

How to use the evaluation board for the ADC120 8-channel analog to digital converter

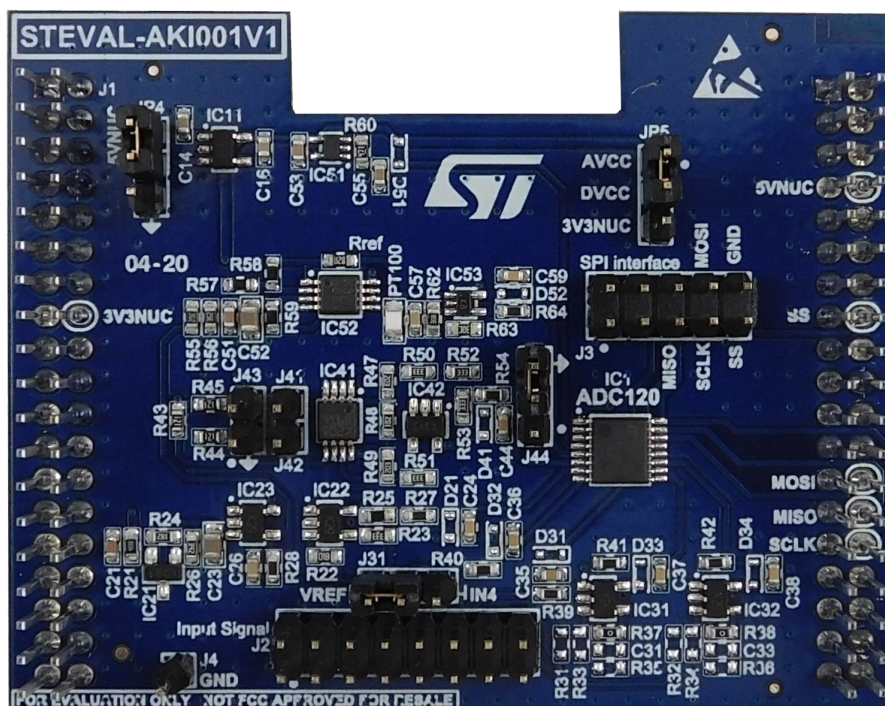
Introduction

The STEVAL-AKI001V1 evaluation board allows the user to evaluate the conversion performance of the ADC120 8-channel analog-to-digital converter designed for 50 ksp/s to 1 Msps conversion.

The board has several on-board sources like temperature sensor and strain gauge signals, and can accept external signals to allow measurement and evaluation of the ADC120 conversion performance based on its successive approximation register (SAR) with internal track-and-hold cell.

The board is supplied ready-to-use in standalone mode, or it can be plugged onto a NUCLEO-L476RG board with SMT32 microcontroller, which enables further signal processing and PC communication.

Figure 1. STEVAL-AKI001V1 evaluation board for the ADC120

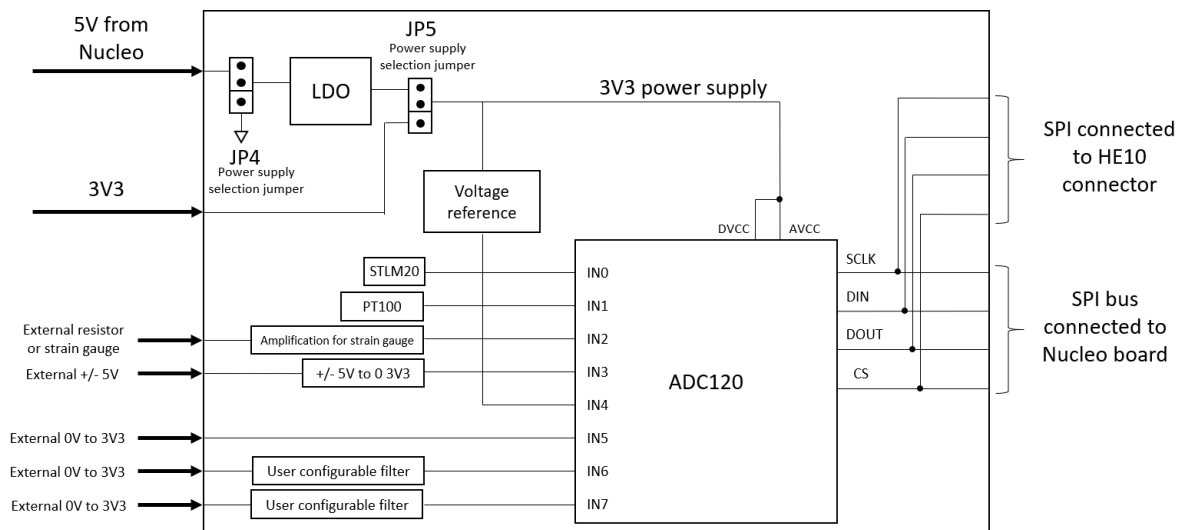


1 Board overview

The board inputs are configured on the following J2 connector pins:

- Pin 8 (In3): input for $\pm 5V$ signal
- PIN 10 (In4): input configurable to measure around 1.7 V reference voltage or external 0 to 3V3 voltage (selected using jumper J31)
- Pin 12 (In5): input for 0 to 3V3 signal (no filtering)
- Pin 14 (In6): input not directly connected, footprints are left to the user to allow amplification
- Pin 16 (In7): input not directly connected, footprints are left to the user to allow amplification

Figure 2. STEVAL-AKI001V1 block diagram



The STEVAL-AKI001V1 evaluation board includes the following hardware functionality:

- 2.54mm, 38cts double female connectors to be plugged to the STM32L476RG Nucleo development board (J1)
- 2.54mm, 10cts, double male connector to connect an SPI to UART communication module (J3)
- Several configuration jumpers to select power supply input
- 3V3 LDO for power supply (JP4 5V jumper and JP5 LDO 3V3)
- A TS3431 voltage reference
- An analog to digital converter ADC120 SAR, 12 bits, 8 inputs (IN0 to IN7)
- An STLM20 temperature sensor on IN0
- A PT100 resistance thermometer on IN1
- Acquisition of a $\pm 5V$ signal on IN3
- Voltage reference sampling necessary for precise calculations
- Sampling of a 0 to 3V3 voltage input
- Acquisition of amplified inputs (not connected) configurable by the user on 2 channels (IN6 and IN7)
- Instrumentation amplifier for a strain gauge on IN2

The SPI communication lines are connected to the SPI communication lines of the STM32L476RG Nucleo development board and to the connector dedicated to the SPI to UART communication module. The jumpers are configured in the following way:

- JP4 - 5VNUC
- JP5 - AVCC

- J31 - VREF
- J44 - GND

2 Board connection and operation

2.1 Power supply

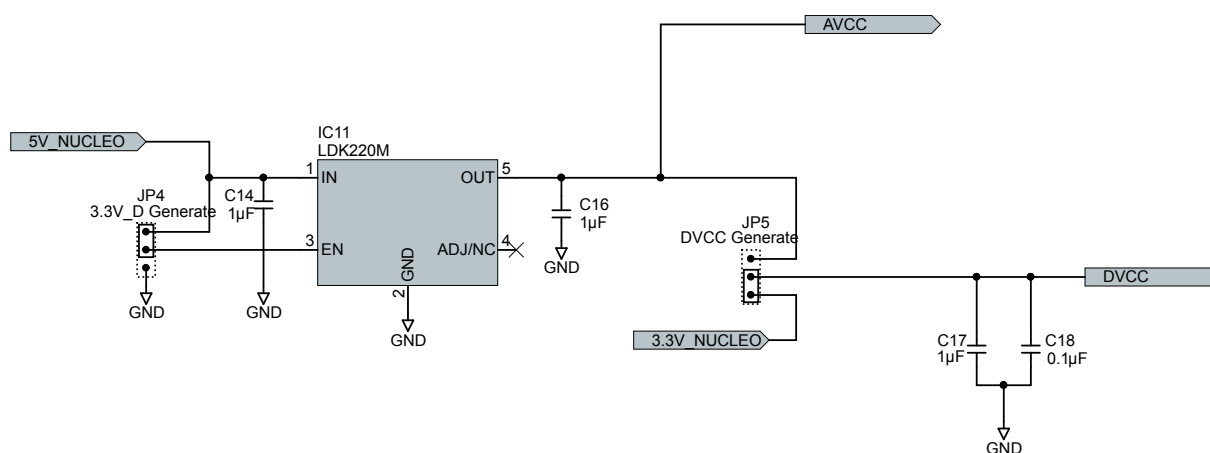
The power supply input can be selected from the following sources:

- 5V from Nucleo board or external supply (if Nucleo is not used)
- 3V3 voltage from Nucleo development board.

JP4 enables the 3V3 LDO that converts the 5V into 3V3.

JP5 chooses between 3V3 via the LDO and 3V3 from the Nucleo

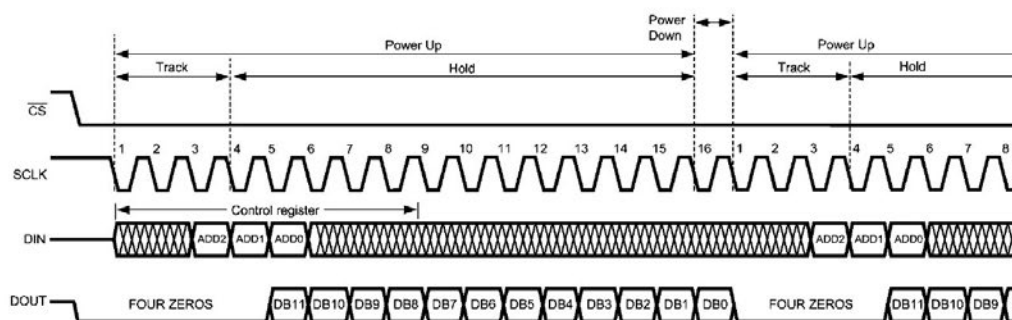
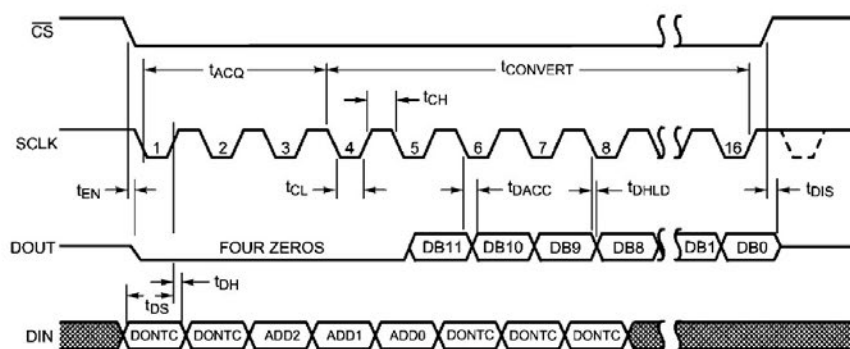
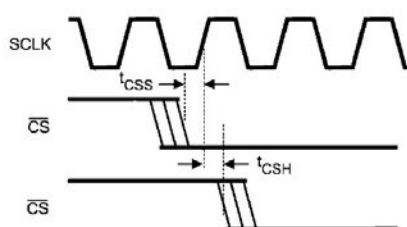
Figure 3. Power supply selection jumpers



2.2 SPI communication

The ADC120 has the following SPI communication inputs and outputs

- DIN line is MOSI (Master Output Slave Input)
- DOUT line is MISO (Master Input Slave Output)
- SCLK line is the clock
- CS line is Chip Select

Figure 4. ADC120 SPI timing diagram

Operational Timing Diagram

Serial Timing Diagram

SCLK and CS Timing Parameters

2.3 Board operation

The ADC120 channel to be read can be selected by sending the proper code through the D_{IN} (MOSI) line. The reading on D_{OUT} provides the converted raw data. A code running inside a microcontroller can calculate the proper value in volts or in degrees Celsius, depending on the analog sensor used.

RELATED LINKS

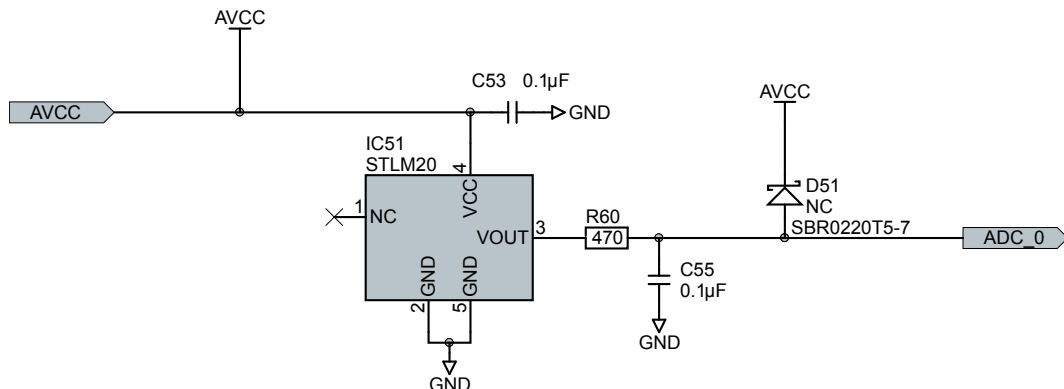
[Visit the ST website to download application note AN5454](#)

3 STEVAL-AKI001V1 ADC inputs

3.1 ADC channel 0: temperature measurement

The input channel 0 on the ADC120 receives the converted output from the STLM20 analog temperature sensor on the evaluation board.

Figure 5. STEVAL-AKI001V1 schematic - temperature measurement with STLM20



The voltage V (V) image of the temperature T ($^{\circ}\text{C}$) is given by the following equation:

$$V_{ADC0} = (-3.88 \cdot 10^{-6} \cdot T^2) + (-1.15 \cdot 10^{-2} \cdot T) + 1.8639 \quad (1)$$

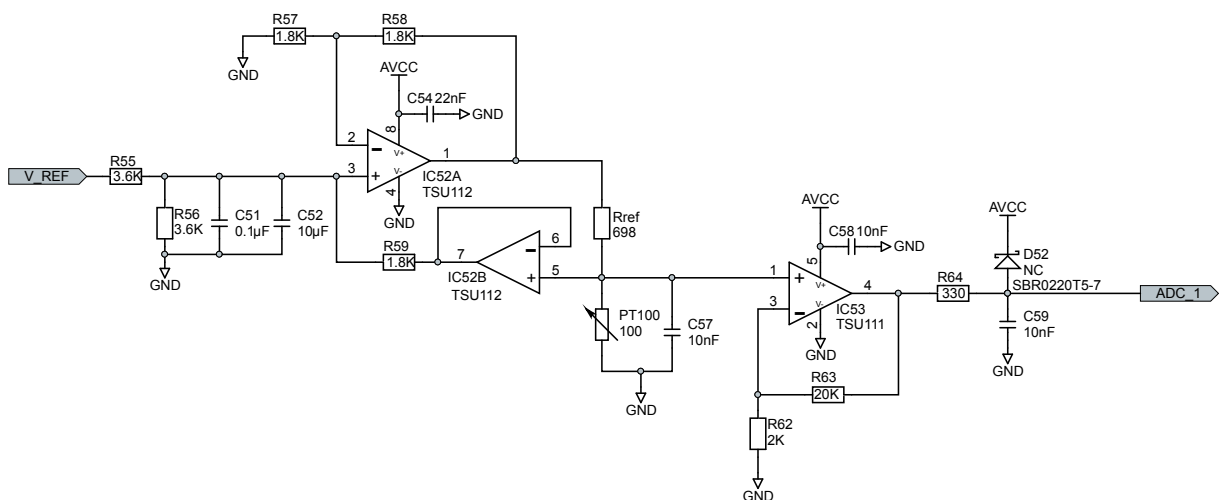
RELATED LINKS

[Visit the STLM20 product page on the ST website for more information regarding this device](#)

3.2 ADC channel 1: temperature measurement

The input channel 1 on the ADC120 receives the voltage image of the PT100 resistor on the evaluation board.

Figure 6. STEVAL-AKI001V1 schematic - temperature measurement with PT100



The resistance R_{100} image of the temperature is given by the following equation:

$$R_{PT100} = \frac{V_{ADC1} * 2 * R_{ref}}{11 * V_{ref}} \quad (2)$$

And the temperature T is given by:

$$T = \frac{\frac{R_{PT100}}{R_0} - 1}{\alpha} \quad (3)$$

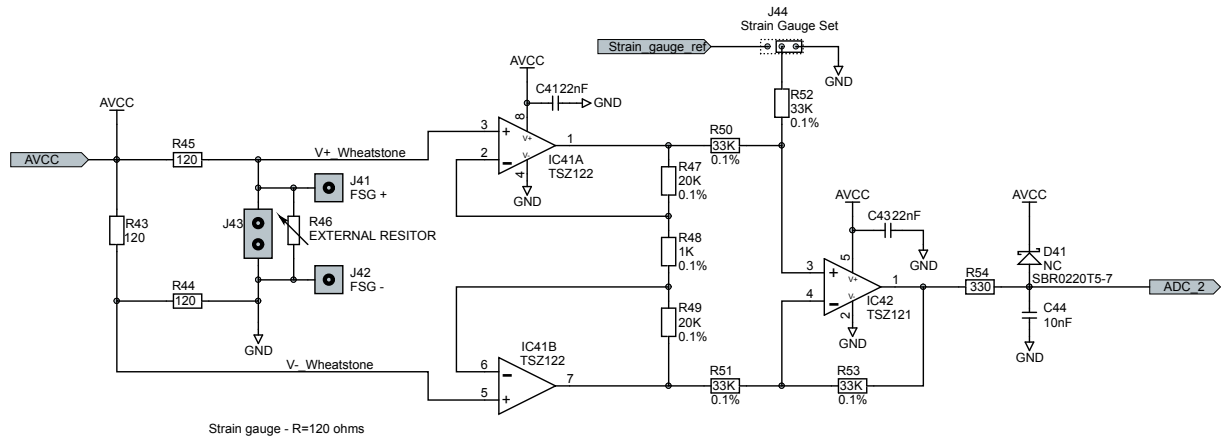
Where:

- $R_0 = 100\Omega$ is the resistance at 0 °C
- $\alpha = 0.00385 \frac{\Omega}{^\circ C}$ is the temperature coefficient

3.3 ADC channel 2: input for strain gauge measurement

The ADC120 input channel 2 measures and amplifies the strain gauge variation via a Wheatstone bridge.

Figure 7. STEVAL-AKI001V1 schematic - instrumentation amplifier for strain gauge measurement



The ADC120 reads the voltage image of the amplified voltage variation.

If jumper J44 is connected to GND, the voltage image of the strain gauge voltage variation is given by the following equation:

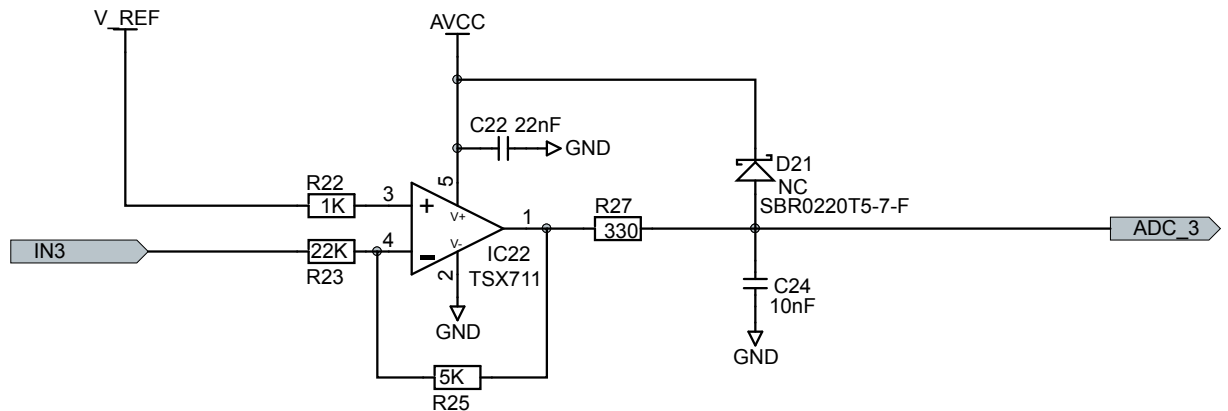
$$V_{ADC2} = (V_{Wheatstone}^- - V_{Wheatstone}^+) \left(\frac{1 + 2 * R_{47}}{R_{48}} \right) \frac{R_{53}}{R_{51}} \quad (4)$$

If jumper J44 is not connected to GND, an offset given by channel input 6 is implemented.

3.4 ADC channel 3: acquisition of a ± 5 V signal on IN3

The ADC120 input channel 3 measures and converts a ± 5 V signal into a 0 to 3V3 signal through the rectifier shown in the figure below.

Figure 8. STEVAL-AKI001V1 schematic - ± 5 V to 0-3V3 voltage rectifier



The ADC120 reads the positive voltage between 0 and 3V3. The rectified voltage is obtained from the equation:

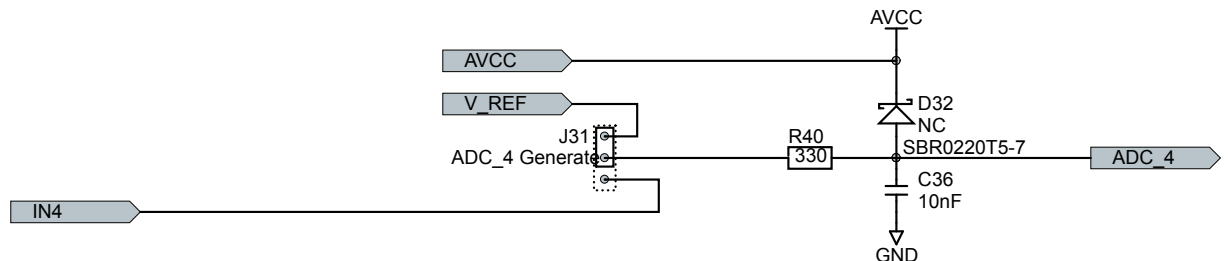
$$V_{ADC3} = \frac{V_{ref} - In_3 * 0.1852}{0.8149} \quad (5)$$

3.5

ADC channel 4: reference voltage measurement

The ADC120 input channel 4 is used to measure the voltage of the inboard reference voltage provided by the TS3431.

Figure 9. STEVAL-AKI001V1 schematic - reference voltage measurement



ADC input 4 can be connected to the reference voltage or to another voltage on pin 10 of connector J2 by setting jumper J31 on the left (VREF) or on the right (In4), respectively.

RELATED LINKS

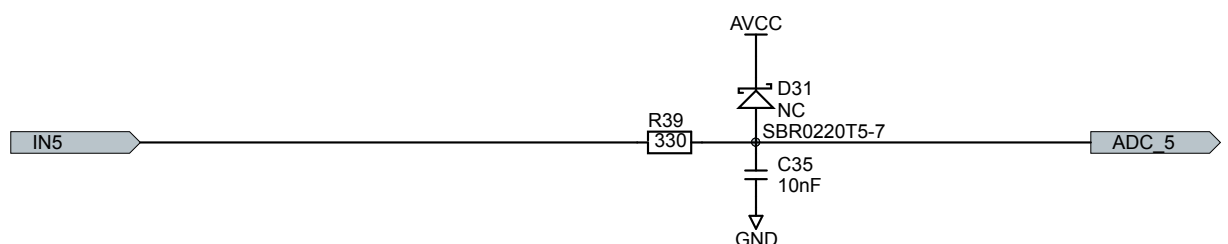
Visit the TS3431 product page on the ST website for more information regarding this device

3.6

ADC channel 5: external 0-3V3 voltage measurement

Pin 12 on connector J2 can be used to connect a 0 to 3V3 voltage to test the conversion of the ADC120 on a custom level voltage. The ADC120 input channel 5 is designed to be operated by the user with any 0 to 3V3 voltage.

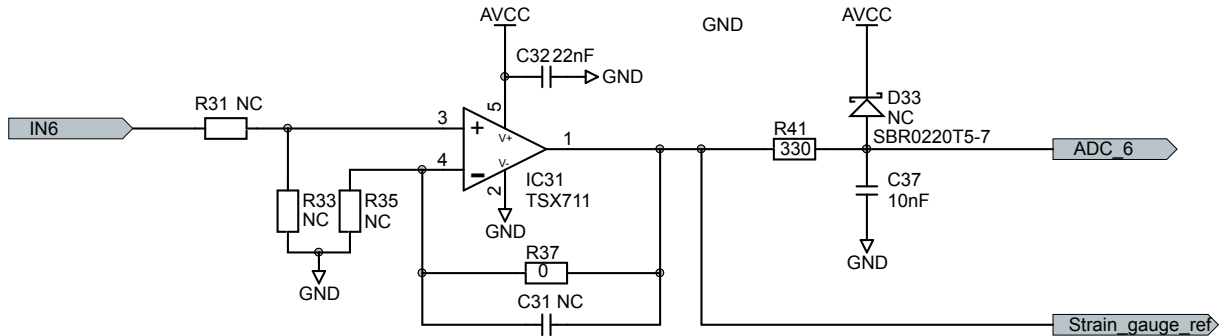
Figure 10. STEVAL-AKI001V1 schematic - ADC input 5



3.7 ADC channel 6: user configurable gain input

Pin 14 of connector J2 can be used to connect a voltage and configure the schematic as shown below to provide amplification, a divider, a filter, etc.

Figure 11. STEVAL-AKI001V1 schematic - user configurable gain ADC channel 6



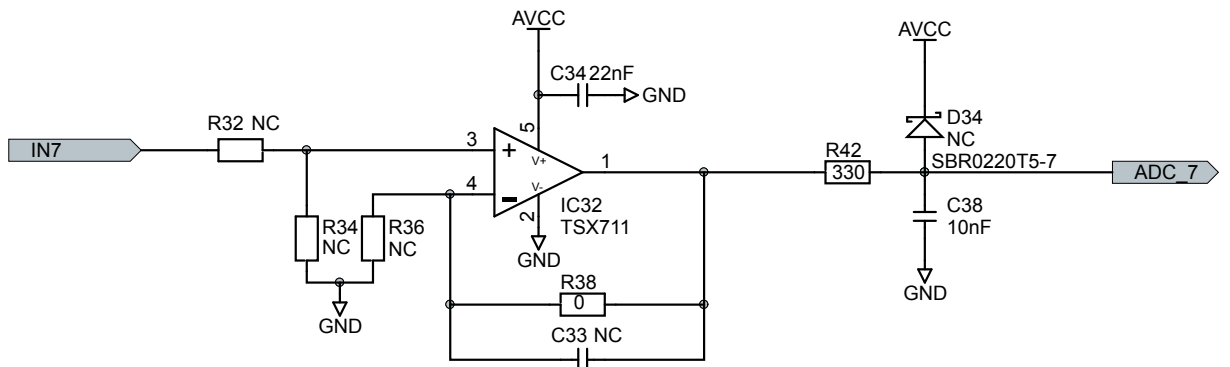
The ADC120 input channel 6 is designed for user configuration with any input voltage that does not surpass the 3V3 maximum input rating of the ADC120.

This channel 6 input voltage can also be used to provide the offset for the instrumentation amplifier on ADC channel 2 by setting the jumper J44 on strain gauge ref.

3.8 ADC channel 7: user configurable gain input

Pin 16 of connector J2 can be used to connect a voltage and configure the schematic as shown below to provide amplification, a divider, a filter, etc.

Figure 12. STEVAL-AKI001V1 schematic - user configurable gain ADC channel 7



The ADC120 input channel 7 is designed for user configuration with any input voltage that does not surpass the 3V3 maximum input rating of the ADC120.

Figure 13. STEVAL-AKI001V1 schematic diagram - functional blocks

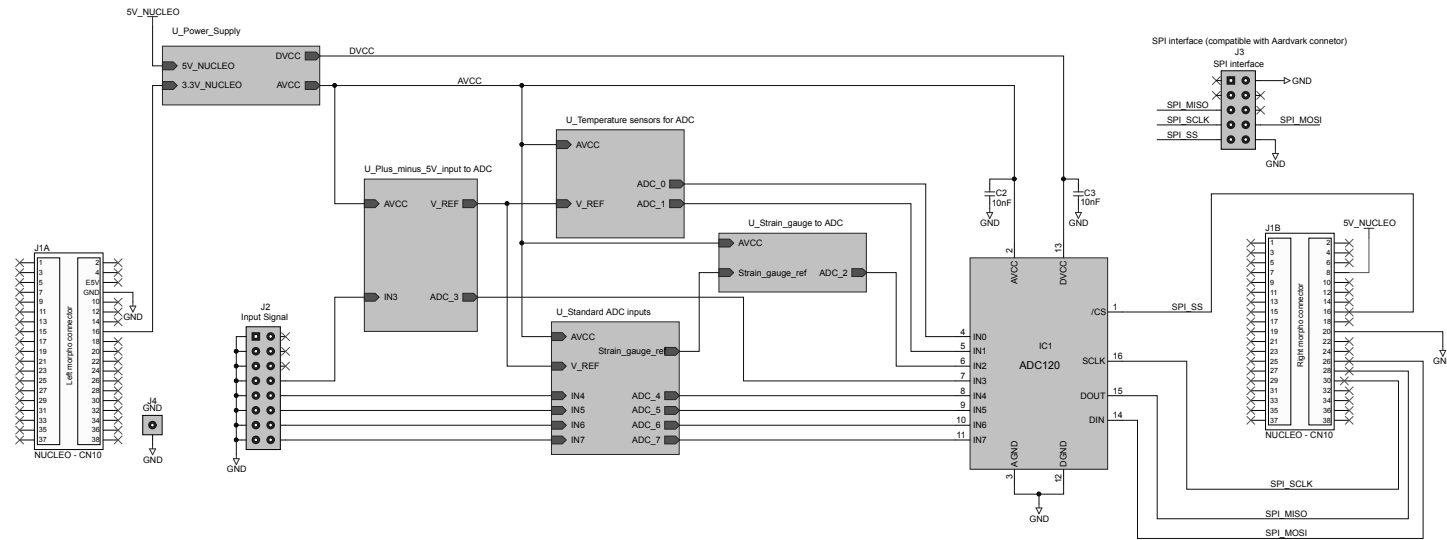


Figure 14. STEVAL-AKI001V1 schematic diagram - power supply 3V3

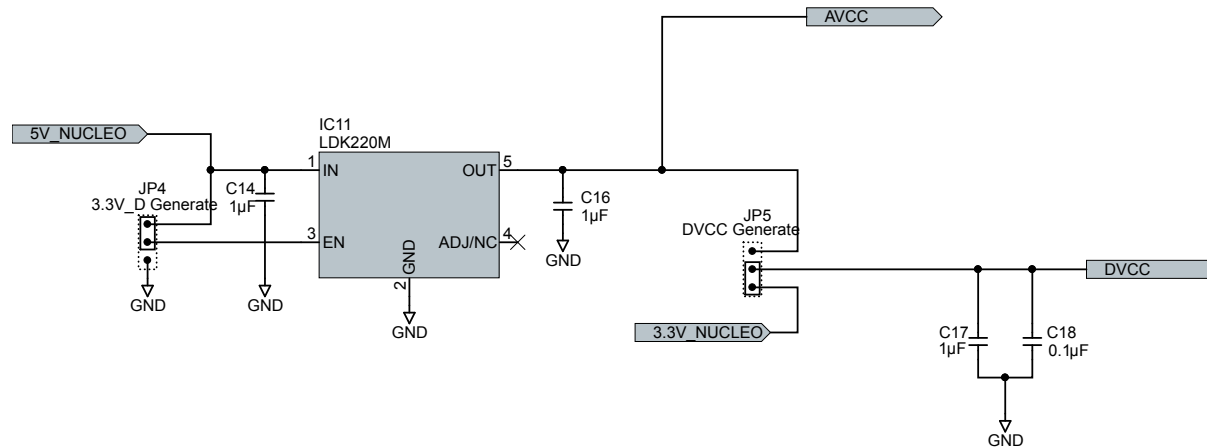
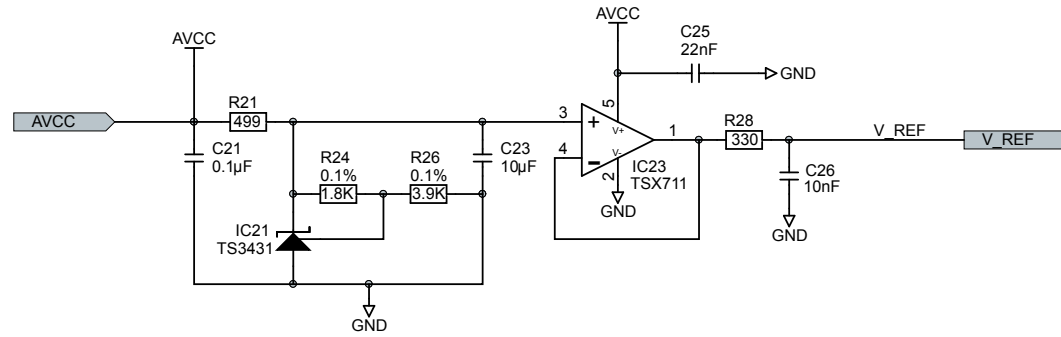


Figure 15. STEVAL-AKI001V1 schematic diagram - reference voltage



±5V input to 0-3V ADC

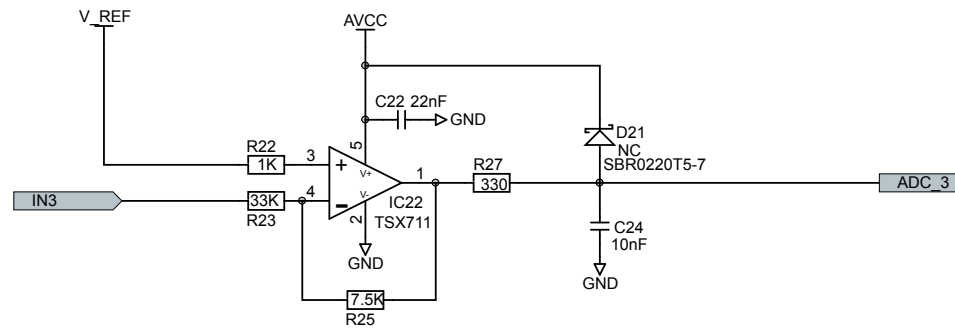
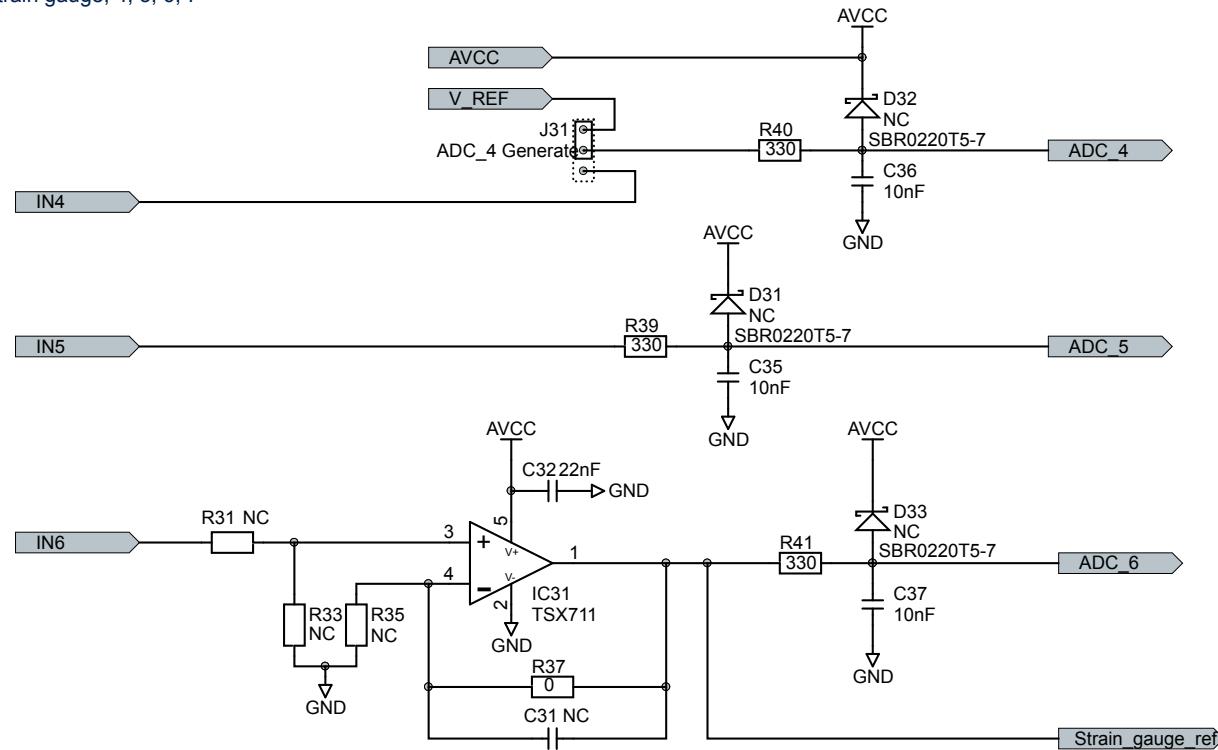
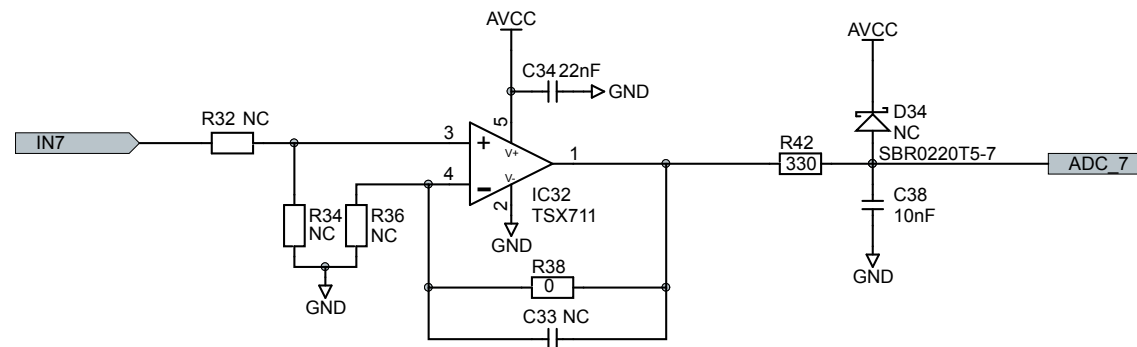


Figure 16. STEVAL-AKI001V1 schematic diagram - ADC inputs

ADC inputs: strain gauge, 4, 5, 6, 7



Resistor divider is used to provide acceptable voltage to ADC input
The gain can be changed by customer



Resistor divider is used to provide acceptable voltage to ADC input
The gain can be changed by customer

Figure 17. STEVAL-AKI001V1 schematic diagram - Instrumentation amplifier for strain gauge

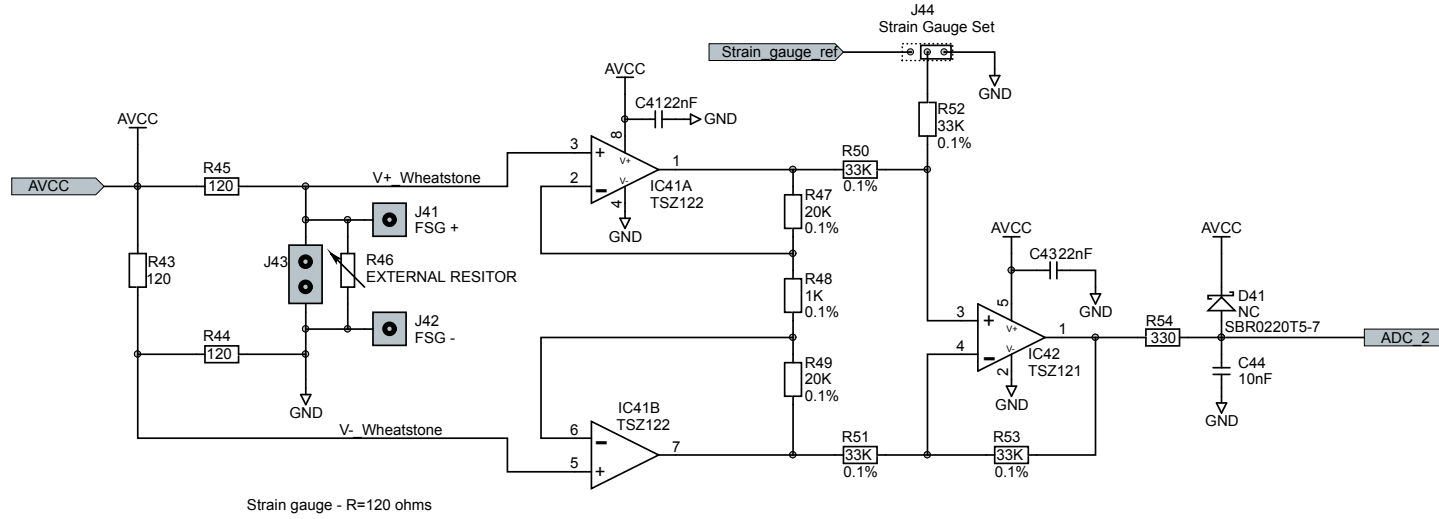
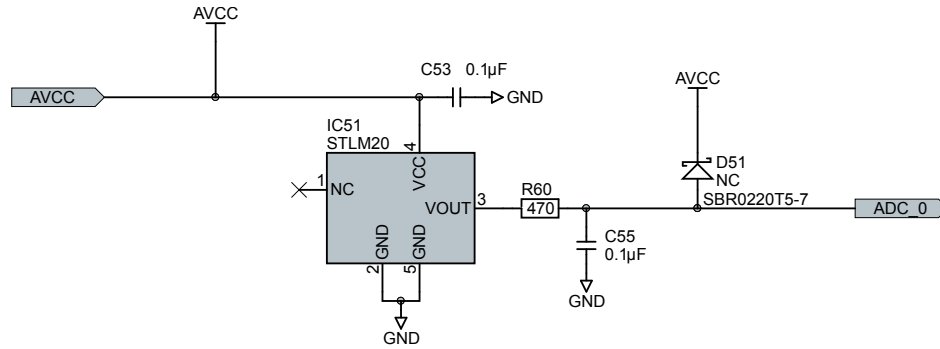
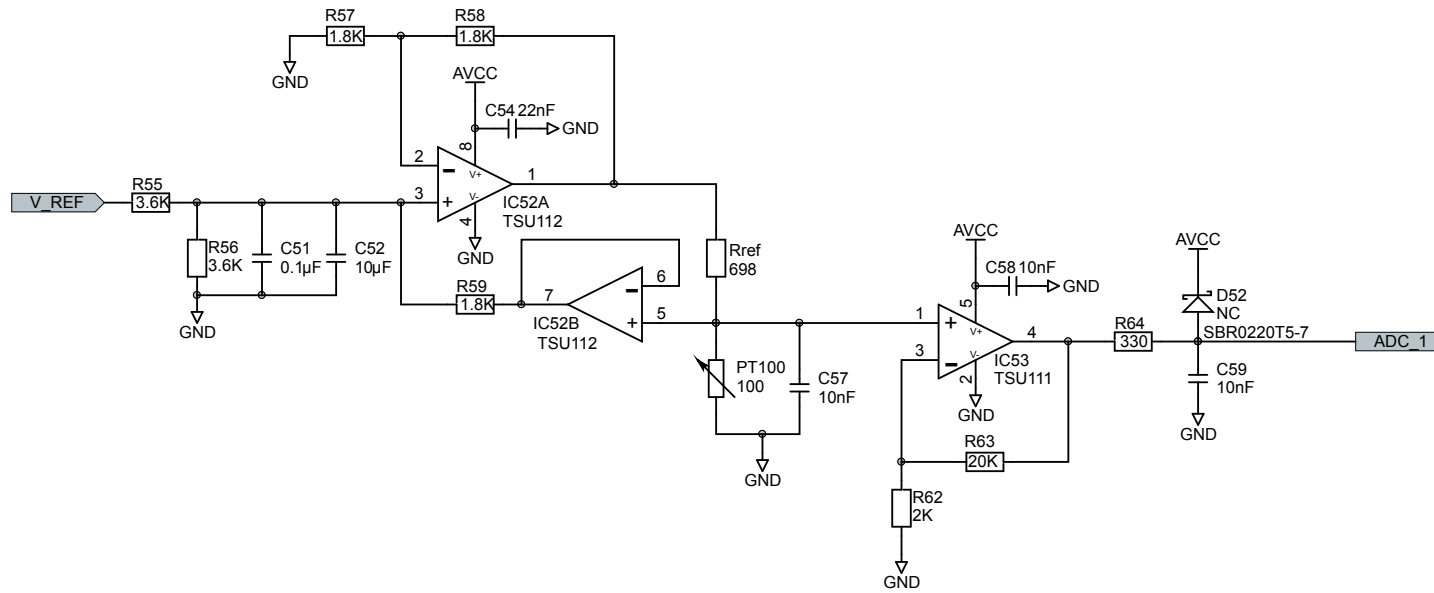


Figure 18. STEVAL-AKI001V1 schematic diagram - temperature measurement



Temperature measurement - STLM20



Temperature measurement - PT100

5 Bill of materials

Table 1. STEVAL-AKI001V1 bill of materials

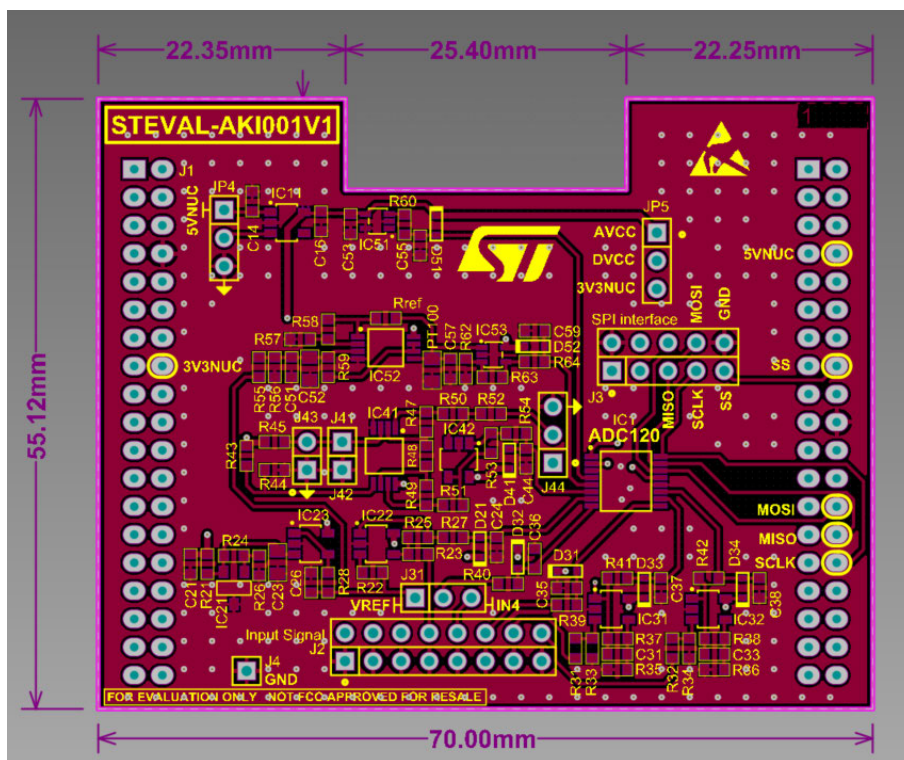
Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
1	12	C2, C3, C24, C26, C35, C36, C37, C38, C44, C57, C58, C59	10nF, SMT 0603, 25V minV	CAPACITOR - CERAMIC	-	-
2	3	C14, C16, C17	1μF, SMT 0603, 25V minV	CAPACITOR - CERAMIC	-	-
3	5	C18, C21, C51, C53, C55	0.1μF, SMT 0603, 25V minV	CAPACITOR - CERAMIC	-	-
4	7	C22, C25, C32, C34, C41, C43, C54	22nF, SMT 0603, 25V minV	CAPACITOR - CERAMIC	-	-
5	1	C23	10μF, SMT 0603, 25V minV	CAPACITOR - CERAMIC	-	-
6	0	C31, C33	NC, SMT 0603, 25V minV	CAPACITOR - CERAMIC	-	-
7	1	C52	10μF, SMT 0805, 25V minV, ±10%	CAPACITOR - CERAMIC, X5R, -55°C TO +85°C, GRM	MURATA	GRM21BR61E106KA73L
8	0	D21, D31, D32, D33, D34, D41, D51, D52	NC, SOD523, 20V, 5A	DIODES & RECTIFIERS SCHOTTKY, -65°C TO 150°C, SBR0220T5	Diodes Incorporated	SBR0220T5-7
9	1	IC1	TSSOP 16, 3.3 V	A/D CONVERTER, -40°C TO 125°C	ST	ADC120
10	1	IC11	SOT 323-5L, 13.2 V, 200mA, 2%	LDO VOLTAGE REGULATORS, -40°C TO 125°C	ST	LDK220M33R
11	1	IC21	SOT 23-3, 25V	VOLTAGE REFERENCES, -40°C TO 105°C	ST	TS3431CILT
12	4	IC22, IC23, IC31, IC32	SOT 23-5, 16V	OPERATIONAL AMPLIFIERS, -40°C TO 125°C	ST	TSX711ILT
13	1	IC41	MSO 8, 5.5V	OPERATIONAL AMPLIFIERS, -40°C TO 125°C, TSZ12X	ST	TSZ122IST
14	1	IC42	SOT 23-5, 5.5V	OPERATIONAL AMPLIFIERS, -40°C TO 125°C, TSZ12X	ST	TSZ121ILT
15	1	IC51	SOT 353, 5.5V	TEMPERATURE SENSORS, -50°C TO 130°C, STLM20	ST	STLM20W87F
16	1	IC52	MSO 8, 5.5V	OPERATIONAL AMPLIFIERS, -40°C TO 85°C, TSU11X	ST	TSU112IST

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
17	1	IC53	SC 70-5, 5.5V	OPERATIONAL AMPLIFIERS, -55°C TO 130°C, TSU11X	ST	TSU111ICT
18	1	J1	NUCLEO - CN10, SIP 19x2 - STEP 2.54MM, 655VDCV, 6.3A	CONNECTOR - HEADER, -55°C TO 125°C, SSQ	SAMTEC	SSQ-119-03-G-D
19	1	J2	Input Signal, SIP 8x2 - STEP 2.54MM, 250V, 3A	CONNECTOR - HEADER, -40°C TO 125°C, WR-PHD	WURTH ELEKTRONIK	61301621121
20	1	J3	SPI interface, SIP 5x2 - STEP 2.54MM, 250V, 3A	CONNECTOR - HEADER, -40°C TO 125°C, WR-PHD	WURTH ELEKTRONIK	61301021121
21	3	J4, J41, J42	HEADER 1CT, SIP 1, 250V, 3A	CONNECTOR - HEADER, -40°C TO 125°C, WR-PHD	WURTH ELEKTRONIK	61300111121
22	4	J31, J44, JP4, JP5	HEADER 3CTS, SIP 3 - STEP 2.54MM, 250V, 3A	CONNECTOR - HEADER, -40°C TO 125°C, WR-PHD	WURTH ELEKTRONIK	61300311121
23	1	J43	Connect Foil Strain Gauges, SIP 2 - STEP 2.54MM, 250V, 3A	CONNECTOR - HEADER, -40°C TO 125°C, WR-PHD	WURTH ELEKTRONIK	61300211121
24	4	Ja31, Ja44, JPa4, JPa5	JUMPER 2.54MM, 250V, 3A	JUMPER, -40°C TO 125°C, WR-PHD	WURTH ELEKTRONIK	60900213421
25	1	PT100	100, SMT 0805	PLATINUM SENSOR, -50°C TO 150°C, SMD	IST INNOVATIVE SENSOR TECHNOLOGY	P0K1.0805.2P.B
26	1	R21	499, SMT 0603, ±1%	RESISTOR	-	-
27	1	R22	1K, SMT 0603, ±1%	RESISTOR	-	-
28	1	R23	33K, SMT 0603, ±1%	RESISTOR	-	-
29	1	R24	1.8K, SMT 0603, ±0.1%	RESISTOR	-	-
30	1	R25	7.5K, SMT 0603, ±1%	RESISTOR	-	-
31	1	R26	3.9K, SMT 0603, ±0.1%	RESISTOR	-	-
32	8	R27, R28, R39, R40, R41, R42, R54, R64	330, SMT 0603, ±1%	RESISTOR	-	-
33	0	R31, R32, R33, R34, R35, R36	NC, SMT 0603, ±1%	RESISTOR	-	-

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
34	2	R37, R38	0, SMT 0603, ±1%	RESISTOR	-	-
35	3	R43, R44, R45	120, SMT 0603, ±0.1%	RESISTOR	-	-
36	2	R47, R49	20K, SMT 0603, ±0.1%	RESISTOR	-	-
37	1	R48	1K, SMT 0603, ±0.1%	RESISTOR	-	-
38	4	R50, R51, R52, R53	33K, SMT 0603, ±0.1%	RESISTOR	-	-
39	2	R55, R56	3.6K, SMT 0603, ±1%	RESISTOR	-	-
40	3	R57, R58, R59	1.8K, SMT 0603, ±1%	RESISTOR	-	-
41	1	R60	470, SMT 0603, ±1%	RESISTOR	-	-
42	1	R62	2K, SMT 0603, ±1%	RESISTOR	-	-
43	1	R63	20K, SMT 0603, ±1%	RESISTOR	-	-
44	1	Rref	698, SMT 0603, ±0.1%	RESISTOR	-	-

6 Board layout

Figure 19. STEVAL-AKI001V1 board dimensions



PCB layout of the STEVAL-AKI001V1 evaluation board. The board features a central STM32F405 microcontroller (IC1) with various peripheral components including resistors (R1-R60), capacitors (C1-C16), and connectors (J1, J2, J3, J4). It includes a 5VNUC and 3V3NUC voltage regulators, an SPI interface, and an ADC120. The board is marked with the ST logo and a warning symbol.

Figure 23. STEVAL-AKI001V1 board bottom silkscreen

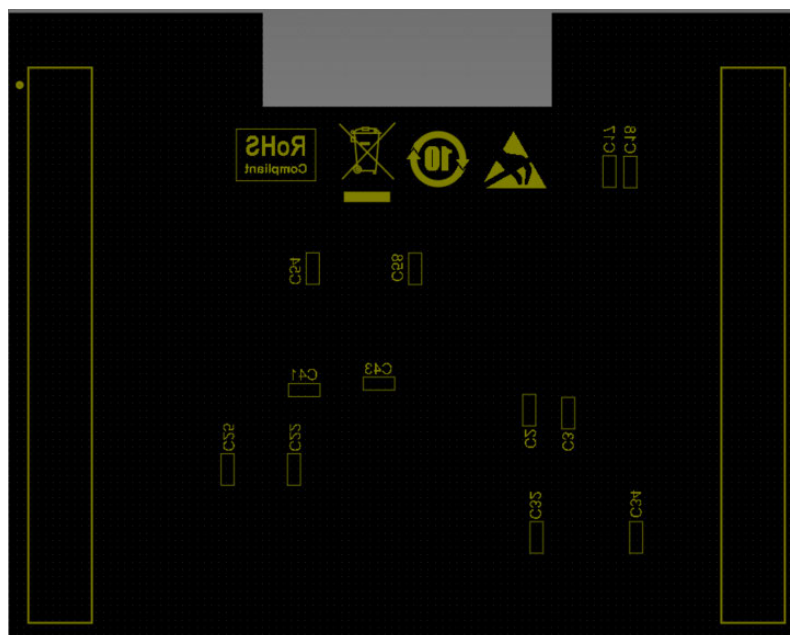


Figure 24. STEVAL-AKI001V1 board top solder

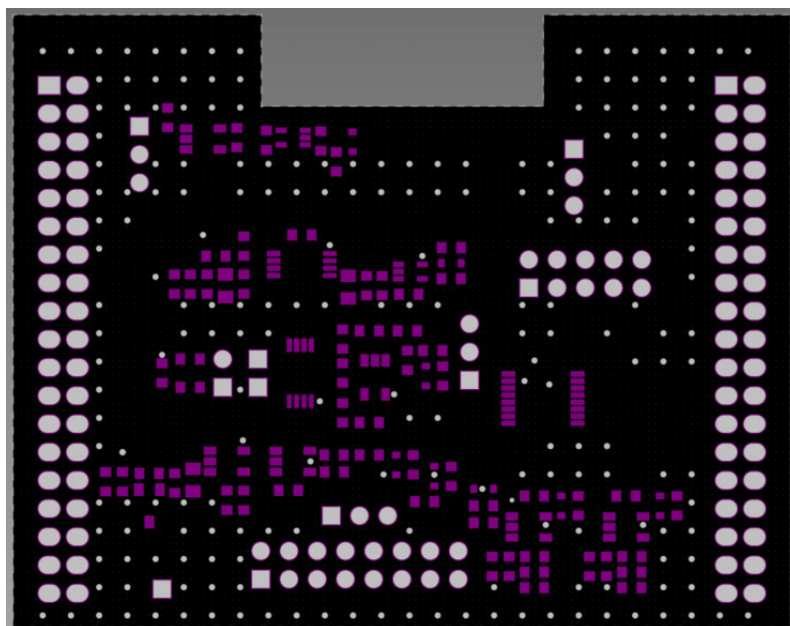


Figure 25. STEVAL-AKI001V1 board bottom solder

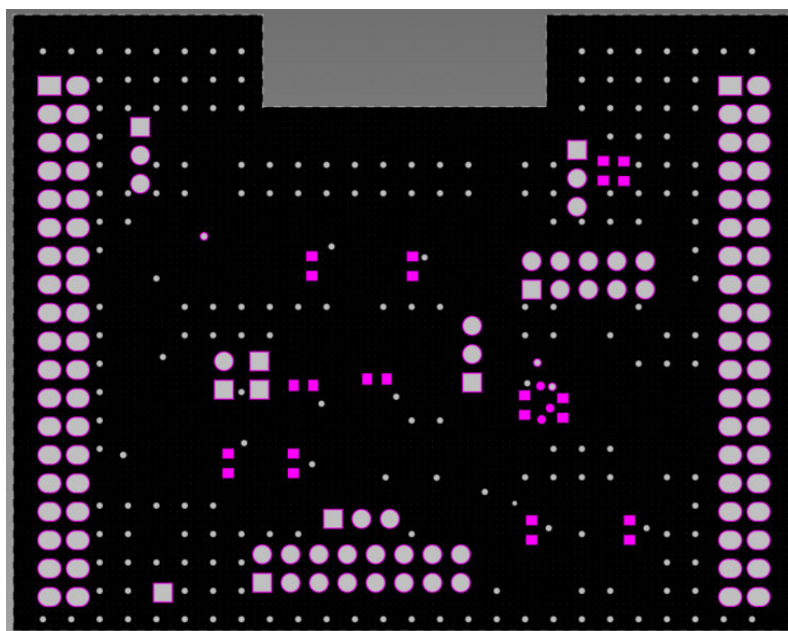


Figure 26. STEVAL-AKI001V1 board top assembly

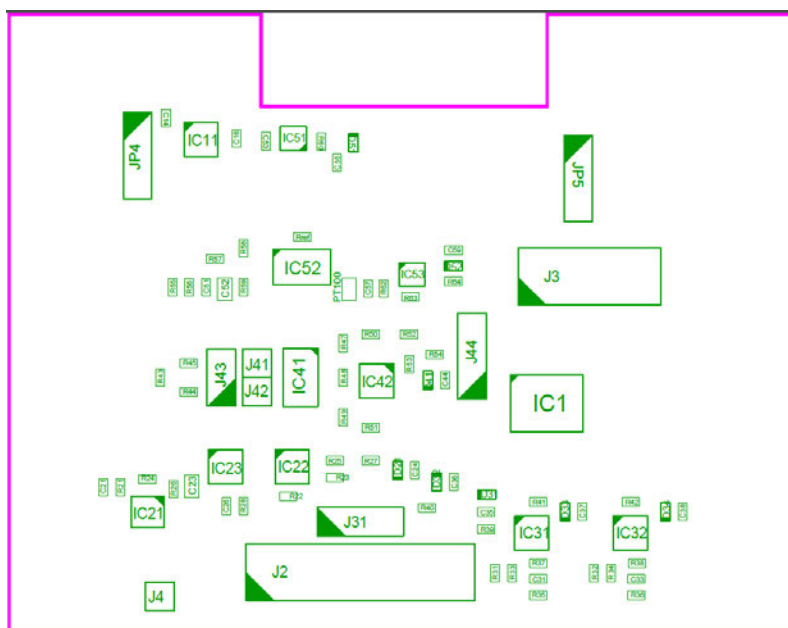
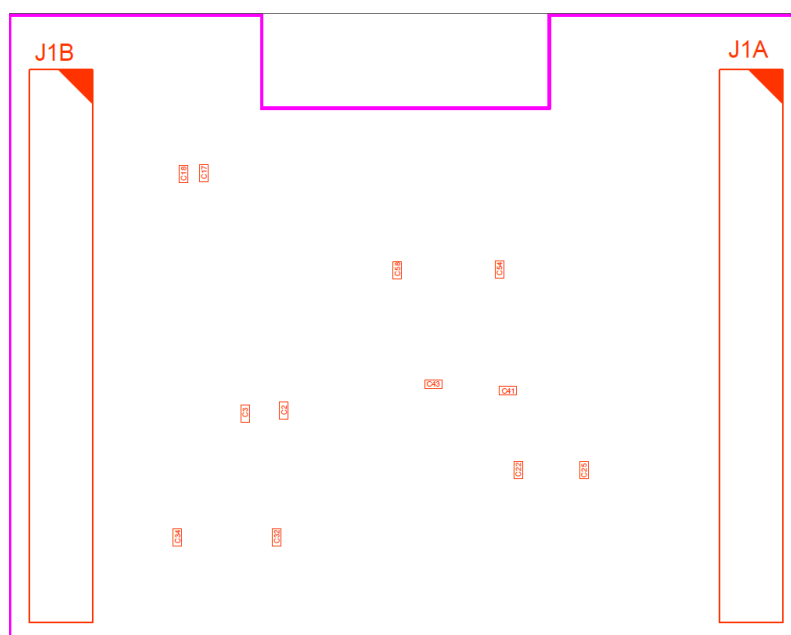


Figure 27. STEVAL-AKI001V1 board bottom assembly



Revision history

Table 2. Document revision history

Date	Version	Changes
08-Apr-2020	1	Initial release.
23-Sep-2020	2	Updated Section 1 Board overview, Section 3.4 ADC channel 3: acquisition of a ± 5 V signal on IN3 and Section 4 Schematic diagrams.

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