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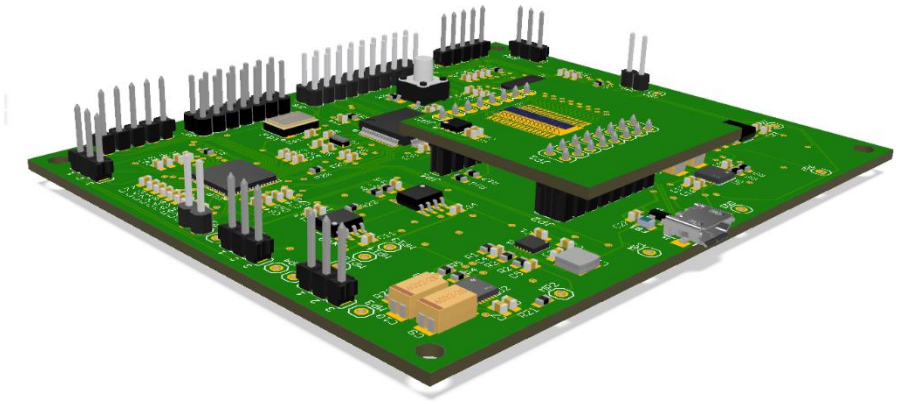
Multi-Pixel Evaluation Kit by trinamiX

User guide

PCB V2, Firmware V1.3

Key features

- USB power supply
- 16 channels
- 4 kHz default sampling frequency
- 16 Bit default resolution
- On-board temperature sensor
- Read out and data analysis with standalone software
- Plug & Play



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Release Date: July 3rd, 2020
ver. 1.5

Contents

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 be, for instance, be customized to directly fit into a prototype system of a customer.

Fig. 2 illustrates a functional block diagram of the Evaluation Kit including the main PCB, the adapter PCB and the Multi-Pixel detector.

The Evaluation Kit is designed to be powered from a micro USB port (min. USB 2.0) and does not need any additional external power supply. The same connection is employed to transfer the recorded data to a computer. From the voltage delivered by the USB port, the main PCB generates the required supply voltages and a stabilized bias voltage of 10 V for the Multi-Pixel detectors. The raw signal of each Multi-Pixel detector and the signal of a temperature sensor sitting adjacent to the detector chip is amplified on the adapter PCB. Two analog-digital converters (ADC) are employed to digitize the analog output signals simultaneously. A microcontroller processes the digitized data and transfer the data to a computer via the USB port.

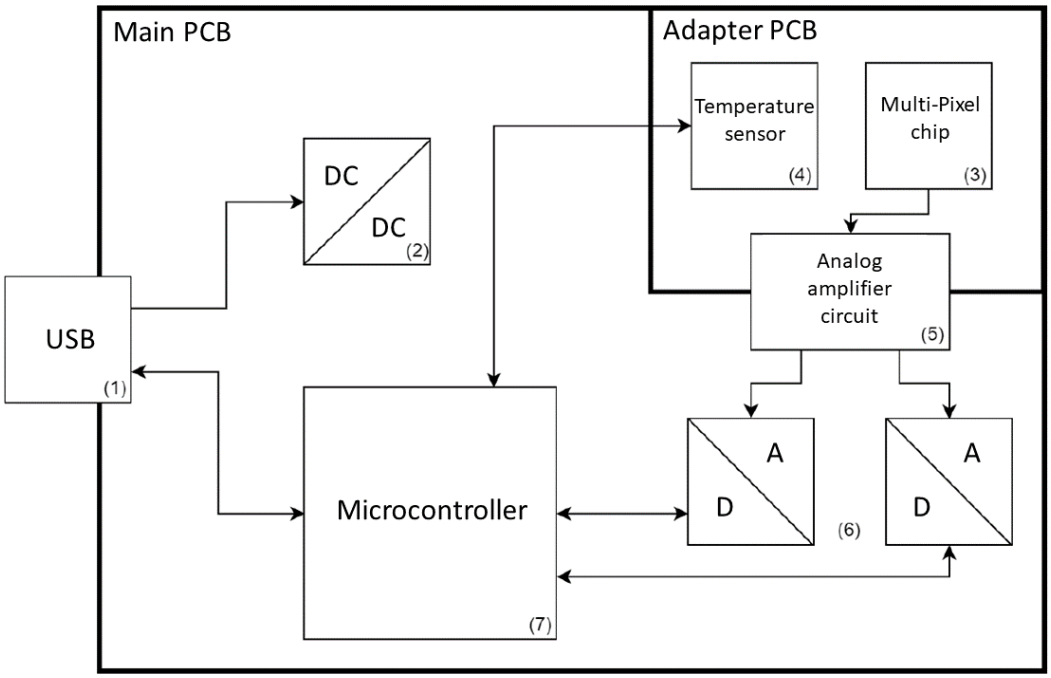


Figure 2: Multi-Pixel Evaluation Kit functional block diagram: (1) USB, (2) power supply, (3) Multi-Pixel chip, (4) temperature sensor, (5) analog amplifier circuit, (6) two ADCs, and (7) microcontroller.

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)	5	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 3: 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.msi*" and follow the instructions.

4. Functionality test

Proper functioning of the Evaluation Kit can be verified by measuring following measurement points (MP) on the main PCB (Table 3):

Measurement point	Typ.	Unit
MP1 (V_{IN})	5	V
MP2	11.5	V
MP3	10.8	V
MP4	5	V
MP5 (V_{BIAS})	10	V
MP6	3.3	V
MP7	2.5	V
MP8	1.65	V
MP9	1.65	V

Table 3: Voltages at different measurement points (MP).

In order to monitor the analog Multi-Pixel detector signal after the amplifier circuit and before the ADC, additional measurement points are available on the main PCB for channel 1 and channel 13. MP10 and MP13 are located directly after the analog amplifier where the signal is amplified by a factor of 11 and is afflicted with an offset of 5V.

To fit the analog input range of the ADC, the signal is brought to an offset of 1.65 V using a high pass filter (MP11 and MP14).
In order to protect the ADC from voltage spikes, a voltage clipper is employed (MP12 and MP15). An overview of the measurement points for the analog circuit are listed in Table 4.

Channel	Measurement point	Description	DC Offset
CH1	MP10	Analog signal after amplifier	5 V
	MP11	Analog signal after high pass	1.65 V
	MP12	Analog signal after voltage clipper	1.65 V
CH13	MP13	Analog signal after amplifier	5 V
	MP14	Analog signal after high pass	1.65 V
	MP15	Analog signal after voltage clipper	1.65 V

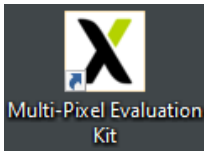
Table 4: Analog signal at different measurement points.

5. Data recording and analysis

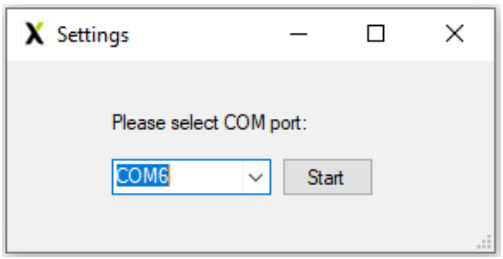
Please note that for working with the Multi-Pixel Evaluation Kit, an external modulated/chopped infrared radiation source is required. The allowed frequency range of the Evaluation Kit is 10 Hz to 2 kHz.

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

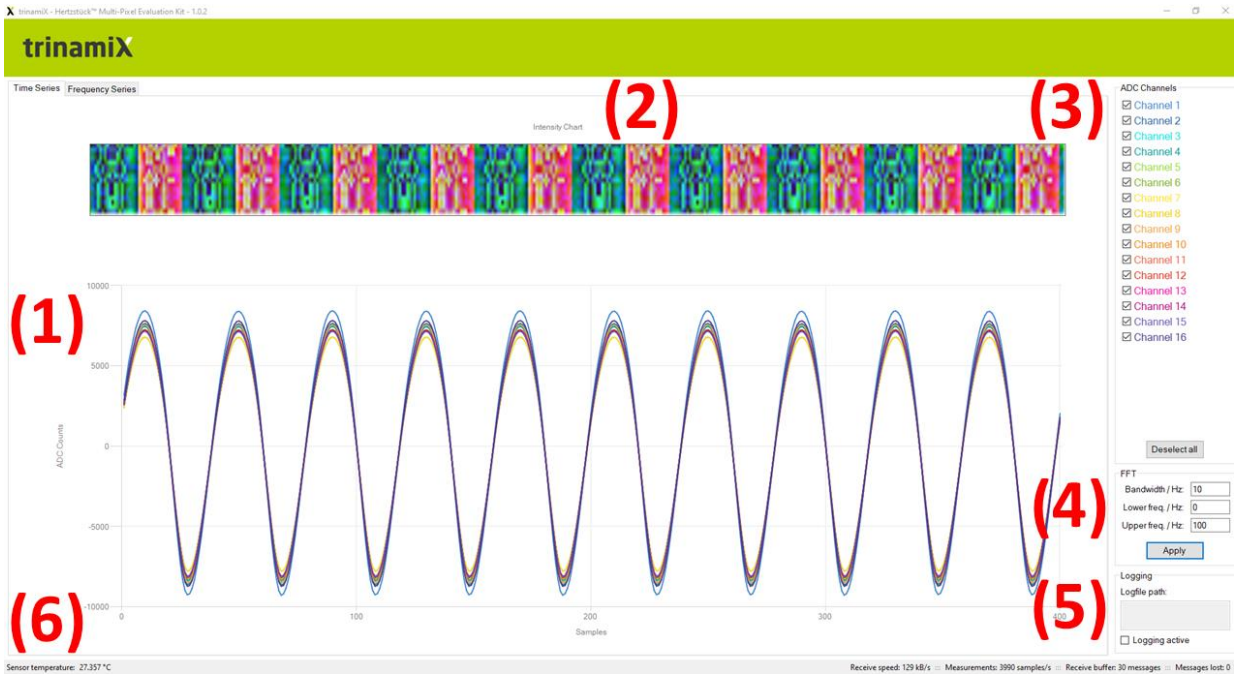
1. Connect the micro USB port via the supplied cable to an available USB port of the computer.
2. Open the shortcut "*Multi-Pixel Evaluation Kit*" on your desktop to run the software:



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

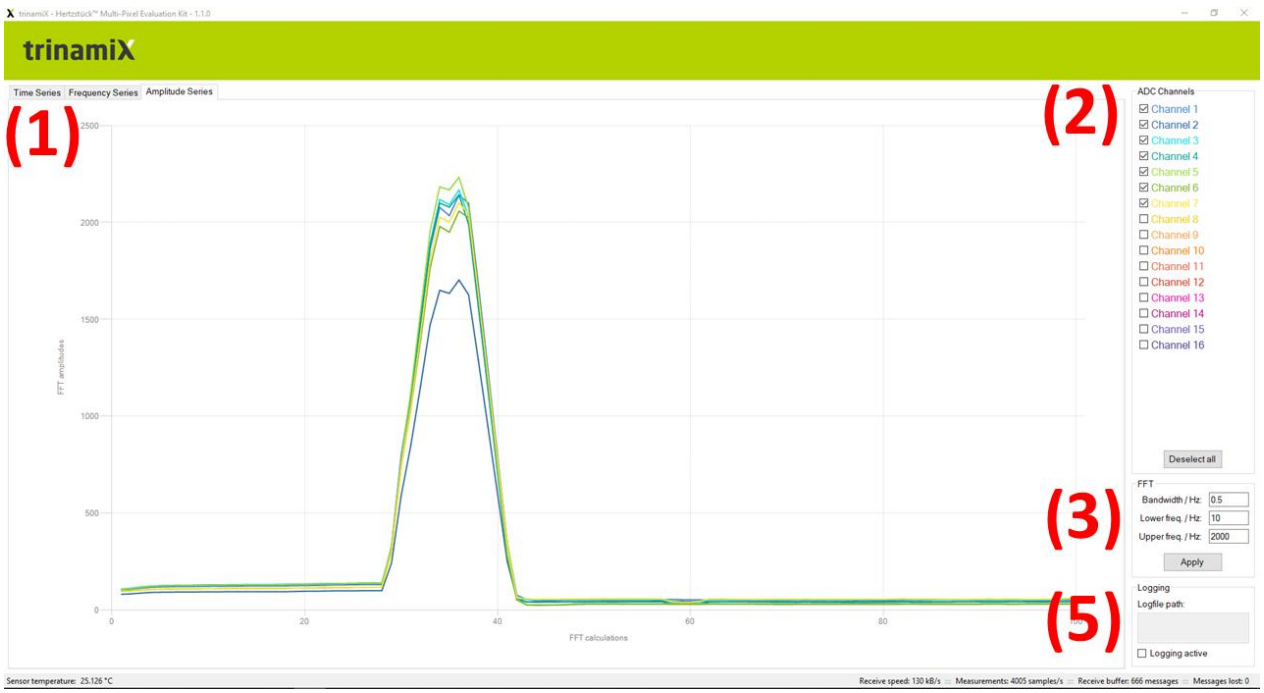


4. Tab "*Time series*":
5. This tab provides the ADC signal counts over samples for all channels of the Evaluation Kit **(1)** including an intensity chart **(2)**. The channels to be displayed can be selected by the bar top right **(2)**. The number of samples shown on the x-axis can be varied by increasing or decreasing the bandwidth value **(4)**. In order to activate and save a Logfile, please tick the box down right **(6)** and select a file name and file path. The value of the temperature sensor on the adapter PCB is displayed down left **(6)**.



6. 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.

7. 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 **(2)**.
   The bandwidth of the calculated FFT can be varied in the box down right **(3)**.
   Again, in order to activate and save a Logfile, please tick the box down right **(4)** and select a file name and file path.



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.

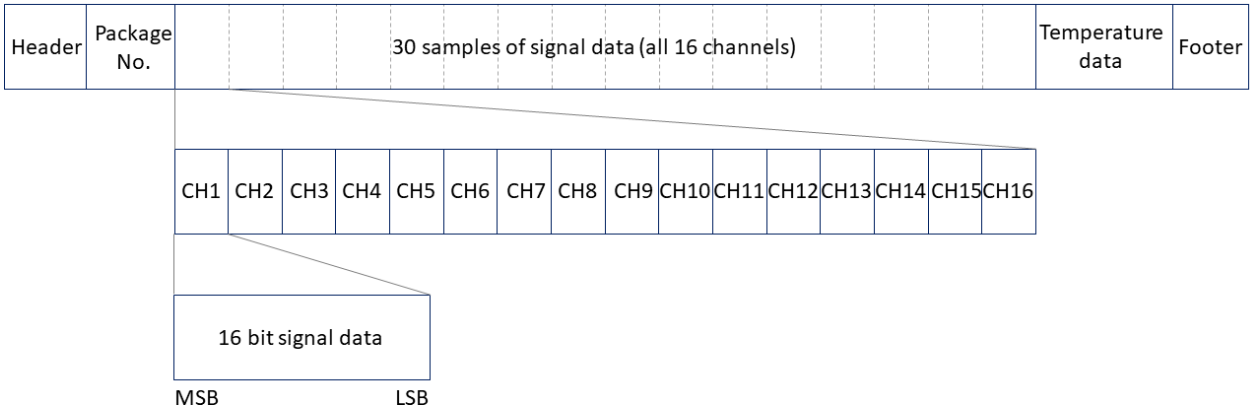


Figure 4: Bit order of data packages provided by USB.

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.

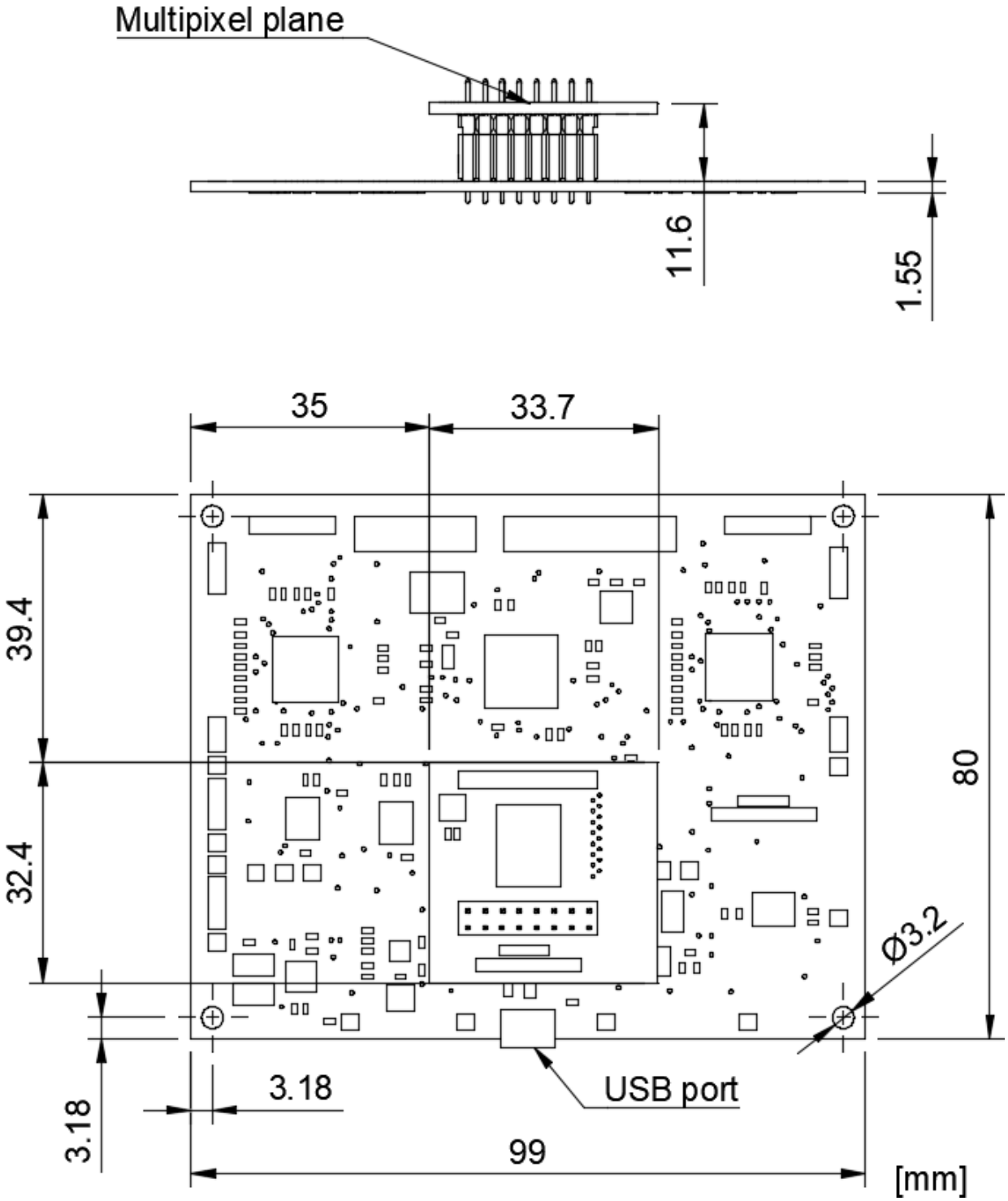
For the correct voltage value representation in a Root Mean Square value (RMS), please use the following expression:

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

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

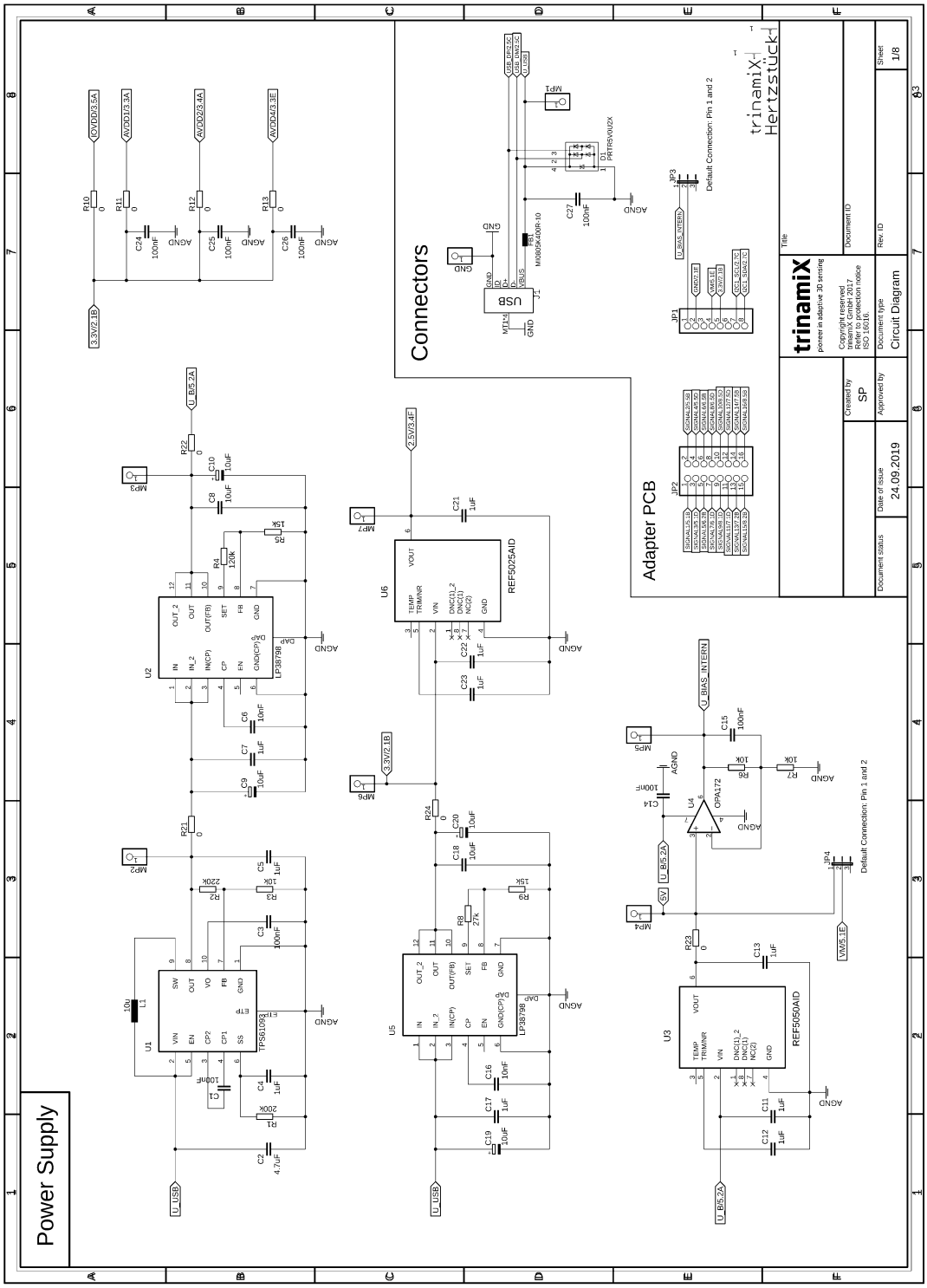
7. Appendix

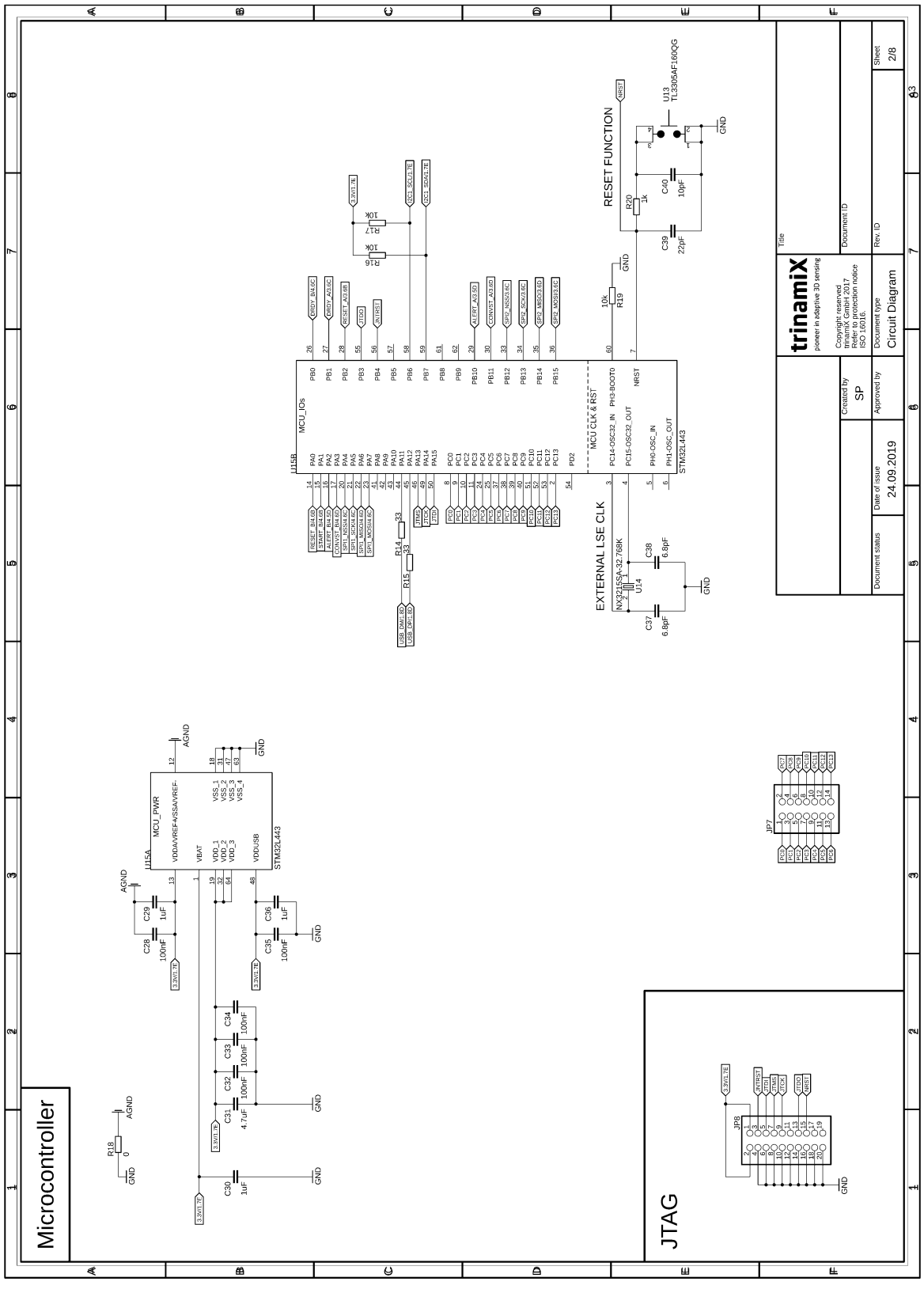
7.1. Technical drawing



7.2. Circuit schematics

7.2.1. Main PCB

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MCU_PWR
MCU CLK & RST
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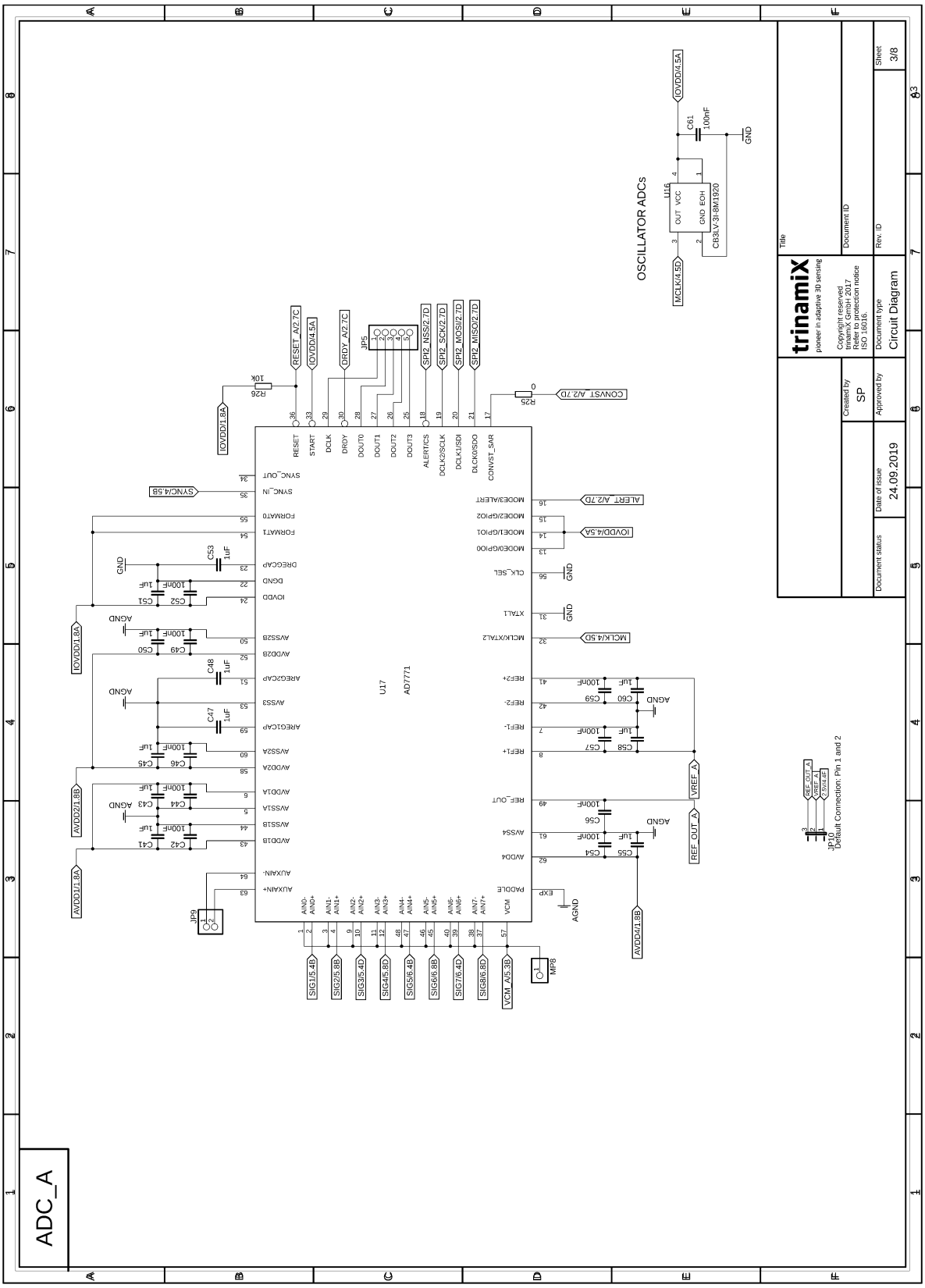
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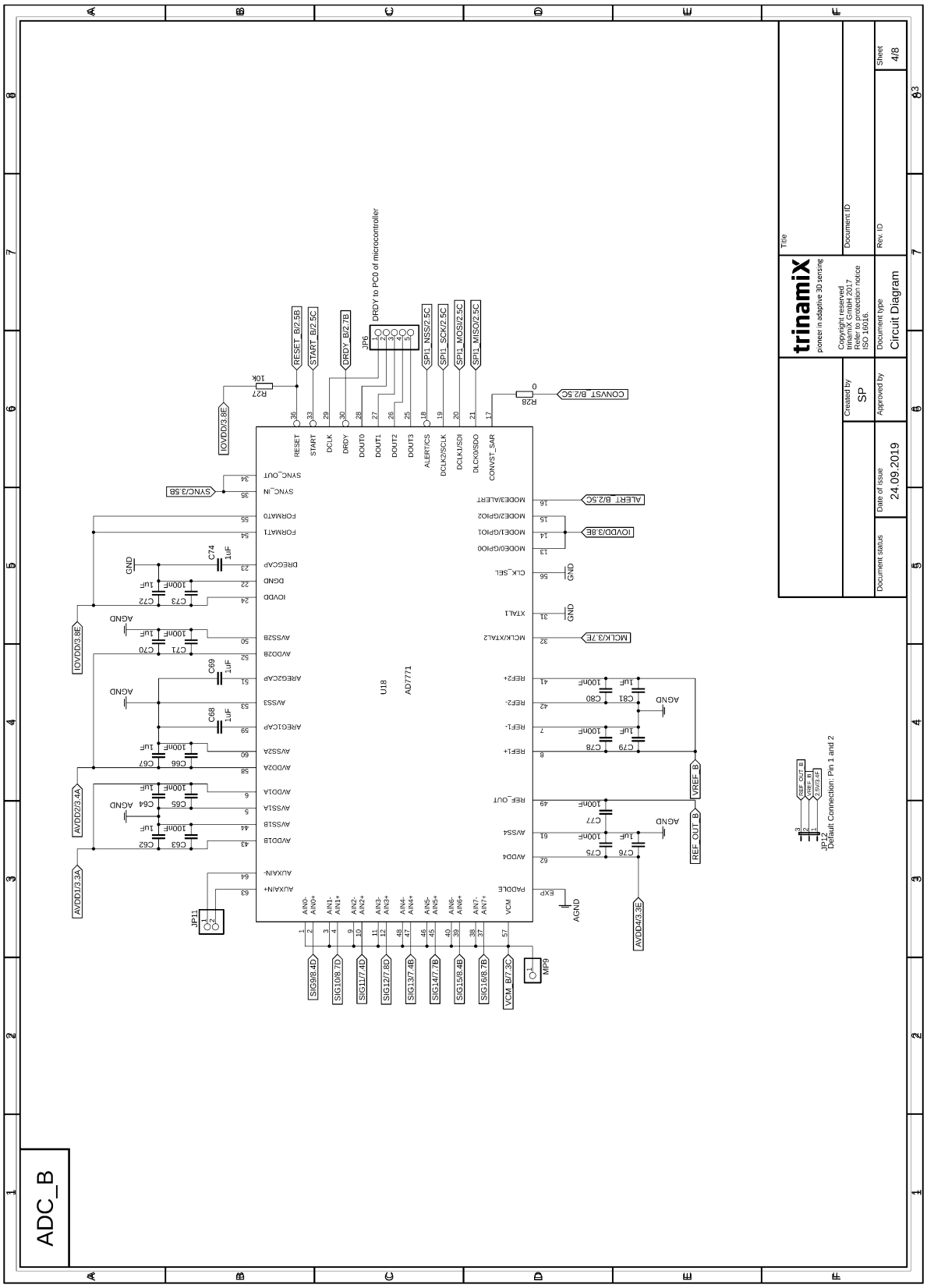

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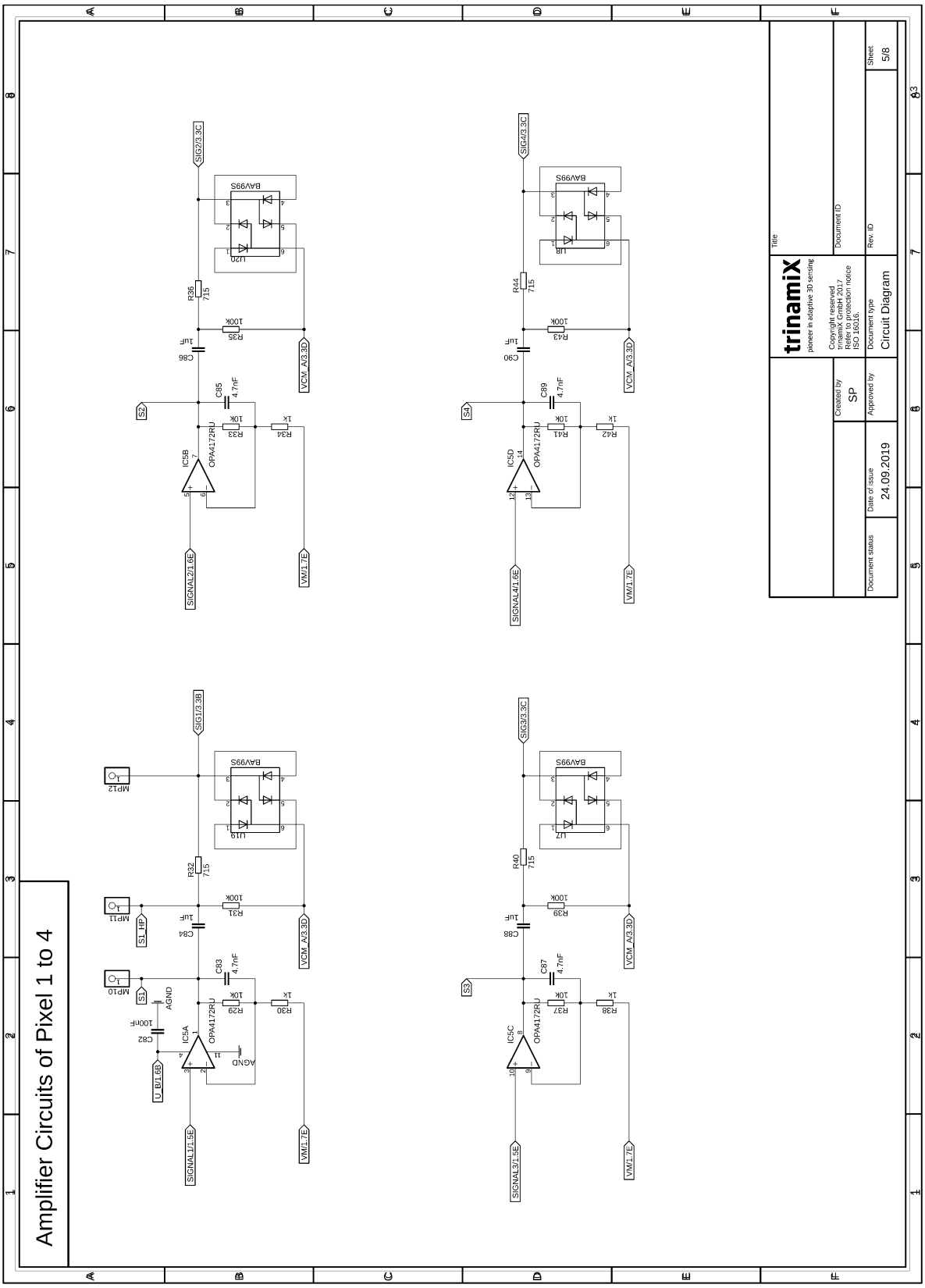
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SIG4/3.3C
SIG1/3.3B
SIG3/3.3C
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R44 715
R32 715
R40 715
100K
1UF
C86
C90
C84
C88
C85 4.7nF
C89 4.7nF
C83 4.7nF
C87 4.7nF
S2
S4
S1
S3
IC5B
IC5D
IC5A
IC5C
OPA4172RU
R33 10K
R41 10K
R29 10K
R37 10K
R34 1K
R42 1K
R30 1K
R38 1K
VCM_A/3.3D
VM/1.7E
SIGNAL2/1.6E
SIGNAL4/1.6E
SIGNAL1/1.5E
SIGNAL3/1.5E
MP12
MP11
MP10
S1_HP
AGND
C82 100nF
U_B/1.6B
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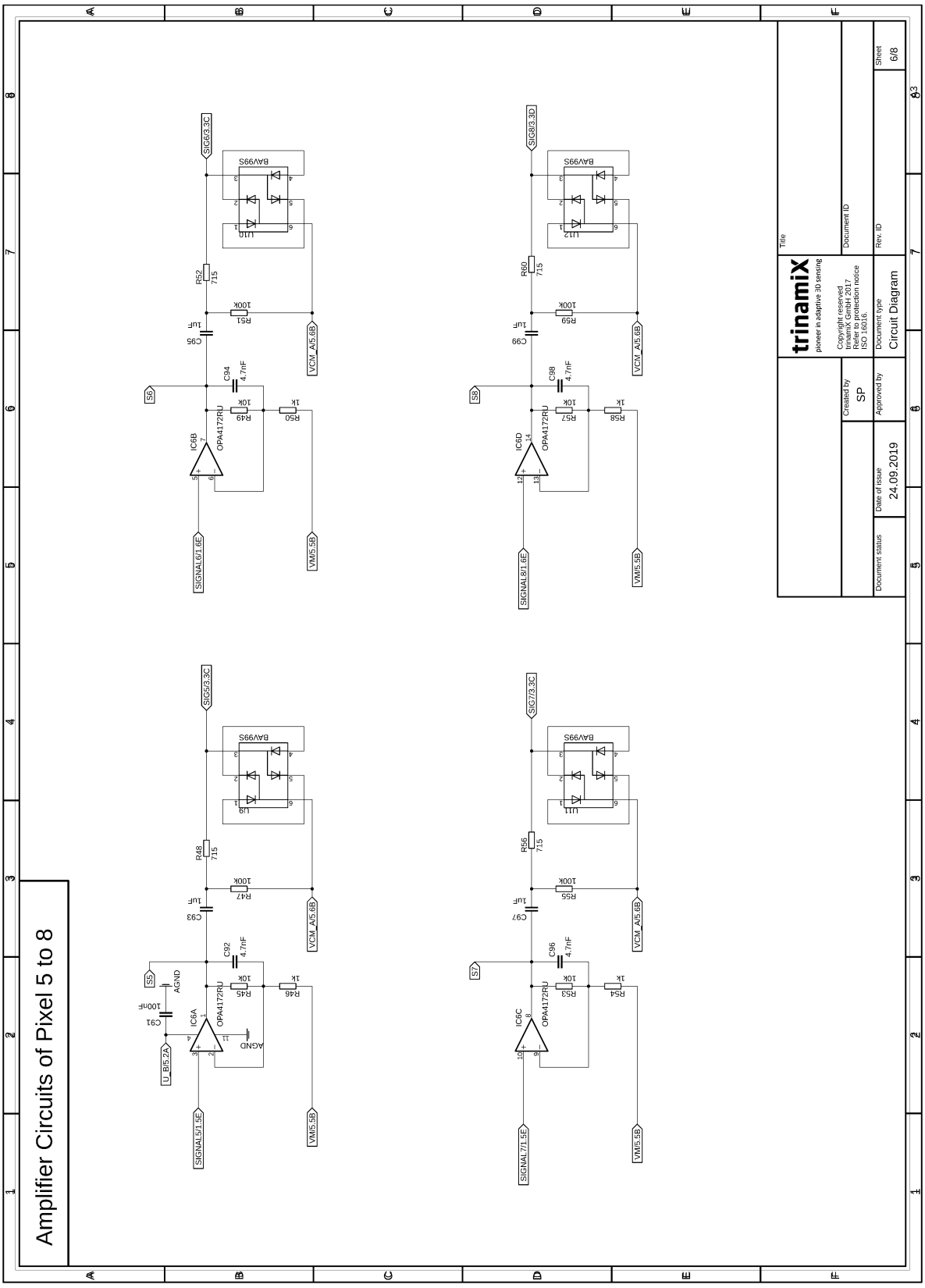
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R48 715
R47 100K
C93 1uF
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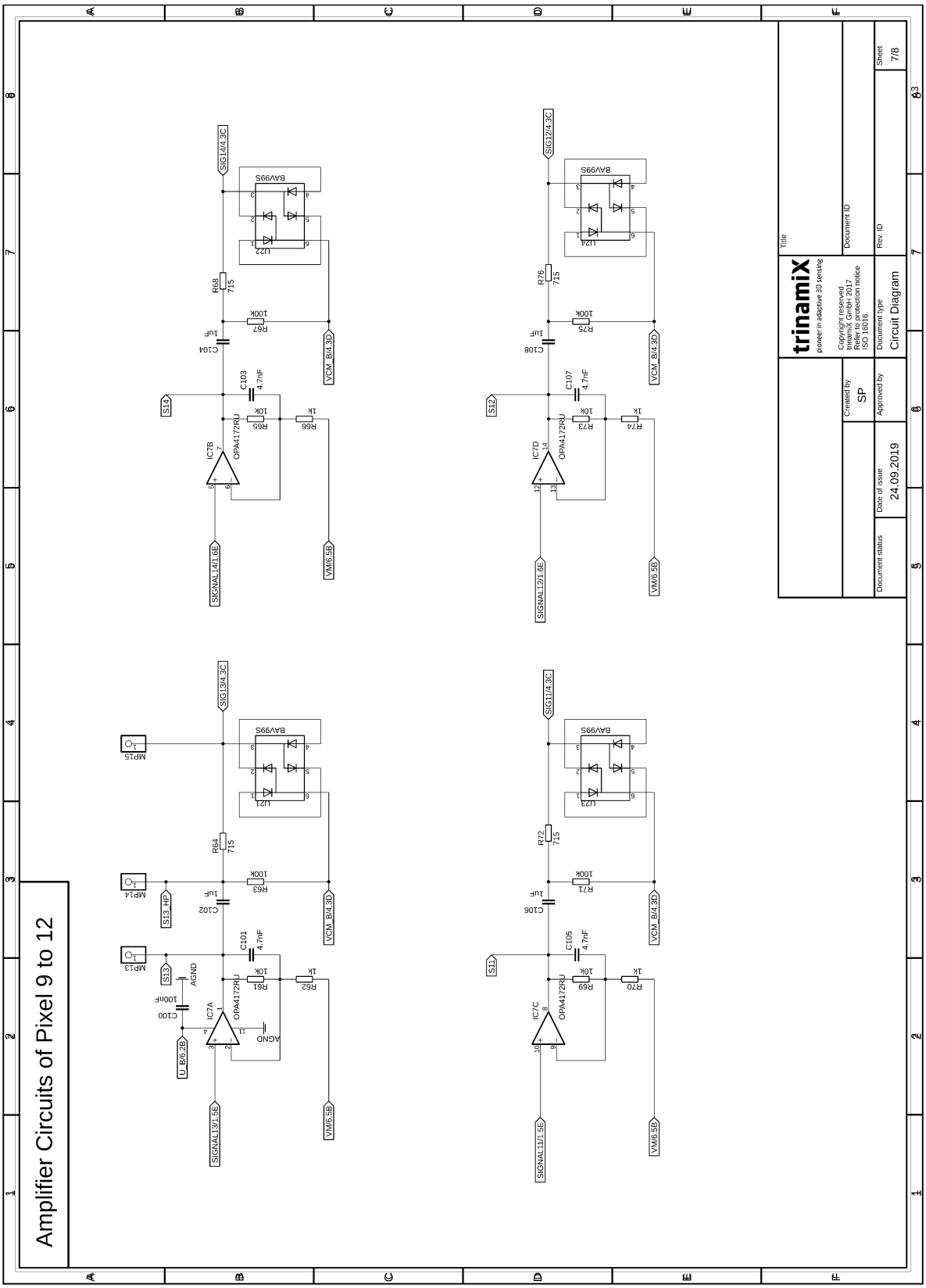

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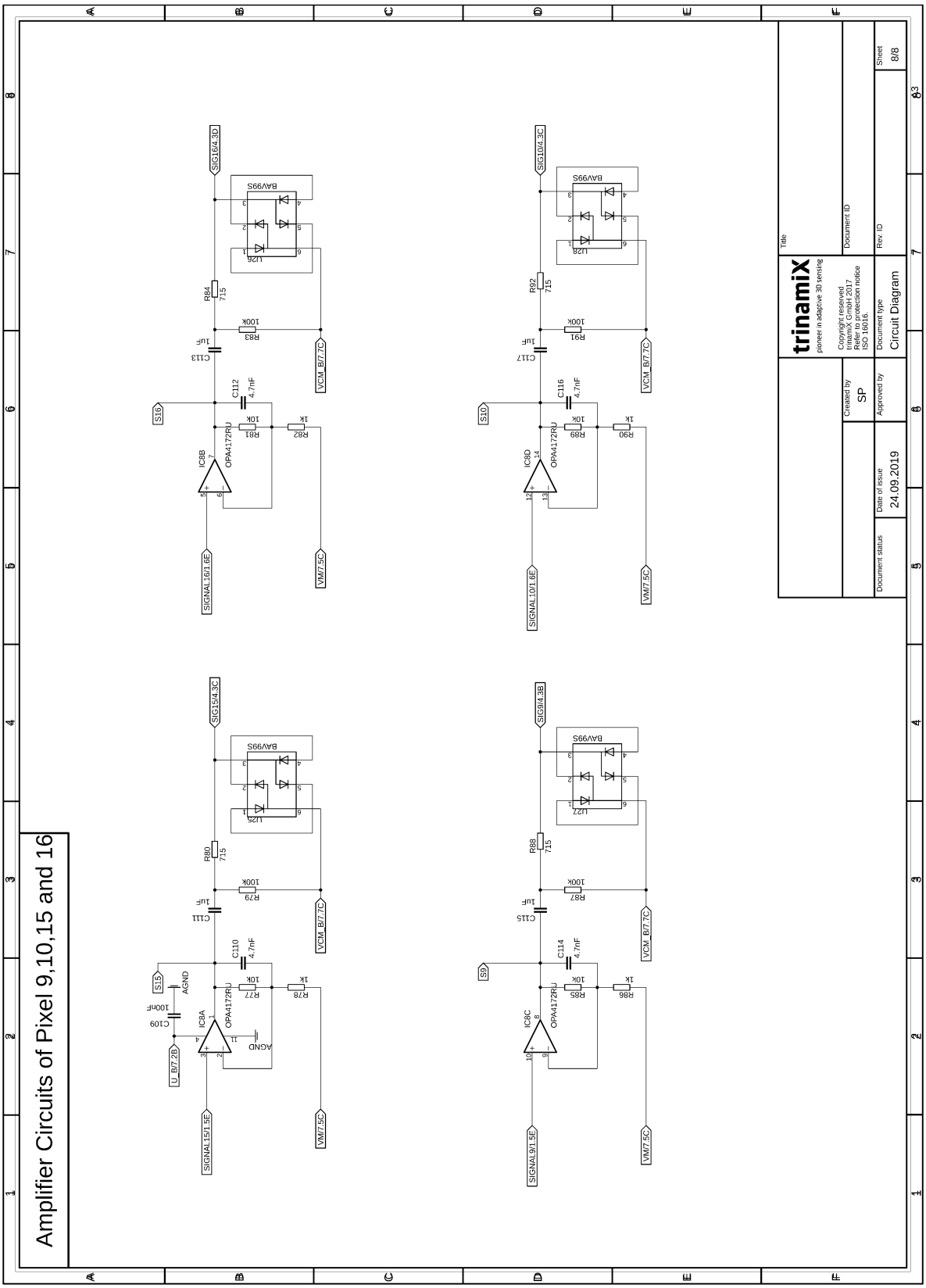
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SIG15/4.3C
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R83
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4.7nF
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VM/7.5C
VCM_B/7.7C
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R91
C117
C116
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R89
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R80
R79
C111
C110
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R77
R78
AGND
C109
100nF
IC8A
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SIGNAL15/1.5E
R88
R87
C115
C114
S9
R85
R86
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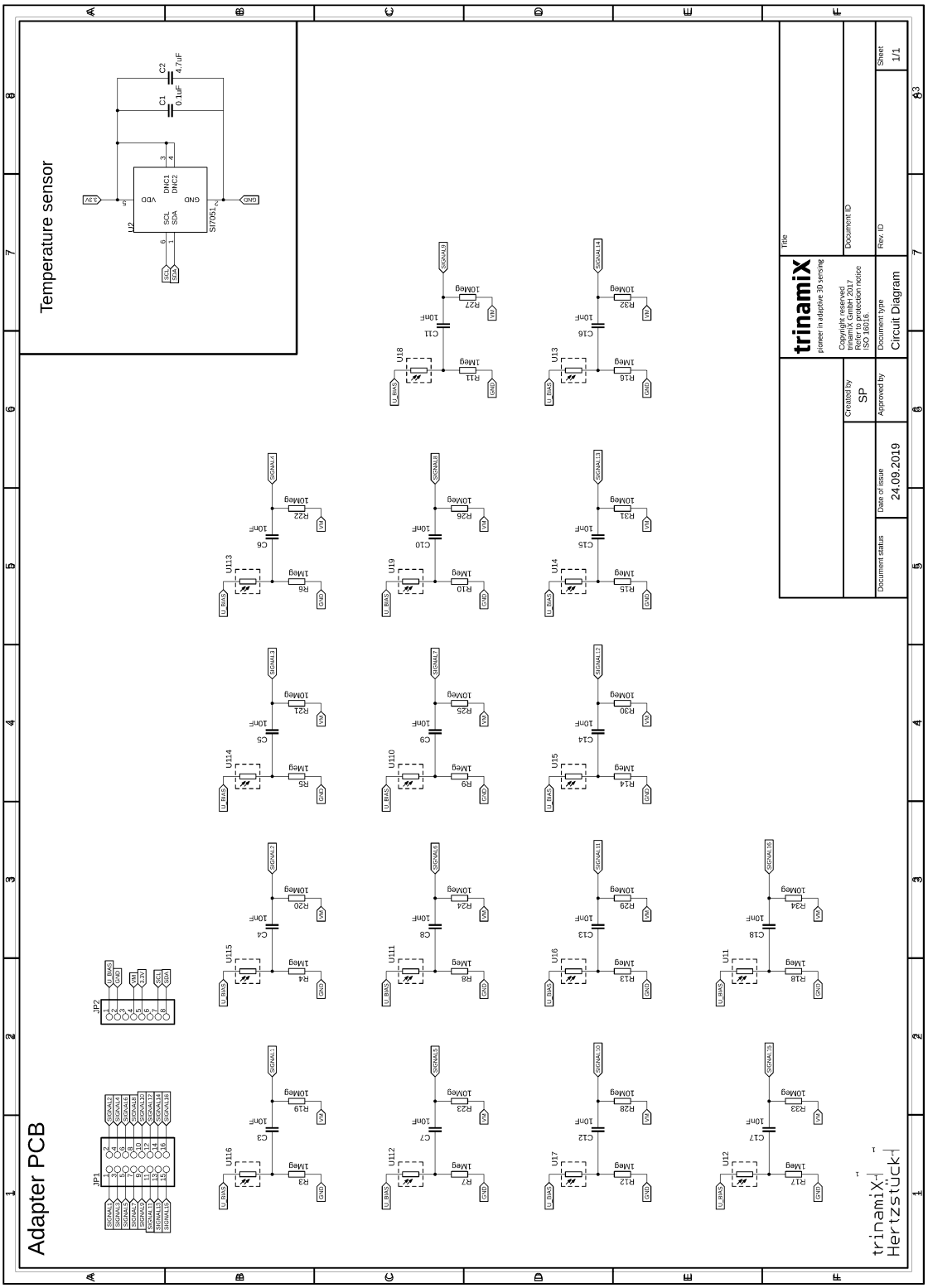
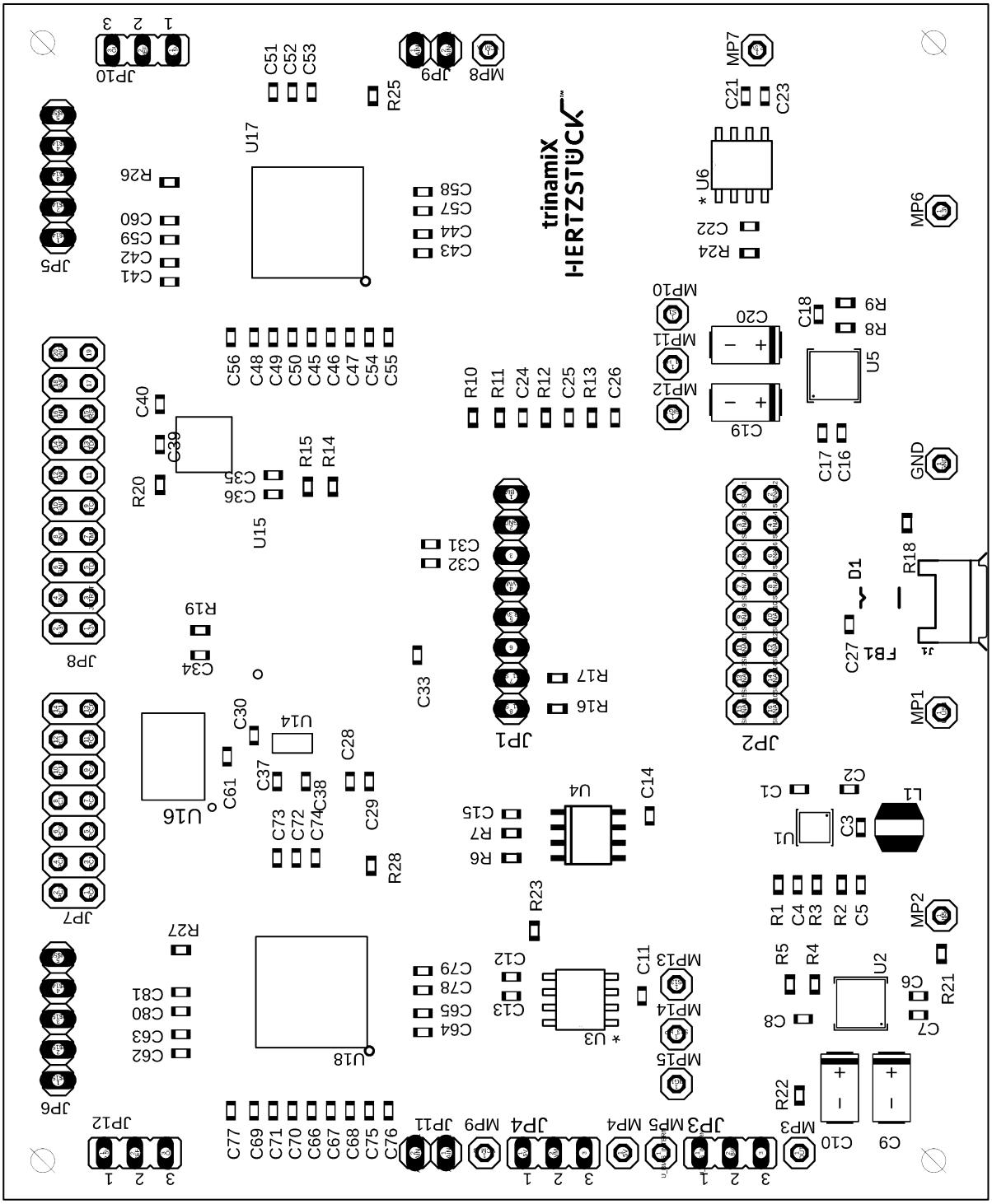
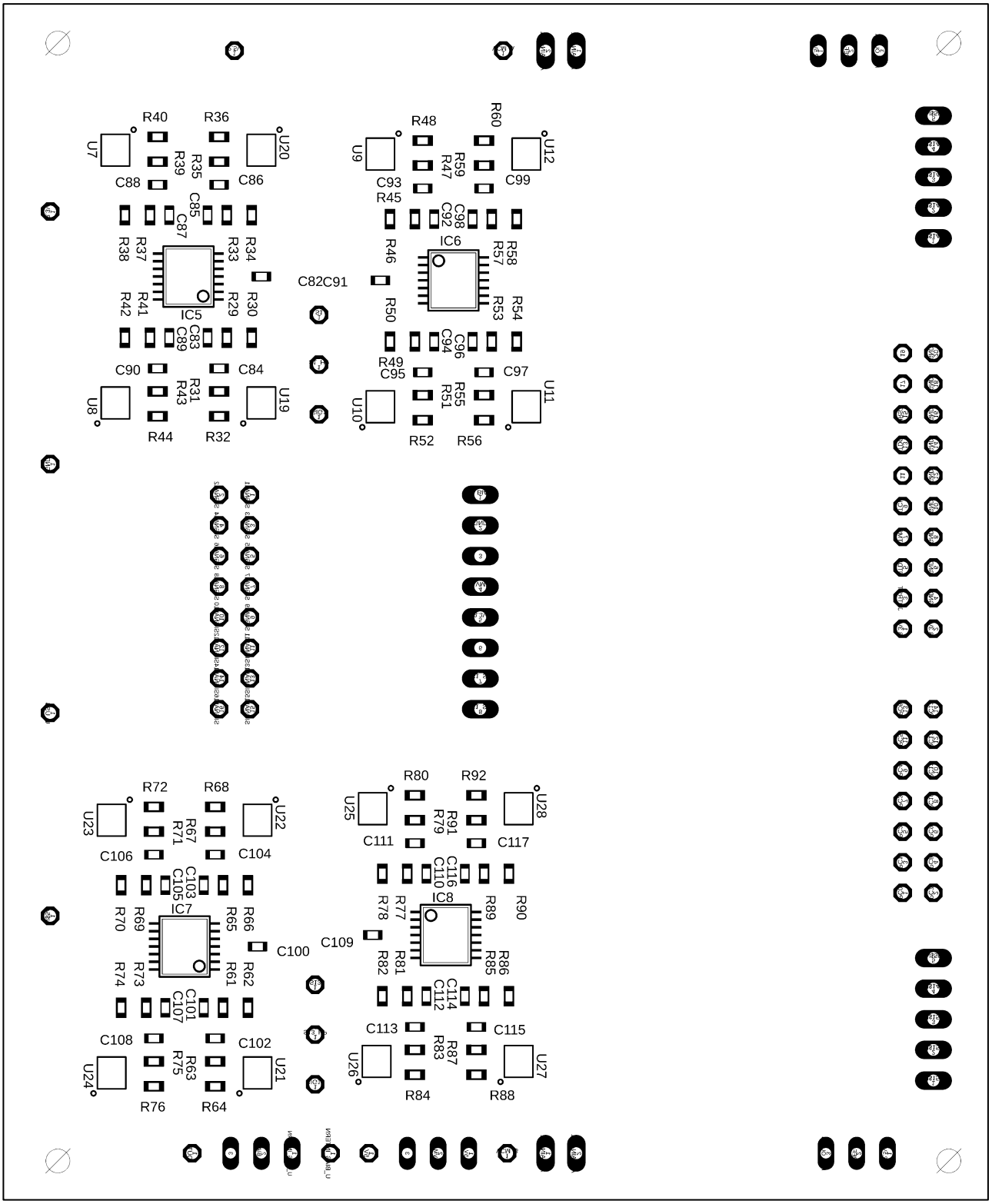
7.2.2. Adapter PCB



7.3. Bill of materials

7.3.1. Main PCB

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R68
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C106
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IC7
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C100
R74
R73
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C116
C110
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IC8
R89
R90
C109
R82
R81
R86
R85
C114
C112
C113
C115
U26
U27
R87
R83
R84
R88

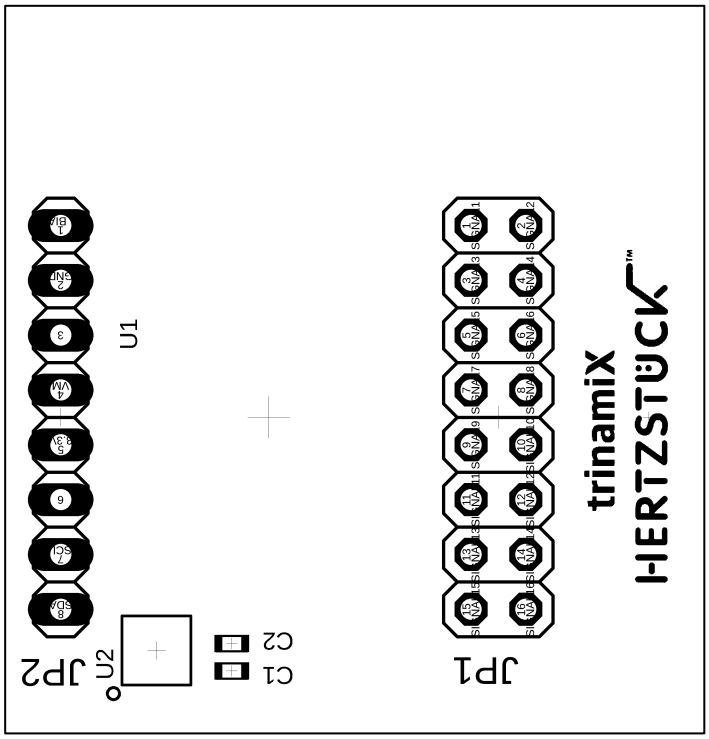
Designator	Value	Description
C1, C3, C14, C15, C24, C25, C26, C27, C28, C32, C33, C34, C35, C42, C44, C46, C49, C52, C54, C56, C57, C59, C61, C63, C65, C66, C71, C73, C75, C77, C78, C80, C82, C91, C100, C109	100 nF	Capacitor, 0603, X7R, 50V, ±10%
C2, C31	4.7 µF	Capacitor, 0603, X5R, 16V, ±10%
C4, C5, C7, C11, C12, C13, C17, C21, C22, C23, C29, C30, C36, C41, C43, C45, C47, C48, C50, C51, C53, C55, C58, C60, C62, C64, C67, C68, C69, C70, C72, C74, C76, C79, C81, C84, C86, C88, C90, C93, C95, C97, C99, C102, C104, C106, C108, C111, C113, C115, C117	1 µF	Capacitor, 0603, X5R, 16V, ±10%
C6, C16	10 nF	Capacitor, 0603, X7R, 50V, ±10%
C8, C18	10 µF	Capacitor, 0603, X5R, 25V, ±10%
C9, C10, C19, C20	10 µF	Capacitor, Tantalum 6032, 25V, ±10%
C37, C38	6.8 pF	Capacitor, 0603, C0G, 50V, ±0.1pF
C39	22 pF	Capacitor, 0603, X7R, 50V, ±10%
C40	10 pF	Capacitor, 0603, C0G, 50V, ±0.1pF
C83, C85, C87, C89, C92, C94, C96, C98, C101, C103, C105, C107, C110, C112, C114, C116	4.7 nF	Capacitor, 0603, X7R, 16V, ±10%
D1	PRTR5V0U2X	ESD protection diode
FB1	MI0805K400R-10	Ferrite Bead, 40Ω, 0805
IC5, IC6, IC7, IC8	OPA4172RU	Op-Amp, TSSOP14
J1		Connector, Micro-USB Type B
JP1		Connector, Board-to-Board, 1x8 Pins
JP2		Connector, Board-to-Board, 2x8 Pins
JP3, JP4, JP10, JP12		Connector, Board-to-Board, 1x3 Pins
JP5, JP6		Connector, Board-to-Board, 1x5 Pins
JP7		Connector, Board-to-Board, 2x7 Pins
JP8		Connector, Board-to-Board, 2x10 Pins
JP9, JP11		Connector, Board-to-Board, 1x2 Pins
L1	10 µH	VLS4012-100M, Inductance, 890mA, 228MΩ
R1	200 kΩ	Resistor, 0603, ±1%
R2	220 kΩ	Resistor, 0603, ±1%
R3, R6, R7, R16, R17, R19, R26, R27, R29, R33, R37, R41, R45, R49, R53, R57, R61, R65, R69, R73, R77, R81, R85, R89	10 kΩ	Resistor, 0603, ±1%
R4	120 kΩ	Resistor, 0603, ±1%

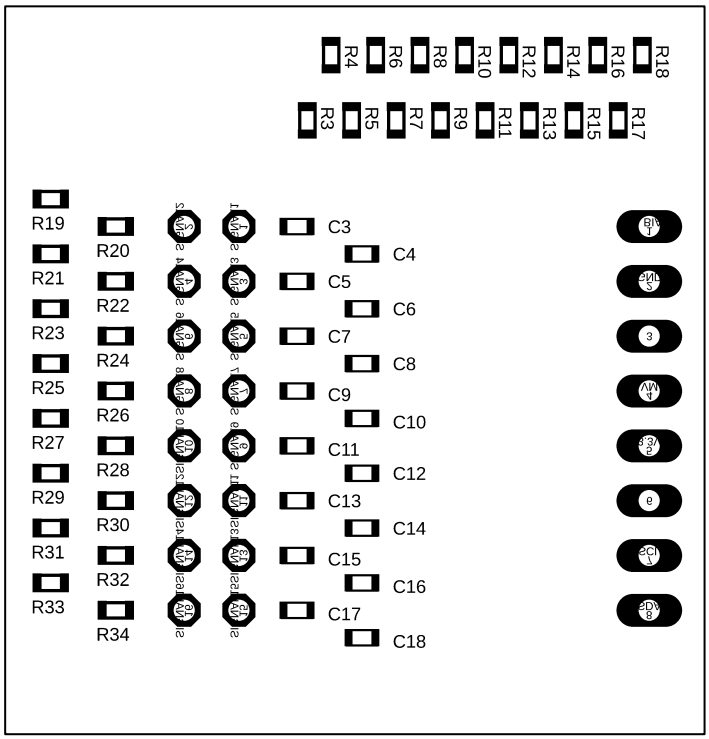
R5, R9	15 kΩ	Resistor, 0603, ±1%
R8	27 kΩ	Resistor, 0603, ±1%
R10, R11, R12, R13, R18, R21, R22, R23, R24, R25, R28	0 Ω	Resistor, 0603, ±1%
R14, R15	33 Ω	Resistor, 0603, ±1%
R20	1 kΩ	Resistor, 0603, ±1%
R20, R30, R34, R38, R42, R46, R50, R54, R58, R62, R66, R70, R74, R78, R82, R86, R90	Standard: 1 kΩ	Resistor, 0603, ±1% (for PbS detectors)
R30, R34, R38, R42, R46, R50, R54, R58, R62, R66, R70, R74, R78, R82, R86, R90	Standard: 100 Ω	Resistor, 0603, ±1% (for PbSe detectors)
R31, R35, R39, R43, R47, R51, R55, R59, R63, R67, R71, R75, R79, R83, R87, R91	100 kΩ	Resistor, 0603, ±1%
R32, R36, R40, R44, R48, R52, R56, R60, R64, R68, R72, R76, R80, R84, R88, R92	720 Ω	Resistor, 0603, ±1%
U1	TPS61093	Boost Converter, WSON-10
U2, U5	LP38798	Regulator, WSON-12
U3	REF5050AID	Reference, SOIC-8, 5V, ±0.05%
U4	OPA172	Op-Amp, SOIC-8
U6	REF5025AID	Reference, SOIC-8, 2.5V, ±0.05%
U7, U8, U9, U10, U11, U12, U19, U20, U21, U22, U23, U24, U25, U26, U27, U28	BAV99S	High-speed switching diodes, SOT-363, quadruple
U13	TL3305AF160QG	Tactile Switch
U14	NX3215SA-32.768K	Crystal, 32.768kHz, ±20ppm
U15	STM32L443RC	Ultra-low-power Arm® Cortex®-M4 32-bit MCU+FPU
U16	CB3LV-3I-8M1920	Oscillator, 8.192MHz,
U17, U18	AD7771	ADC, 8-channel, 24-bit, simultaneous sampling

Please ensure that the jumper connections are set in their default state as listed in the table below:

Jumper	**Default Connection**
JP3	Pin 1 and 2 connected
JP4	Pin 1 and 2 connected
JP10	Pin 1 and 2 connected
JP12	Pin 1 and 2 connected

7.3.2. Adapter PCB





7.4. Bill of materials – Adapter board

Designator	Value	Description
C1	100 nF	Capacitor, 0603, X7R, 50V, ±10%
C2	4.7 µF	Capacitor, 0603, X5R, 16V, ±10%
C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, C17, C18	Value varies with choice of multipixel geometry	Capacitor, 0603
JP1		Connector, Board-to-Board, 1x8 Pins
JP2		Connector, Board-to-Board, 2x8 Pins
R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13, R14, R15, R16, R17, R18	Value varies with choice of multipixel geometry	Resistor, 0603, ±1%
R19, R20, R21, R22, R23, R24, R25, R26, R27, R28, R29, R30, R31, R32, R33, R34	Value varies with choice of multipixel geometry	Resistor, 0603, ±1%
U1		Multipixel Detector
U2	SI7051	Digital I2C Temperature Sensor

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.