result in any property damage, injury or death, even if the EK should fail to perform as described or expected.

4. You will take care of proper disposal and recycling of the EK's electronic components and packing materials. Exceeding the specified EK ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings, please contact a trinamiX field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the EK and/or interface electronics. If there is uncertainty as to the load specification, please contact a trinamiX field representative.

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's Guide. 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.

Agreement to Defend, Indemnify and Hold Harmless. You agree to defend, indemnify and hold trinamiX, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of or in connection with any use of the EK that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EK fails to perform as described or expected.

FCC NOTICE: This EK is designed to allow:

(1) Product developers to evaluate electronic components, circuitry, or software associated with the EK to determine whether to incorporate such items in a finished product and

(2) Software developers to write software applications for use with the end product. This EK is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this EK not cause harmful interference to licensed radio stations and that this EK accept harmful interference. Unless the assembled EK is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the EK must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.