UM3160

User manual

Getting started with the EVAL-RHFAD128V2 evaluation board for the RHFAD128 analog-to-digital converter

Introduction

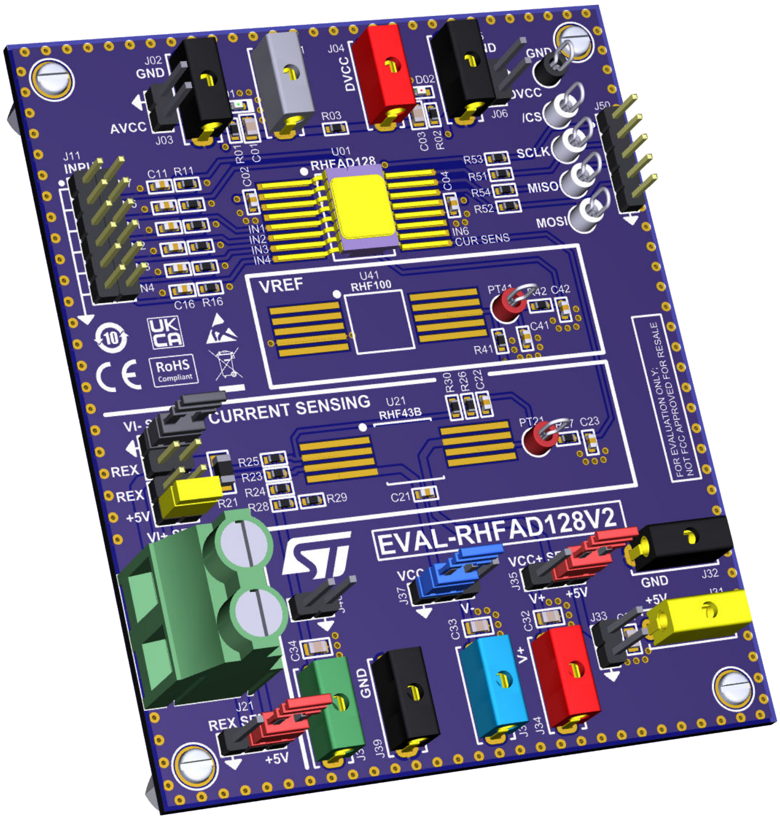
The EVAL-RHFAD128V2 evaluation board allows evaluating the conversion performance of the RHFAD128 eight-channel analog-to-digital converter, which is designed for 50 ksps to 1 Msps conversion.

The board can accept external signals to measure and evaluate the RHFAD128 conversion performance, based on its successive approximation register (SAR) with an internal track-and-hold cell.

The board can be supplied in standalone mode. It can also be connected to a NUCLEO-L476RG development board hosting an STM32 microcontroller, which enables further signal processing and PC communication.

To monitor the EVAL-RHFAD128V2 performance, when connected to the NUCLEO-L476RG, the RHFAD128_GUI can be used.

Figure 1. EVAL-RHFAD128V2 evaluation board



1 Getting started

1.1 Features

- RHFAD128 (Rad-hard, 12-bit 1 MHz A-to-D converter)
- Six direct inputs to the RHFAD128 with RC filters (200 Ω / 10 nF)
- Footprint available for external reference with the RHF100 [1] (Rad-hard 1.2 V fixed Vref)
- Footprint available for single op amp RHF43B [2] for current-sensing and custom test
- 2-layer FR4 printed circuit board
- Single ground-layer that proved the best performance
- Decoupling capacitive network close to the ICs to prevent noise on power supplies
- Connectors on the power supplies and on the output for easy plug-in
- Standard SPI communication pinout
- Numerous test-points

1. *The RHF100 is not mounted on the EVAL-RHFAD128V2. However, the footprint is available on the board.*
2. *The RHF43B is not mounted on the EVAL-RHFAD128V2. However, the footprint is available on the board.*

1.2 Main components

1.2.1 RHFAD128

The RHFAD128 is a low-power, eight-channel CMOS 12-bit analog-to-digital converter for conversion from 50 ksps to 1 Msps.

The architecture is based on a successive-approximation register with an internal track-and-hold cell.

The RHFAD128 features eight single-ended multiplexed inputs. The output serial data is straight binary and is SPI compatible.

1.2.2 RHF100

The RHF100 is an adjustable voltage reference with the following features:

- Fixed shunt: 1.2 V stable on capacitive load
- High precision ± 0.15 %
- Wide operating current: 40 µA to 12 mA
- 15 ppm/°C overtemperature range (-45 °C to 125 °C)
- 2 ppm/°C variation over 3000 hrs
- 0.02% precision stability over 3000 hrs
- 300 krad high and low dose rate
- ELDRS-free up to 300 krad
- Mounted in a Flat-10 hermetic ceramic package

1.2.3 RHF43B

The RHF43B operational amplifier offers high precision functioning with low input. Rail-to-rail output.

It has the following features embedded:

- Bandwidth: 8 MHz gain at 16 V
- Low input offset voltage: 100 μV typ.
- Supply current: 2.2 mA typ.
- Operating from 3 to 16 V
- Input bias current: 30 nA typ.
- ESD internal protection ≥ 2 kV
- Latch-up immunity: 200 mA
- ELDRS free up to 300 krad
- SEL immune at 120 MEV.cm2/mg
- Mounted in a Flat-8 hermetic ceramic package

2 How to use the board

To use the board, follow the procedure below.

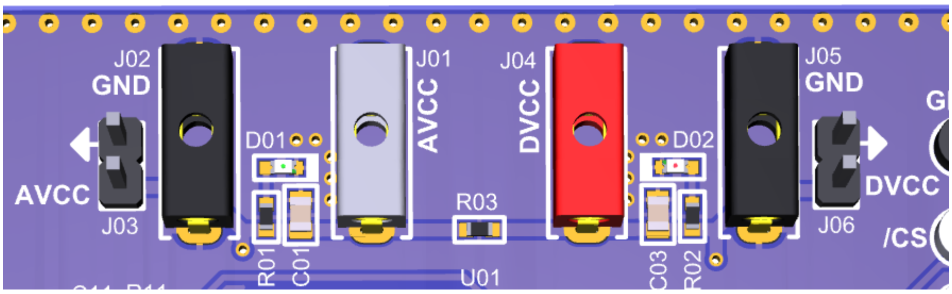
Step 1. Connect the power generators to AVCC and DVCC connectors.

The allowed voltages for AVCC and DVCC are 2.7 to 3.3 V.

Two ways to power the board:

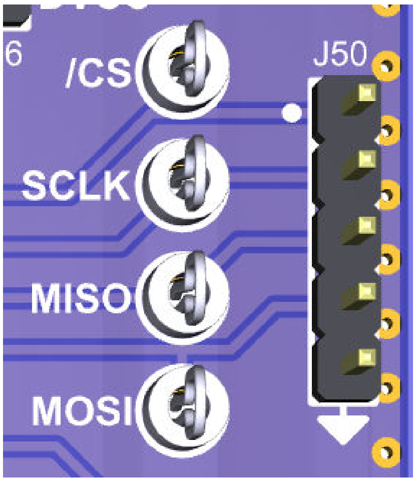
1. AVCC and DVCC are connected separately by 2 different power supplies.
   In this case the resistance R03 is disconnected.
2. AVCC and DVCC are connected to the same power supplies.
   In this case the resistance R03 is connected.

Figure 2. **AVCC and DVCC connectors**



Step 2 Connect the SPI section.

Figure 3. **SPI connection pins**



Step 3. When using the RHFAD128_GUI GUI, refer to the table below for the connection between the EVAL-RHFAD128V2 SPI pins and the NUCLEO-L476RG pins.

Table 1. **Pinout connection between the EVAL-RHFAD128V2 and the NUCLEO-L476RG**

NUCLEO-L476RG pin	EVAL-RHFAD128V2 SPI pin
PB12	Chip select
PB13	SCLK
PB14	MISO
PB15	MOSI

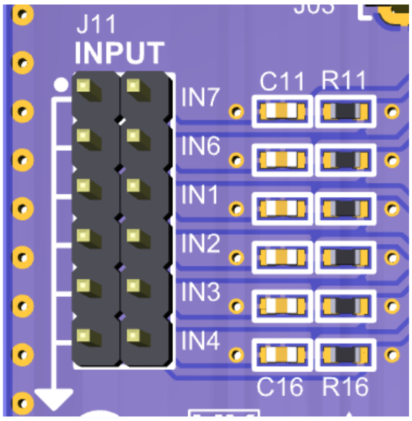
Step 4. Connect your inputs.

Step 4a. IN1, IN2, IN3, IN4, IN6, and IN7: direct inputs with RC filters (for example 200 Ω / 10 nF is a good combination at FCLK = 500 KHz).

Step 4b. IN0: input connected to the reference voltage RHF100.

Step 4c. IN5: input connected to a rail-to-rail amplifier RHF43B.

Figure 4. **Board section for input connection**



3 Communication with the RHFAD128

3.1 Option A: use the STSW-AKI GUI

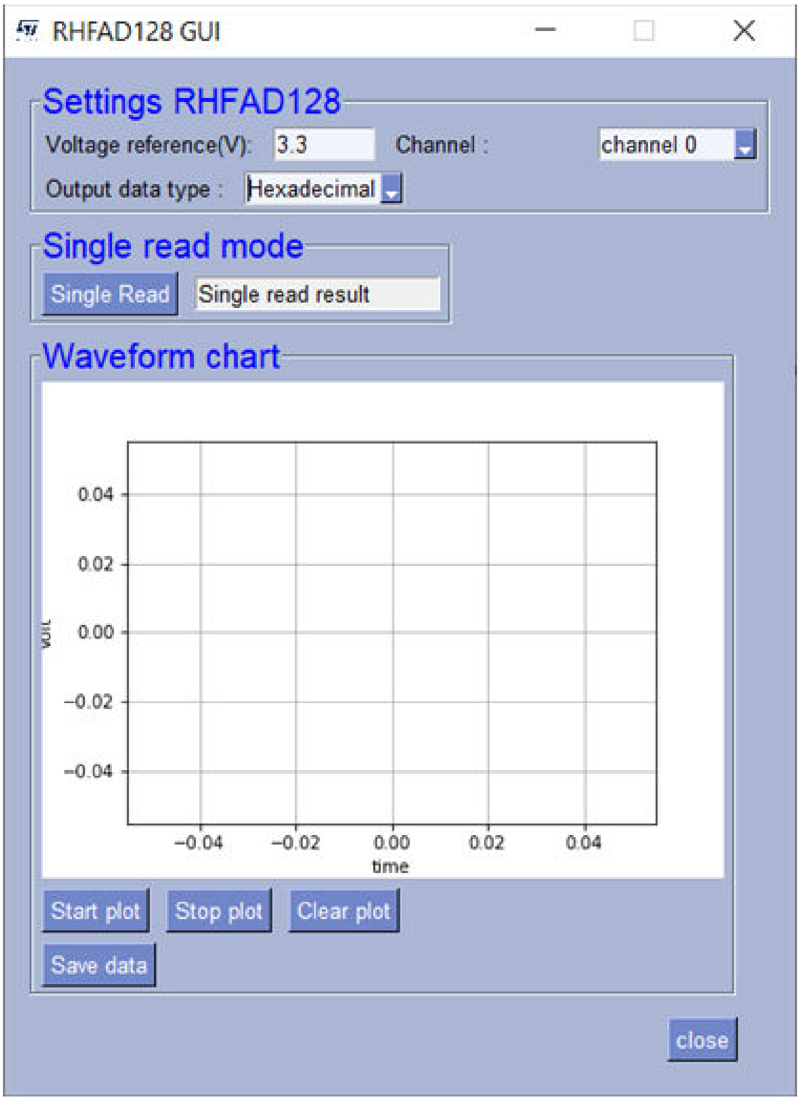
The EVAL-RHFAD128V2 can be used with the STSW-AKI GUI. To use it, it is necessary to use a Nucleo-64 L476RG.

The RHFAD128_GUI runs on an STM32 Nucleo-64 development board. It communicates with the RHFAD128 of the EVAL-RHFAD128V2 through the SPI protocol at 125 ksps.

The RHFAD128_GUI allows the user to monitor each channel and plot data on a graph. It is also a tool to save values measured by the RHFAD128 in a .csv file.

For more information on the RHFAD128_GUI GUI, go to the relevant STMicroelectronics web page.

Figure 5. RHFAD128_GUI: GUI for RHFAD128



3.2 Option B: use the EVAL-RHFAD128V2 directly with your test solution

The EVAL-RHFAD128V2 can be plugged directly to your solution.

The SPI communication to access the RHFAD128 registers giving access to the measured values of each channel is shown in the following tables.

Table 2. Control register bits

Bit #	7 (MSB)	6	5	4	3	2	1	0
Symbol	DONTC	DONTC	ADD2	ADD1	ADD0	DONTC	DONTC	DONTC

Table 3. Control register bit description

Bit #	Symbol	Description
7, 6, 2, 1, 0	DONTC	Don't care
5	ADD2	These bits determine which input channel is converted, as per
4	ADD1	
3	ADD0	

Table 4. Input channel description

ADD2	ADD1	ADD0	Address value (h)	Input channel
0	0	0	00	IN0
0	0	1	08	IN1
0	1	0	10	IN2
0	1	1	18	IN3
1	0	0	20	IN4
1	0	1	28	IN5
1	1	0	30	IN6
1	1	1	38	IN7

4 The use of RHF43B and RHF100

4.1 1.2 V reference voltage on channel 0

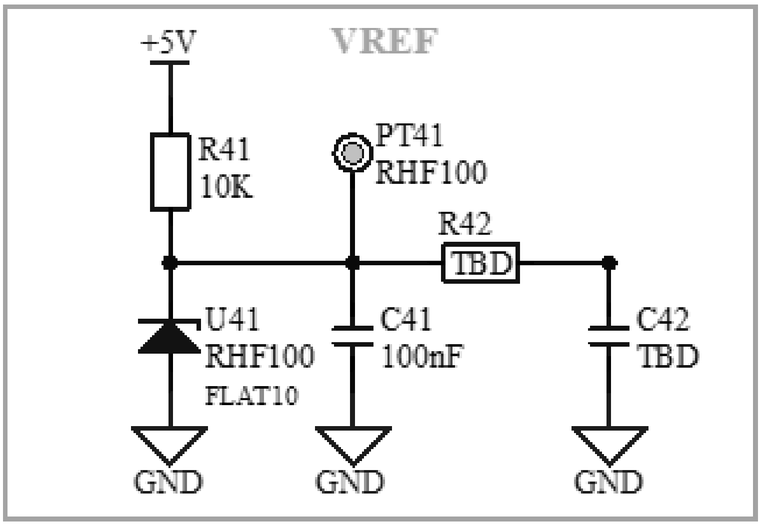
The RHF100 is not mounted on board.

The RHF100 reference voltage can be measured on the channel IN0.

By default, the R42 value can be 0 Ω. However, R42 = 200 Ω and C42 = 10 nF can be a good combination for low-pass filter at FCLK = 500 KHz.

The measured output voltage is 1.2 V.

Figure 6. Reference voltage



4.2 Current sensing

The RHF43B is not mounted on board.

The RHF43B op amp can be used for current sensing or for voltage amplification. It is connected to the RHFAD128 input channel 5 (IN5).

The op amp output voltage Vout must be within the range [0 V, AVCC].

By default, the R27 value can be 0 Ω. However, R27 = 200 Ω and C23=10 nF can be a good combination for low-pass filter at FCLK = 500 KHz.

Figure 7 is an extract of the power supply management schematic.

There are different ways to power the op amp and to measure the current or the voltage:

1. Power supply @ 5 V

- The reference voltage RHF100 * is powered by Vcc = 5 V
- Vcc+ = 5 V → J33 = 5 V → J35 jumper upper side connected
- Vcc- = GND → J37 jumper lower side connected
- REF floating → J38 not connected → R28, R29, R30 not connected

2. Power supply @ custom Vcc- / Vcc+

- Vcc+ = V+ → J34 = custom → J35 jumper lower side connected
- Vcc- = V- → J34 = custom → J37 jumper upper side connected
- REF custom → J38 = custom → R28, R29 connected
- In practice, REF = AVCC
- R28 = R29 = 2 * R26

Figure 7. **RHF100 and RHF43B power supply setup**

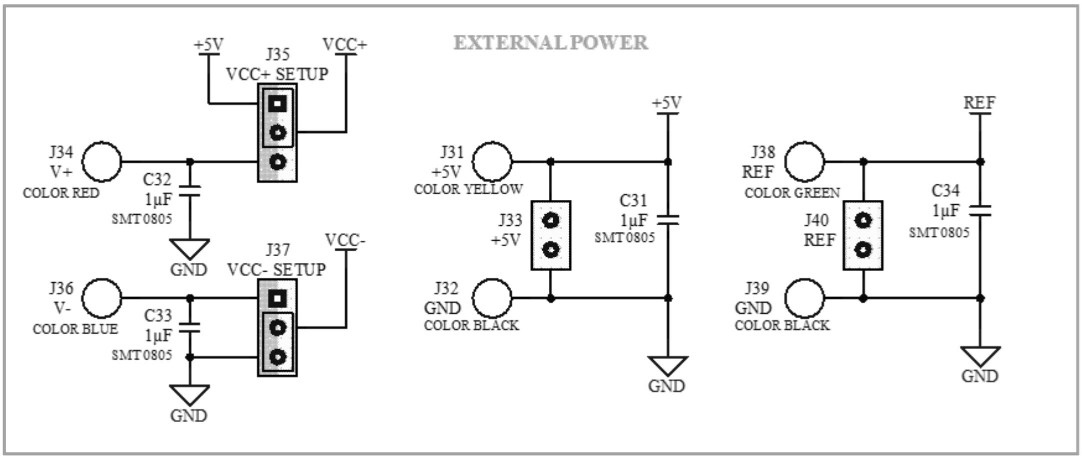


Figure 8 is an extract of the board schematic. It shows the different modes to measure the amplifier output voltage.

4.2.1 Mode 1: Low-side current sensing

An external load could be connected to the connector J22. The current through this load is measured by the following setup:

- J21 = +5 V if the external load is powered by 5 V
- J21 = is open if the external load is powered by external supply
- J22 = LOAD
- J23 = GND
- J24 = REX
- R25 = R23
- R26 = R24

The RHF43B gain is:

- G = R26 / R25

The measured current through the shunt resistance R21 is:

Case 1: REF voltage is not used:

- R24 = R26
- Vout = I * R21 * Gain
- I = Vout / (Gain * R21)

Case 2: REF voltage is used:

- R24 is not connected
- Vout = REF / 2 + I * R21 * Gain
- I = (Vout - REF/2) / (Gain * R21)

4.2.2 Mode 2: High-side current sensing

The setup is the following:

- J21 = GND
- J22 = LOAD
- J23 = REX
- J24 = +5 V if the external load is powered by 5 V
- J24 = is open if the external load is powered by external supply
- R25 = R23

The RHF43B gain is:

- G = R26 / R25

The measured current through the shunt resistance R21 is:

Case 1: REF voltage is not used:

- R24 = R26
- Vout = I * R21 * Gain
- I = Vout / (Gain * R21)

Case 2: REF voltage is used:

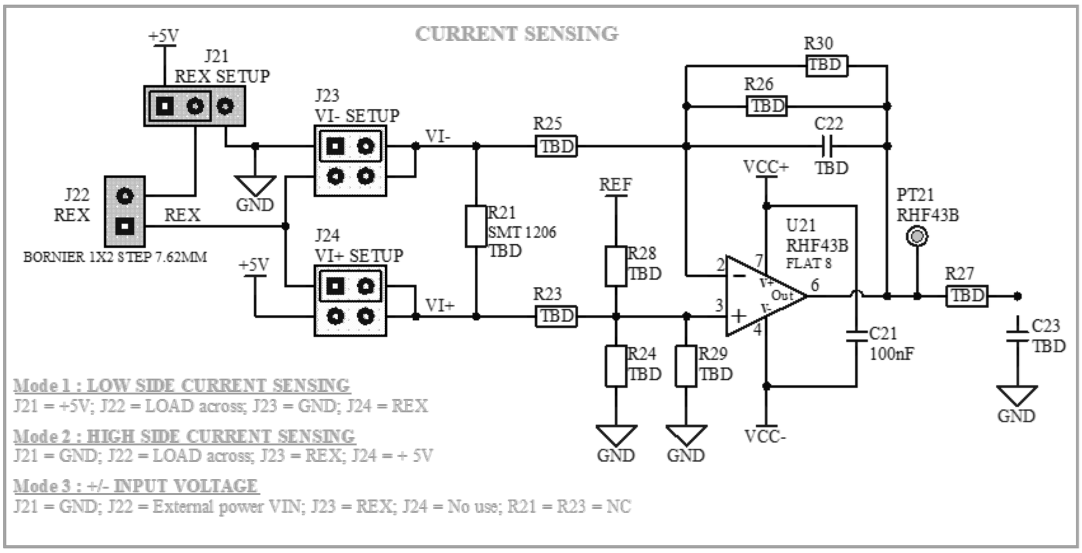
- R24 is not connected
- Vout = REF/2 + I * R21 * Gain
- I = (Vout - REF/2) / (Gain * R21)

4.2.3 Mode 3: Custom input voltage

The setup is:

- J21 = GND
- J22 = External VIN
- J23 = REX
- J24 = No use
- R21 = Not connected
- R25 = R23
- R26 = R24
- Gain = R26/R25
- Vout = REF/2 + VIN * Gain

Figure 8. **RHF43B current sensing**



5 EVAL-RHFAD128V2 versions

Table 5. EVAL-RHFAD128V2 versions

PCB version	Schematic diagrams	Bill of materials
EVAL-RHFAD128V2 (1)	EVAL-RHFAD128V2 schematic diagrams	EVAL-RHFAD128V2 bill of materials

1. *This code identifies the EVAL-RHFAD128V2 expansion board first version. It is printed on the board PCB.*

6 Schematic diagrams

Figure 9. EVAL-RHFAD128V2 board schematic

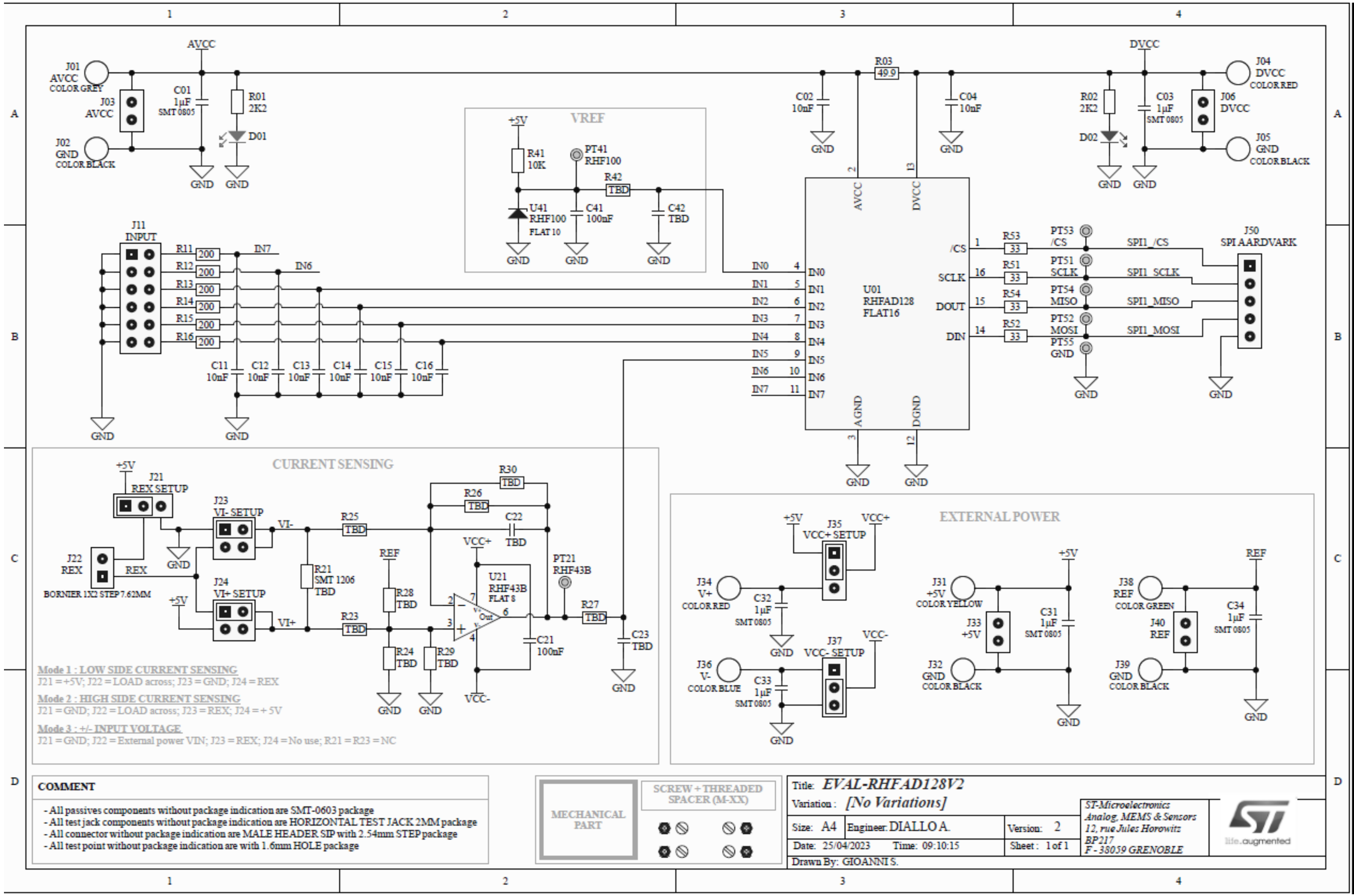


Figure 10. EVAL-RHFAD128V2 board PCB top layer

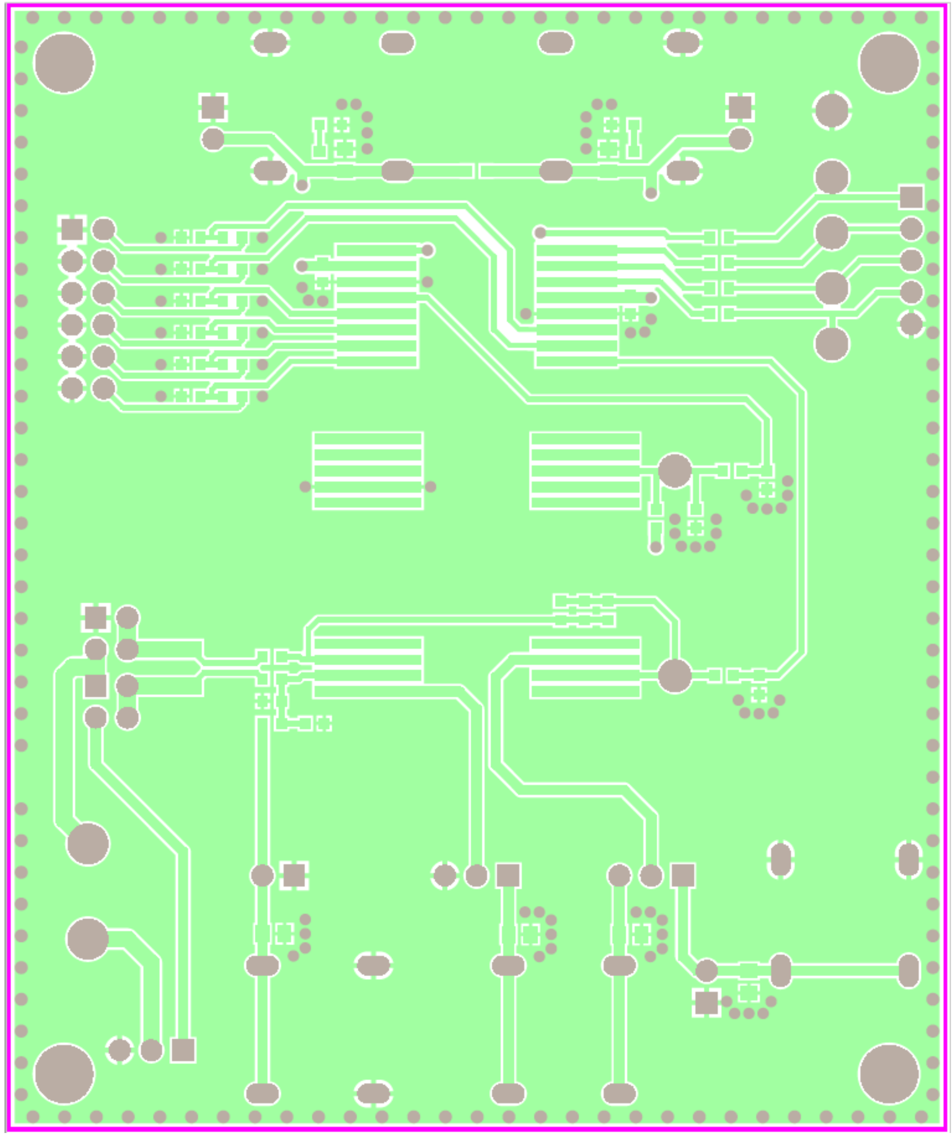


Figure 11. EVAL-RHFAD128V2 board PCB bottom layer

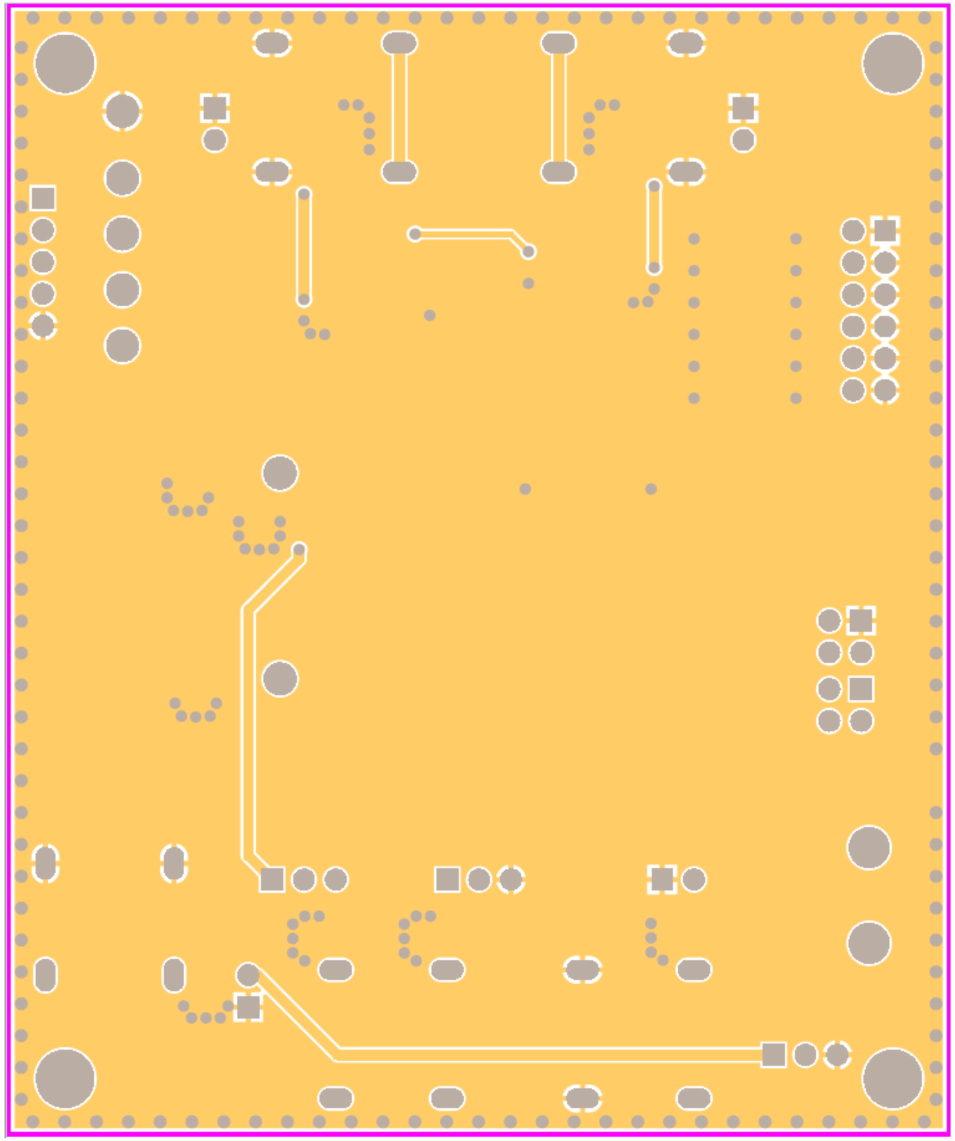
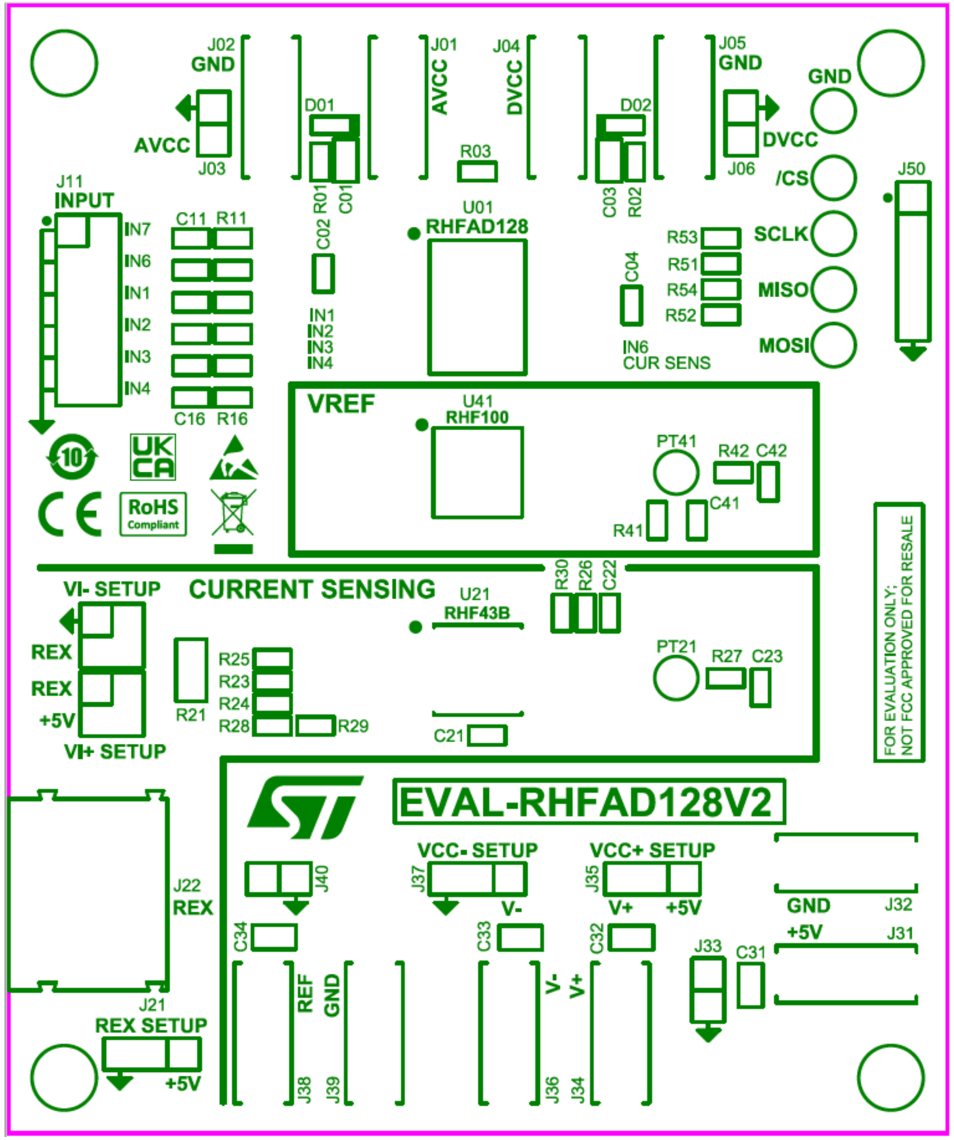


Figure 12. EVAL-RHFAD128V2 board PCB top overlay



7 Bill of materials

Table 6. EVAL-RHFAD128V2 bill of materials

Item	Quantity	Reference	Value	Package	Description	Voltage	Manufacturer	Manufacturer's part number
1	6	C01, C03, C31, C32, C33, C34	1μF	SMT 0805	CAPACITOR - CERAMIC	25V	WURTH ELEKTRONIK	885012207078
2	8	C02, C04, C11, C12, C13, C14, C15, C16	10nF	SMT 0603	CAPACITOR - CERAMIC	50V	WURTH ELEKTRONIK	885012206089
3	2	C21, C41	100nF	SMT 0603	CAPACITOR - CERAMIC	50V	WURTH ELEKTRONIK	885012206095
	3	C22, C23, C42	TBD	SMT 0603	CAPACITOR - CERAMIC	50V		
5	1	D01	COLOR GREEN	SMT 0603	LED	2V	WURTH ELEKTRONIK	150060VS55040
6	1	D02	COLOR RED	SMT 0603	LED	2V	WURTH ELEKTRONIC	150060RS55040
7	1	J01	COLOR GREY	HORIZONTAL TEST JACK 2MM	TEST JACK 2MM	2100V	JOHNSON - CINCH CONNECTIVITY	105-0763-001
8	4	J02, J05, J32, J39	COLOR BLACK	HORIZONTAL TEST JACK 2MM	TEST JACK 2MM	1500V	JOHNSON - CINCH CONNECTIVITY	105-0753-001
9	4	J03, J06, J33, J40	SIP 1X2 MALE	SIP 2 STEP 2.54MM	PIN HEADER	250VAC	WURTH ELEKTRONIK	61300211121
10	2	J04, J34	COLOR RED	HORIZONTAL TEST JACK 2MM	TEST JACK 2MM	2100V	JOHNSON - CINCH CONNECTIVITY	105-0752-001
11	1	J11	SIP 2X6 MALE	SIP 2X6 STEP 2.54MM	CONNECTOR - HEADER	250VAC	WURTH ELEKTRONIK	61301221121
12	3	J21, J35, J37	SIP 1X3 MALE	SIP 2 STEP 2.54MM	CONNECTOR - HEADER	250VAC	WURTH ELEKTRONIK	61300311121
13	1	J22	SIP 1X2 MALE	BORNIER 1X2 STEP 7.62MM	CONNECTOR - TERMINAL BLOCK	1.6KV	WURTH ELEKTRONIC	691218410002
14	2	J23, J24	SIP 2X4 MALE	SIP 2X4 STEP 2.54MM	CONNECTOR - HEADER	250VAC	WURTH ELEKTRONIK	61300421121
15	1	J31	COLOR YELLOW	HORIZONTAL TEST JACK 2MM	TEST JACK 2MM	2100V	JOHNSON - CINCH CONNECTIVITY	105-0757-001
16	1	J36	COLOR BLUE	HORIZONTAL TEST JACK 2MM	TEST JACK 2MM	2100V	JOHNSON - CINCH CONNECTIVITY	105-0760-001
17	1	J38	COLOR GREEN	HORIZONTAL TEST JACK 2MM	TEST JACK 2MM	2100V	JOHNSON - CINCH CONNECTIVITY	105-0754-001
18	1	J50	SIP 1X5 MALE	SIP 5 STEP 2.54MM	PIN HEADER	250VAC	WURTH ELEKTRONIK	61300511121
19	1	JU21	WHITE COLOR	STEP 2.54MM	JUMPER	250VAC	Harwin	M7684-46

Item	Quantity	Reference	Value	Package	Description	Voltage	Manufacturer	Manufacturer's part number
20	1	JU23	BLACK COLOR	STEP 2.54MM	JUMPER	250VAC	WURTH ELEKTRONIK	609002115121
21	1	JU24	YELLOW COLOR	STEP 2.54MM	JUMPER	650VAC	RS	251-8525
22	1	JU35	RED COLOR	STEP 2.54MM	JUMPER	250VAC	Harwin	M7681-05
23	1	JU37	BLUE COLOR	STEP 2.54MM	JUMPER	250VAC	Harwin	M7683-05
24	4	M-01, M-02, M-03, M-04	10MM	HOLE M2	THREADED SPACER		WURTH ELEKTRONIK	970100244
25	4	M-05, M-06, M-07, M-08	6MM	HOLE M3	SCREW		MULTICOMP PRO	MP006574
26	2	PT21, PT41	RED COLOR	HOLE 1.6MM	TEST POINT		KEYSTONE	5010
27	4	PT51, PT52, PT53, PT54	WHITE COLOR	HOLE 1.6MM	TEST POINT		KEYSTONE	5012
28	1	PT55	BLACK COLOR	HOLE 1.6MM	TEST POINT		KEYSTONE	5011
29	2	R01, R02	2K2	SMT 0603	RESISTOR		PANASONIC	ERJPA3F2201V
30	1	R03	49.9	SMT 0603	RESISTOR		PANASONIC	ERJPA3F49R9V
31	6	R11, R12, R13, R14, R15, R16	200	SMT 0603	RESISTOR		PANASONIC	ERJPA3F2000V
32	7	R21, R23, R24, R25, R26, R27, R42	TBD	SMT 1206, SMT 0603	RESISTOR			
33	3	R28, R29, R30	TBD	SMT 0603	RESISTOR			
34	1	R41	10K	SMT 0603	RESISTOR		PANASONIC	ERJPA3F1002V
35	4	R51, R52, R53, R54	33	SMT 0603	RESISTOR		PANASONIC	ERJPA3F33R0V
36	1	U01	RHFAD128	Flat-16	8 MULTIPLEXED CHANNEL - 500Ksps TO 1Msps - 12-BIT ADC	2.7V TO 5.5V	STMicroelectronics	RHFAD128
37	0	U21	RHF43B	Flat-8	IC - Rad-hard precision bipolar single operational amplifier	3V TO 16V	STMicroelectronics	RHF43BK1
38	0	U41	RHF100	Flat-10	Rad-hard, 1.2V, precision shunt, voltage reference	Vk = 1.2V	STMicroelectronics	RHF100K1

8 Regulatory compliance information

Notice for US Federal Communication Commission (FCC)

For evaluation only, not FCC approved for resale FCC NOTICE - This kit is designed to allow:

Product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product.

This kit 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 product does not cause harmful interference to licensed radio stations and that this product accepts harmful interference. Unless the assembled kit is designed to operate under part 15, part 18, or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter 3.1.2.

Notice for Innovation, Science and Economic Development Canada (ISED)

For evaluation purposes only. This kit generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to Industry Canada (IC) rules.

À des fins d'évaluation uniquement. Ce kit génère, utilise et peut émettre de l'énergie radiofréquence et n'a pas été testé pour sa conformité aux limites des appareils informatiques conformément aux règles d'Industrie Canada (IC).

Notice for the European Union

This device is in conformity with the essential requirements of the Directive 2014/30/EU (EMC) and of the Directive 2015/863/EU (RoHS).

Notice for the United Kingdom

This device is in compliance with the UK Electromagnetic Compatibility Regulations 2016 (UK S.I. 2016 No. 1091) and with the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (UK S.I. 2012 No. 3032).

Revision history

Table 7. **Document revision history**

Date	Version	Changes
24-May-2023	1	Initial release.

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