

Getting started with the STEVAL-AETKT2V1 evaluation kit for high precision bidirectional current sense amplifiers

Introduction

The STEVAL-AETKT2V1 evaluation kit implements bidirectional current sense amplifiers by placing a sense resistor either in the high side or in the low side.

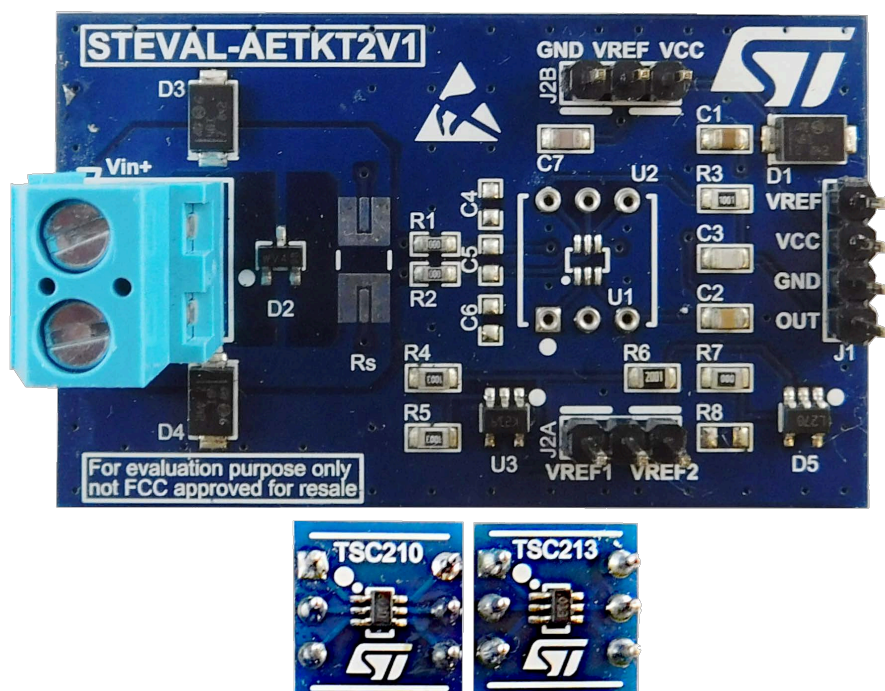
The STEVAL-AETKT2V1 kit consists of a mother board and two different daughter boards for different gain configurations.

TSC21x family implements zero drift technology and is specially designed to accurately measure current by amplifying the voltage across a shunt resistor connected to its input. The voltage drop (V_{sense}) is then amplified by an amplifier.

Thanks to the use of thin film resistors, TSC21x offers an extremely precise gain and very high CMRR performance.

Moreover, thanks to the possibility of fixing the output common mode voltage through a reference pin, the TSC21x can be either used as unidirectional or bidirectional current sensing amplifier.

Figure 1. STEVAL-AETKT2V1 evaluation kit



1 Getting started

1.1 Overview

- Input common mode voltage: 26 V
- Offset voltage: $\pm 35 \mu\text{V}$ ($\pm 100 \mu\text{V}$) max.
- Offset drift: $0.1 \mu\text{V}/^\circ\text{C}$ max.
- Gain drift: $20 \text{ ppm}/^\circ\text{C}$ max.
- 2.7 to 26 V supply voltage
- Quiescent current: $100 \mu\text{A}$ max.
- SC70-6 and QFN10 (1.8 x 1.4 mm) package
- Temperature range: -40 to 125°C
- Gain configuration from 50 V/V to 1000 V/V
- RoHS compliant

1.2 Shunt resistance

The **STEVAL-AETKT2V1** offers the possibility of soldering a shunt resistance directly on the PCB. The board can host standard 2512 package size shunts on 4 W footprint optimized for minimal reading error.

You can choose the appropriate shunt package and value for your own application. If the chosen shunt is not compatible with the footprint, it has to be connected outside the evaluation kit.

The selection of the shunt resistor is a tradeoff between dynamic range and power dissipation. Generally, in high current sensing applications, the focus is to reduce as much as possible the power dissipation (I^2R) by choosing a shunt with the smallest value.

The recommended shunt value is obtained from the following equation:

$$R_{sense} = \left(\frac{V_{outMax} - V_{ol}}{Gain \cdot (1 + Error_{gain})} - 2 \cdot |V_{io}| \right) \cdot \frac{1}{I_{range}} \quad (1)$$

Where V_{outMax} is the maximum output voltage usually equal to the device V_{CC} or the ADC connected to the output, V_{ol} is the output low swing value for the TSC21x family (in this case, it is 30 mV), Gain is the gain of the selected device (for example, TSC213 has a gain of 50), $ERROR_{gain}$ equals to 1%, V_{io} represents the input offset voltage ($100 \mu\text{V}$ can be considered for TSC213), I_{range} is the actual range to be measured.

Note: *It is recommended to take a bit smaller shunt value to have some margin and prevent saturation.*

The actual current range is calculated by the following equations:

$$I_{maxPositive} = \frac{V_{outMax} - V_{ref}}{R_{Shunt} \cdot Gain} \quad (2)$$

$$I_{maxNegative} = \frac{V_{ref} - V_{outMin}}{R_{Shunt} \cdot Gain} \quad (3)$$

Table 1. Examples of current ranges with 3mOhm shunt over different gain, V_{CC} and V_{ref} values

Device	V_{CC} (V)	V_{ref} (V)	Range $I_{positive}$ (A)	Range $I_{Negative}$ (A)
TSC213	3.3	2.5	4.66	-16
	5	2.5	16	-16
TSC210	3.3	2.5	1.16	-4
	5	2.5	4	-4

1.3 Connection

The **STEVAL-AETKT2V1** evaluation kit can be connected to the application design via J1 header.

Table 2. J1 pin-out description

J1 pin	Description
REF	Output or input voltage reference (see Section 1.4 Voltage reference settings)
VCC	Supply voltage
GND	Ground
OUT	TSC21x analog output value

1.4 Voltage reference settings

As the TSC21x family devices can measure current in both directions, some voltage reference has to be provided. Voltage reference can be generated directly on the **STEVAL-AETKT2V1** evaluation kit by a precision op-amp or by shunt voltage reference. Another option is to use an external reference voltage source. Refer to the following table for proper jumper settings.

Important: Only one jumper at a time can be placed on the kit.

Table 3. Voltage reference J2A and J2B jumper settings

J2A	J2B	Functionality
NA	GND	Unidirectional
NA	VCC	Unidirectional Inverted
REF1	NA	V_{ref} generated by op-amp TSB711 (default $V_{cc}/2$) ⁽¹⁾
REF2	NA	V_{ref} generated by shunt reference TS431 (default 1.24V) ⁽¹⁾
REF1 or REF2	GND or VCC	Not allowed ⁽²⁾
NA	NA	External voltage reference provided from J1

1. The reference voltage value can be adjusted by resistor values.

2. IC components might be damaged

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Schematic diagrams

Figure 2. STEVAL-AETKT2V1 main board (STEVAL-AET011V1B) circuit schematic

The STEVAL-AET011V1B board is not available for separate sale

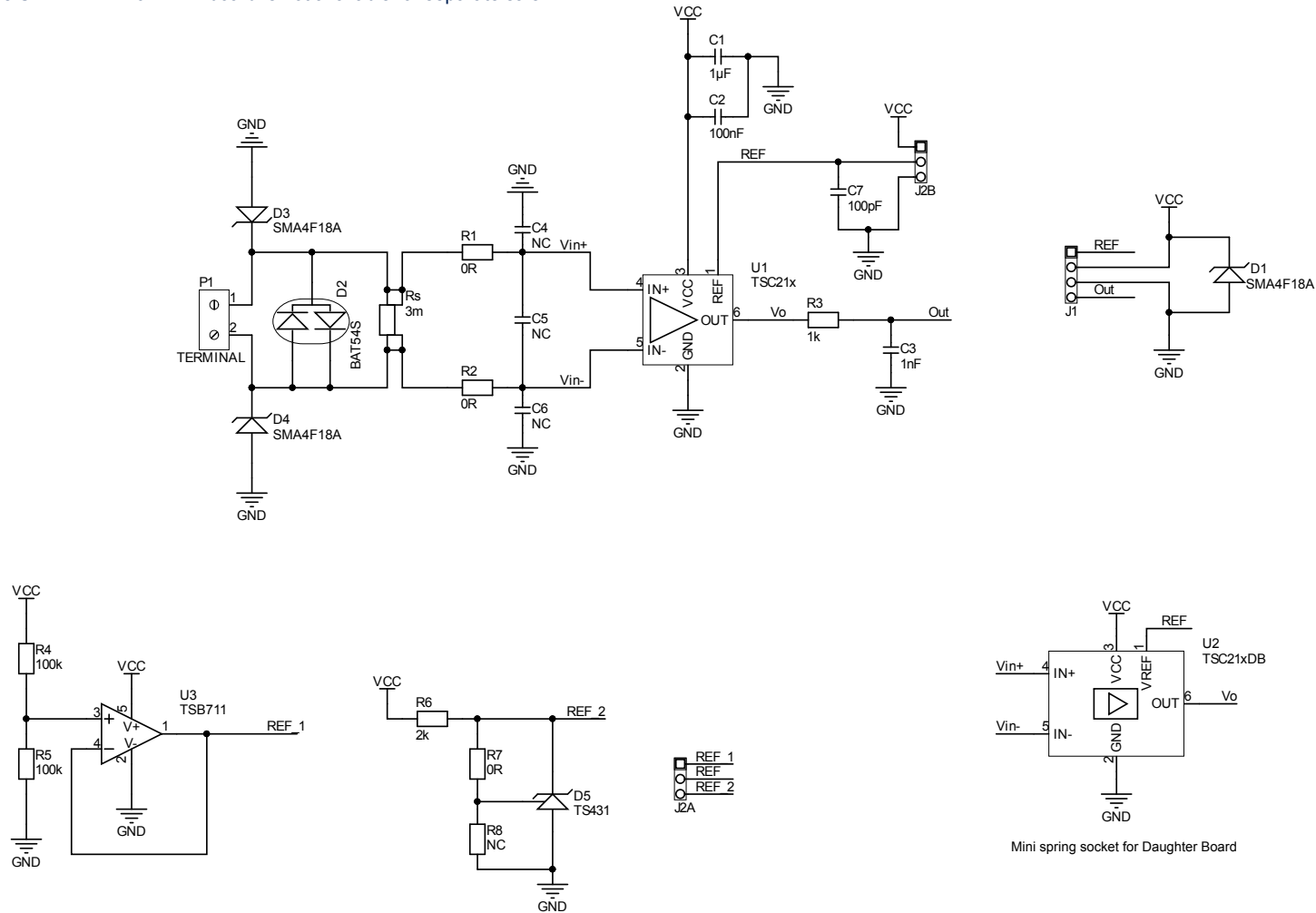


Figure 3. STEVAL-AETKT2V1 daughter board (STEVAL-AET012V1B) circuit schematic

The STEVAL-AET012V1B board is not available for separate sale

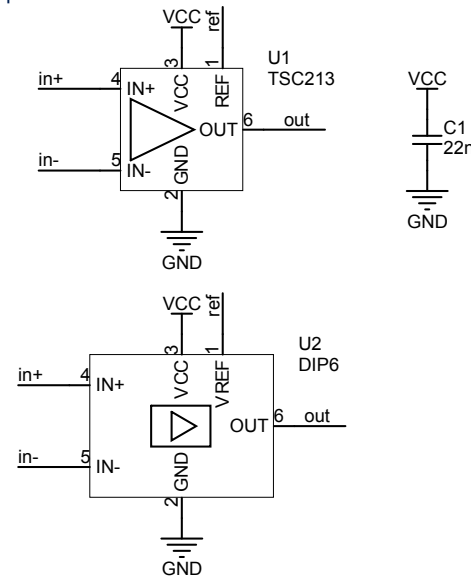
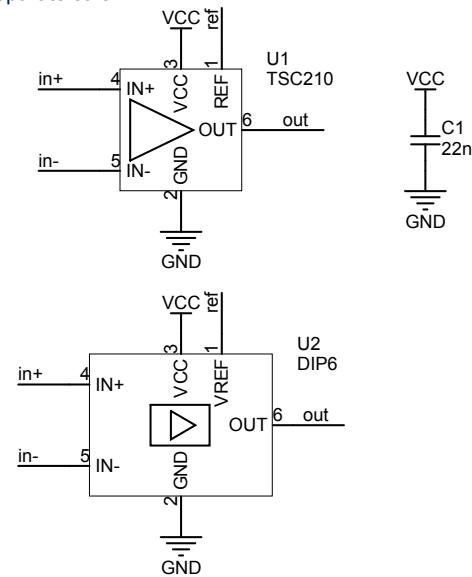


Figure 4. STEVAL-AETKT2V1 daughter board (STEVAL-AET013V1B) circuit schematic

The STEVAL-AET013V1B board is not available for separate sale



3 Bill of materials

Table 4. STEVAL-AETKT2V1 bill of materials

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	1	Table 5. STEVAL-AET011V1B		Main board	ST	Not available for separate sale
2	1	Table 6. STEVAL-AET012V1B		Daughter board	ST	Not available for separate sale
3	1	Table 7. STEVAL-AET013V1B		Daughter board	ST	Not available for separate sale

Table 5. STEVAL-AET011V1B bill of materials

The STEVAL-AET011V1B board is supplied with the kit and is not available for separate sale

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	1	P1	1x2, 5.08mm	Terminal Block for PCB	CUI devices	TB009-508-02BE
2	6	U2	DIP6, - 6x 6-5330808-5 TE DIP 6	Mini spring socket	TE Connectivity / AMP	6-5330808-5
3	2	R1, R2	0 R, 0603	Resistors	Vishay/Dale	CRCW06030000Z0EAC
4	1	R7	0R, 0805	Resistor	Vishay/Dale	CRCW08050000Z0EAC
5	2	R4, R5	100 k, 0805, 100 V, $\pm 1\%$	Resistors	Vishay/Dale	CRCW0805100KFKEA
6	1	C2	100 nF, 0805, 50 V, $\pm 10\%$, X7R	Capacitor	KEMET	C0805C104K5RACTU
7	1	C7	100pF, 0805, 50V, $\pm 10\%$, COG/NP0	Capacitor	KEMET	C0805C101K5GACTU
8	1	R3	1 k, 0805, 100 V, 100 mW, $\pm 1\%$, ± 100 ppm/K	Resistor	Vishay/Dale	CRCW08051K00FKEA
9	1	C3	1 nF, 0805, 50 V, $\pm 10\%$, COG/NP0	Capacitor	KEMET	C0805C102K5GACTU
10	1	C1	1 μ F, 0805, 50 V, $\pm 10\%$, X7R	Capacitor	KEMET	C0805C105K5RACTU
11	1	R6	2 k, 0805, 100 V, $\pm 1\%$, 100 mW, ± 100 ppm/K	Resistor	Vishay/Dale	CRCW08052K00FKEA
12	1	Rs	3m, 2512 Shunt 4 W improved	Power metal strip resistors, surface mount, 4-terminal (not assembled)	Bourns	CSS2H-2512K-3L00FE
13	1	D2	BAT54S, SOT-23	40 V, 300 mA general purpose signal Schottky diode	ST	BAT54SFILM

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
14	2	J2A, J2B	Header 3, HDR1X3, step 2.54 mm	Connector M/ - 1 row	Würth Elektronik	61300311121
15	1	J1	Header 4, HDR1X4, step 2.54 mm	Connector M/ - 1 row	Würth Elektronik	61300411121
16	1	R8	NC, 0805, $\pm 1\%$, 75 V, 100 mW, ± 100 ppm/K	Resistor (not assembled)	Any	
17	3	C4, C5, C6	NC, 0603, 50 V, $\pm 10\%$	Ceramic capacitor (not assembled)	Any	
18	3	D1, D3, D4	SMA4F18A, SMA Flat	400 W TVS in SMA Flat	ST	SMA4F18A
19	1	D5	TS431, SOT-23-5, $\pm 5\%$	Adjustable shunt voltage reference IC	ST	TS431BILT
20	1	U3	TSB711, SOT-23-5	Precision, 6 MHz, RR IO, 36 V BiCMOS operational amplifier	ST	TSB711ILT
21	1	U1	TSC21x, SC70-6	High/low-side, bidirectional, zero-drift current sense amplifier (not assembled)	ST	TSC21x

Table 6. STEVAL-AET012V1B bill of materials

The STEVAL-AET012V1B board is supplied with the kit and is not available for separate sale

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	1	C1	22 n, 0603, 50 V, $\pm 10\%$, X7R	Capacitor (not mounted)	KEMET	C0603C223K5RACTU
2	2	U2	DIP6 - 2x TS-103-T-A, 1x3, 2.54 mm	Precision header	Samtec	TS-103-T-A
3	1	U1	TSC213, SC70-6	High/low-side, bidirectional, zero-drift current sense amplifier	ST	TSC213ICT

Table 7. STEVAL-AET013V1B bill of materials

The STEVAL-AET013V1B board is supplied with the kit and is not available for separate sale

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	1	C1	22 n, 0603, 50 V, $\pm 10\%$, X7R	Capacitor (not assembled)	KEMET	C0603C223K5RACTU
2	2	U2	DIP6 - 2x TS-103-T-A, 1x3, 2.54 mm	Precision header	Samtec	TS-103-T-A
3	1	U1	TSC210, SC70-6	High/low-side, bidirectional, zero-drift current sense amplifier	ST	TSC210ICT

Revision history

Table 8. Document revision history

Date	Revision	Changes
08-Jun-2021	1	Initial release.

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