Evaluation kit for high voltage current sense amplifier with comparator

Introduction

The STEVAL-AETKT3V1 is an evaluation kit demonstrating TSC200, TSC201, TSC202 performances.

These devices are current sense amplifier with an overcurrent protection function that can operate in both high side and low side configuration.

The STEVAL-AET31V1B is a mother board, which can accept different daughter boards to use different gain configuration.

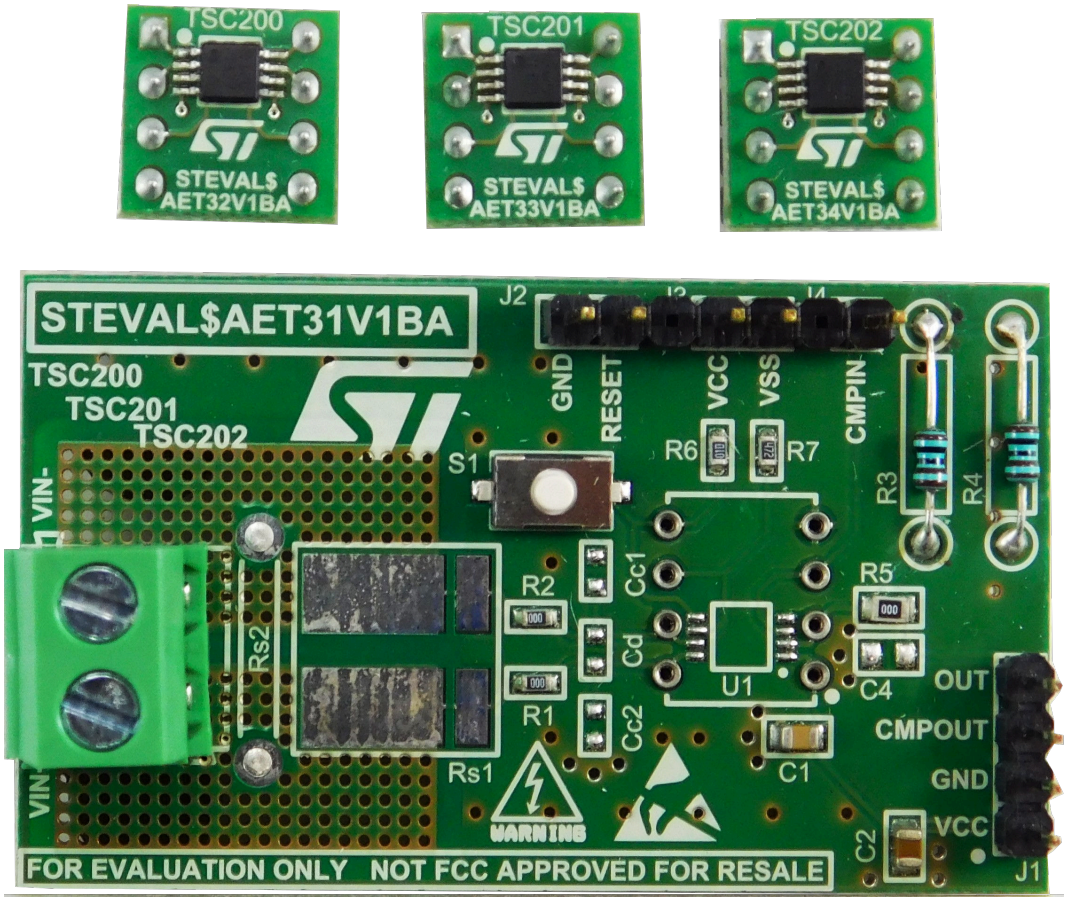
STEVAL-AET32V1B is a daughter board with a TSC200 mounted with a gain of 20.

STEVAL-AET33V1B is a daughter board with a TSC201 mounted with a gain of 50.

STEVAL-AET34V1B is a daughter board with a TSC202 mounted with a gain of 100.

TSC20x is specially designed to accurately measure current by amplifying the voltage across a shunt resistor connected to its input.

Figure 1. STEVAL-AETKT3V1 evaluation kit



Notice: *For dedicated assistance, submit a request through our online support portal at **www.st.com/support**.*

1 Hardware configuration

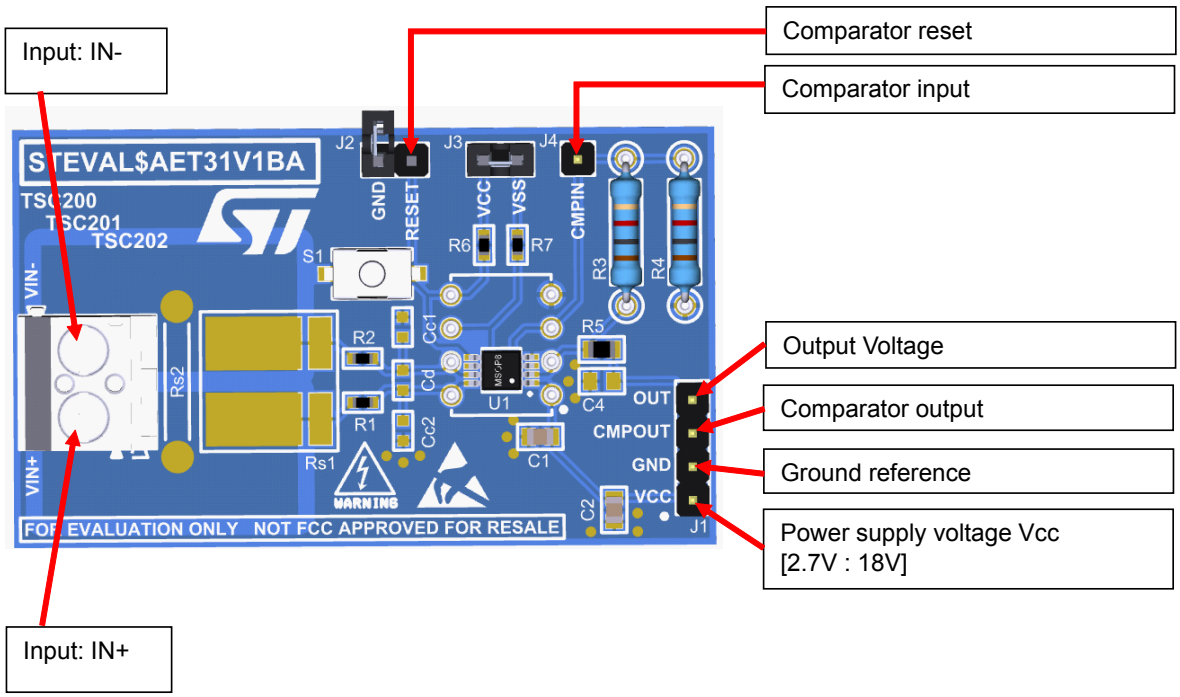
1.1 Setting

The connector J1 (4 pins) on the bottom right corner of the board allows you to set up the power supply voltage and also to read the current sense output voltage and the comparator output.

The connector J4, on the top of the board is used to set the input of the TSC20x comparator.

The connector J5, on the left of the board is used to set the inputs of the TSC20x current sense amplifier.

Figure 2. Board presentation



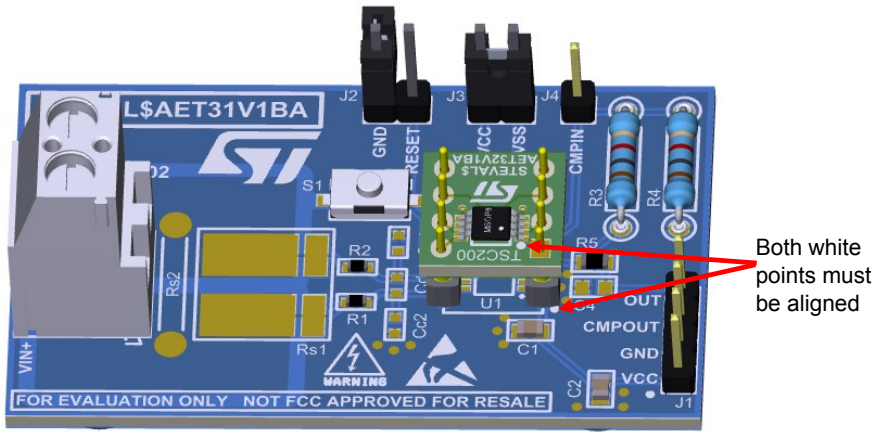
1.2 Set up

To set up the TSC20x comparator, the connector J2, J3 can be used to set the output voltage and to reset the pin voltage.

1.3 Daughter board connection

The STEVAL-AETKT3V1 evaluation kit allows you to use 3 different current sense amplifiers, and each of them can be connected on the mother board STEVAL-AET31V1B as suggested by the Figure 3. Daughter board connection.

Figure 3. Daughter board connection

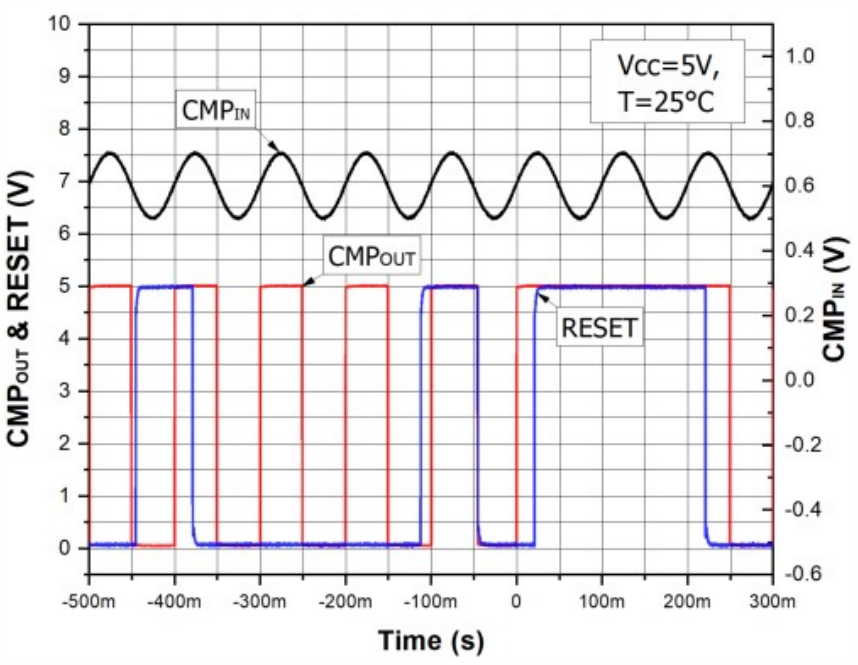


2 Comparator

The TSC20x family integrates an open-drain comparator, which can be useful for an overcurrent protection function. It is generally recommended to use a 4.7 kΩ pull-up resistance on the output. The voltage applied on the pull-up resistance must be in the 2.7 to 18 V range, regardless of the V_{CC}. This comparator offers a 300 ns (typical) response time for a small overdrive of 5 mV and lower than 100 ns for an overdrive higher than 50 mV.

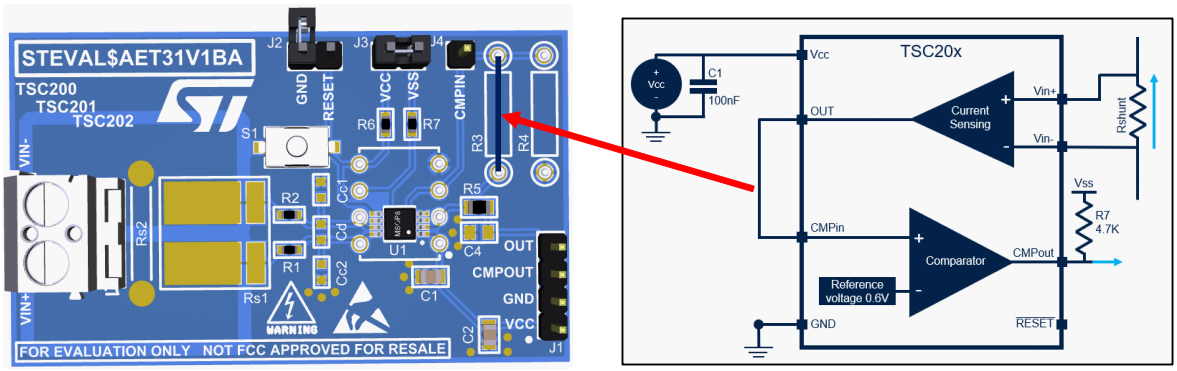
The comparator can latch the information and reset it thanks to the RESET pin. Nevertheless, if the RESET pin is left open or connected to the ground, the output latch feature is not functional anymore, and the output acts as a classic comparator. If the RESET pin is connected to a voltage higher than 1.1 V, once CMP_{IN} rises above 608 mV, CMP_{OUT} latches and remains in this state even if CMP_{IN} drops below 608 mV. Pulsing the RESET pin to the ground for at least 0.1 µs resets the latch (see Figure 4. Comparator latching capability).

Figure 4. Comparator latching capability



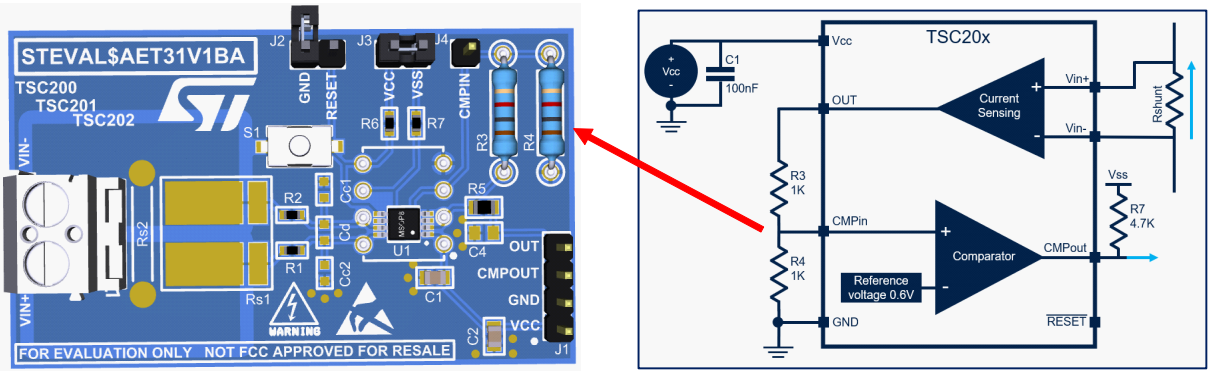
The STEVAL-AET31V1B has two possibilities for the input way. The comparator input can be connected directly to the current sensing output pin by setting R3 to 0 Ω.

Figure 5. Comparator input pin and schema with input pin



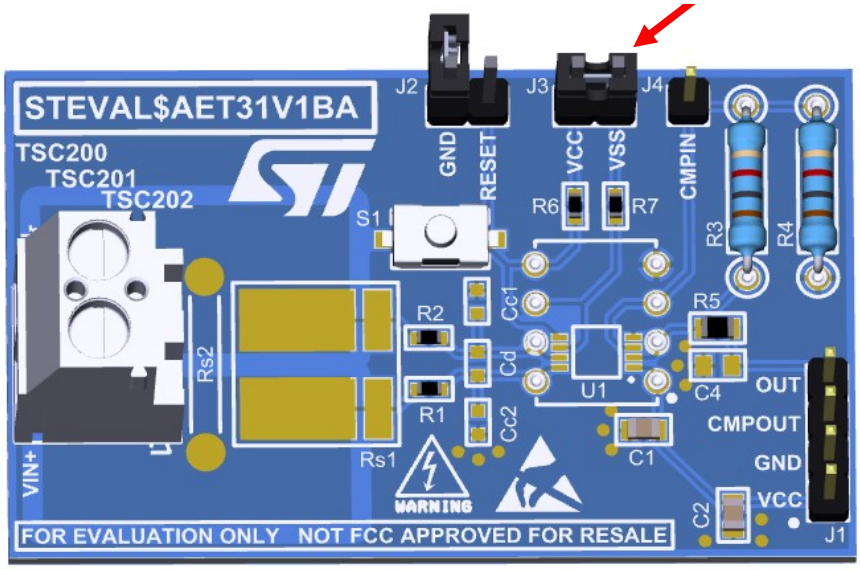
Or you can use the two resistors R3 and R4 to have a tension divider bridge directly connected to the output current sensor. Here the two resistors have the same value (1 KΩ) but other values can be used to adapt the voltage in CMP_{IN} pin for your application.

Figure 6. Divider bridge resistor and schema with input resistor



Regarding the output comparator you have to choose the pull-up voltage (V_{SS}). You can connect him to V_{CC} with J3 jumper (use by default) or connect directly to a voltage source in the range of (2.7 V to 18 V) independent of V_{CC}.

Figure 7. Pull-up voltage jumper



2.1 Comparator power-on reset

The TSC20x's comparator integrates a power-on reset, allowing it to have a defined output state.

The TSC20x comparator has an open drain output, so while the V_{CC} power supply is lower than 1.5 V, the output is ever equal to V_{cc}. When V_{CC} is above 1.5 V, the output is in a low state if the $COMP_{IN}$ voltage is lower than 0.6 V, as described by Figure 8. CMPOUT at startup when CMPIN < 0.6 V, or a high state if the $COMP_{IN}$ voltage is higher than 0.6 V as described by Figure 9. CMPOUT at startup when CMPIN > 0.6 V.

Figure 8. CMPOUT at startup when CMPIN < 0.6 V

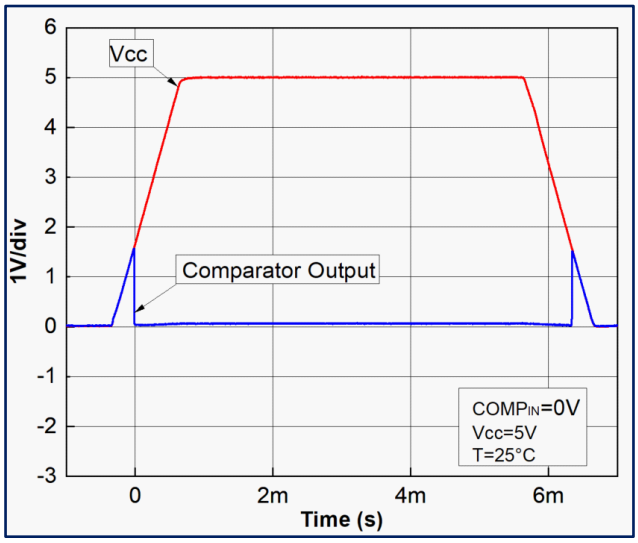
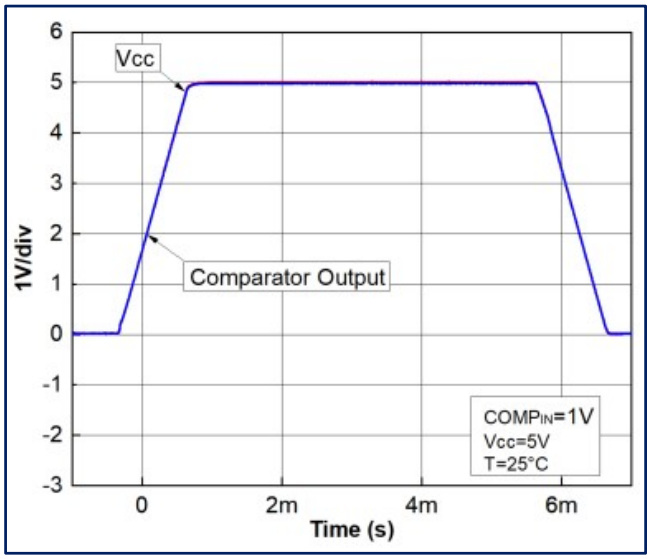
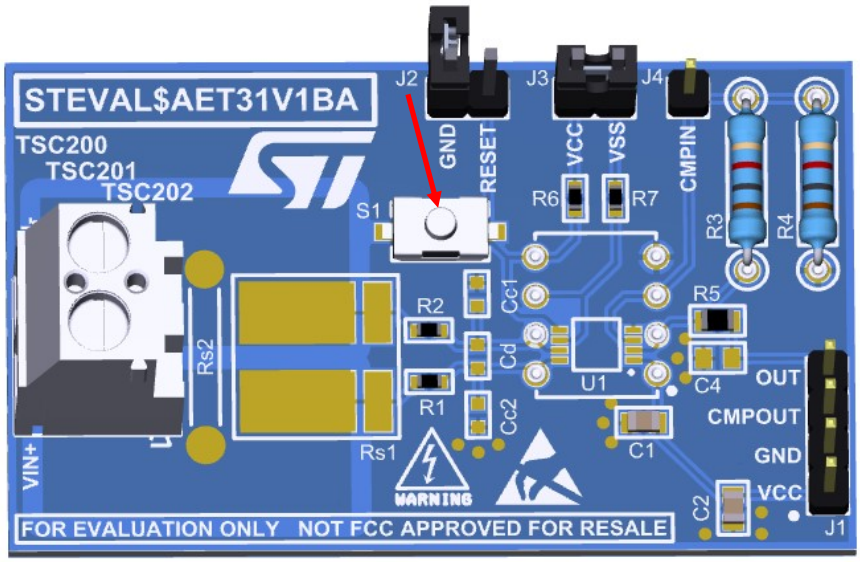


Figure 9. CMPOUT at startup when CMPIN > 0.6 V



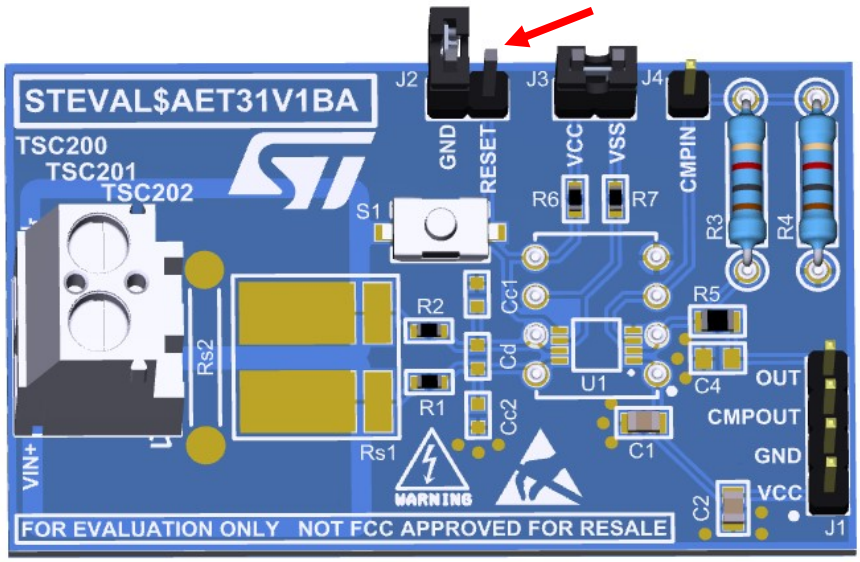
The reset pulse can be done pushing button S1.

Figure 10. Reset push button



You can also directly connect the RESET pin to GND with J2, like that the reset stays activated in order to disable the latch function.

Figure 11. Reset jumper



3 Shunt resistance

The STEVAL-AET31V1B offers the possibility to solder shunt resistance directly on the PCB. Two footprints have been defined.

A two-wire connection shunt as described by the Figure 12. Shunt 2 wires connections and a four-wire connection shunt as described by the Figure 13. Shunt 4 wires connections.

It is up to the user to choose the most appropriate shunt for its application. If the chosen shunt is not compatible with both footprints, it should be connected outside this evaluation board.

Figure 12. Shunt 2 wires connections

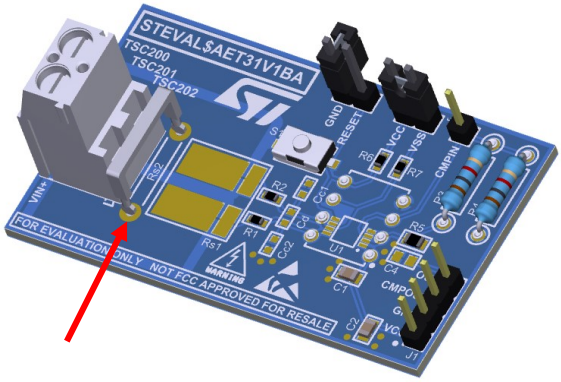
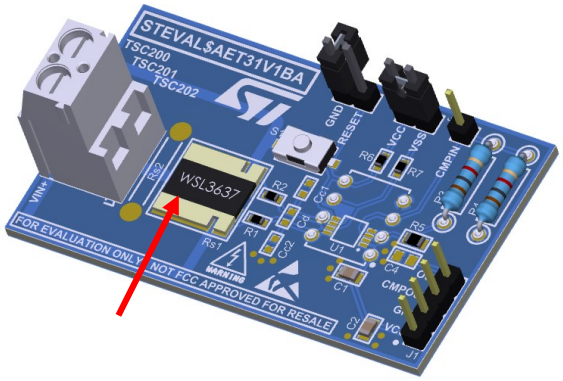


Figure 13. Shunt 4 wires connections



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 the power dissipation (RI^2) as much as possible by choosing the lowest shunt value. It is quite easy if the full-scale current to be measured is low.

In low current application, the Rsense value could be higher to minimize the impact of the offset voltage of the circuit. Keep in mind that due to the input bias of several µA the TSC20x cannot measure current in the same range.

The tradeoff is mainly when the dynamic range of current to be measured is large, meaning there is an ability to measure with the same shunt value low current to high current. The current full-scale Imax defines the shunt value thanks to the full output voltage range, the gain of the TSC20x.

At first order, the full current range to measure through Rsense can be defined by the equation, just by taking the gain error and input offset voltage as inaccuracy parameters:

$$Isense\_full\_scale \cdot Rsense = \frac{V_{cc} - 250mV}{TSC_{Gain(1+Eg)}} - |Vio|$$

Its purpose is to highlight that the product Rsense * TSC_gain is determined by the application, and that once one of these two parameters is selected, the maximum value of the second one can be calculated.

4 Schematic diagrams

Figure 14. STEVAL-AET31V1B (mother board) circuit schematic

The STEVAL-AET31V1B board is not available for separate sale.

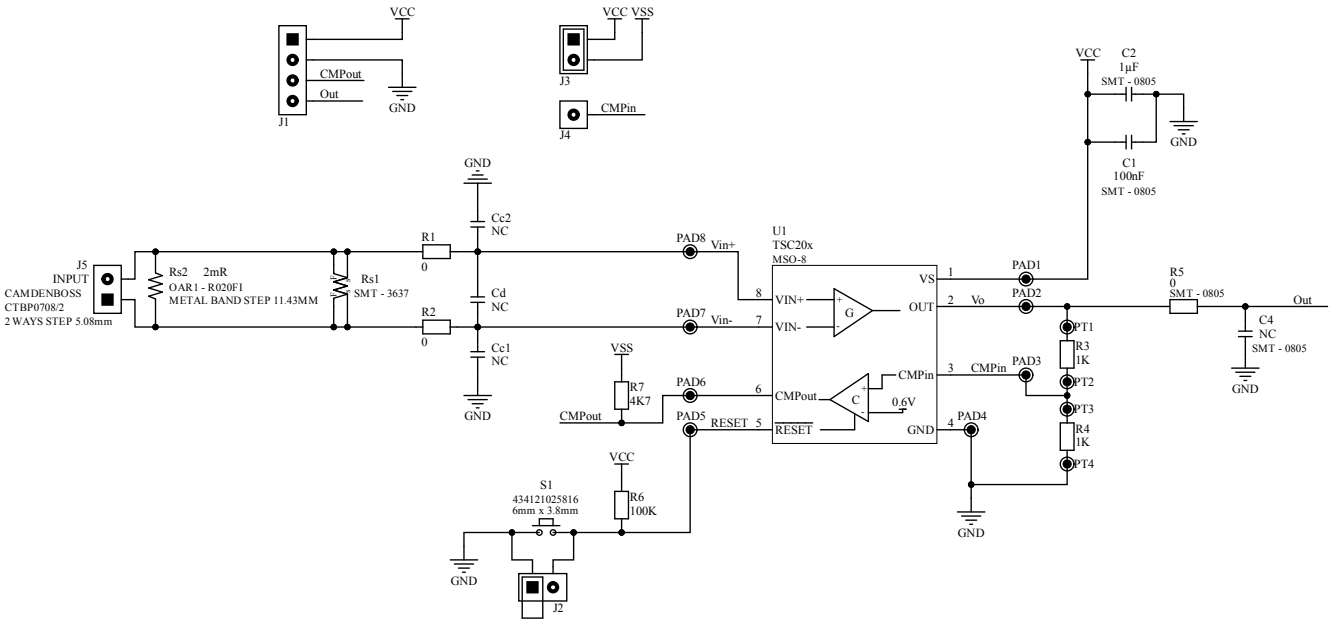


Figure 15. STEVAL-AET32V1B (daughter board) circuit schematic

The STEVAL-AET32V1B board is not available for separate sale.

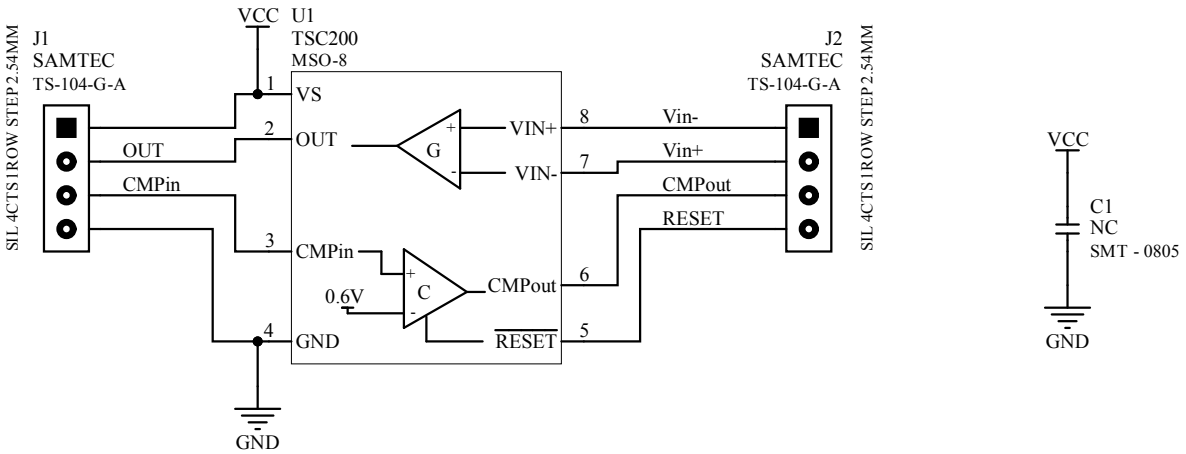


Figure 16. STEVAL-AET33V1B (daughter board) circuit schematic

The STEVAL-AET33V1B board is not available for separate sale.

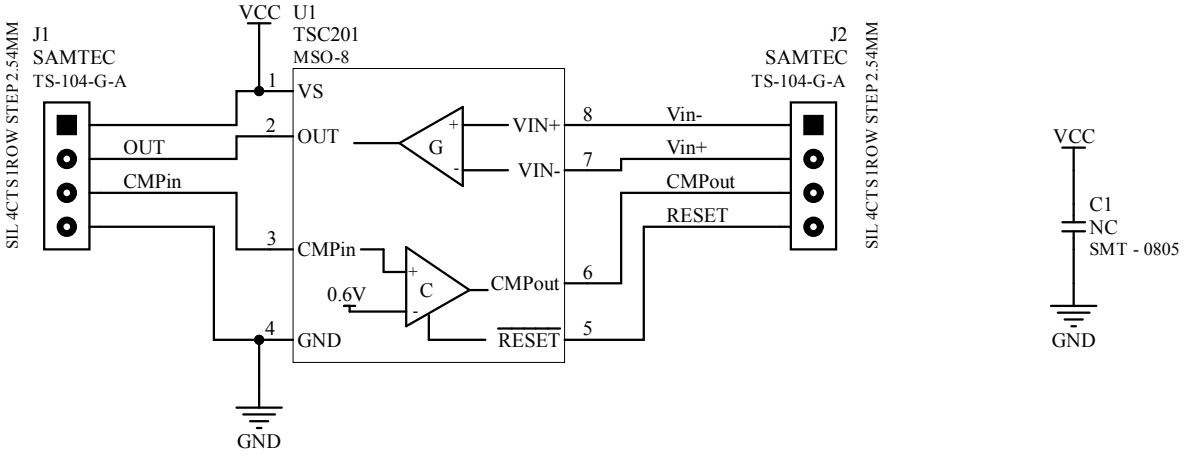
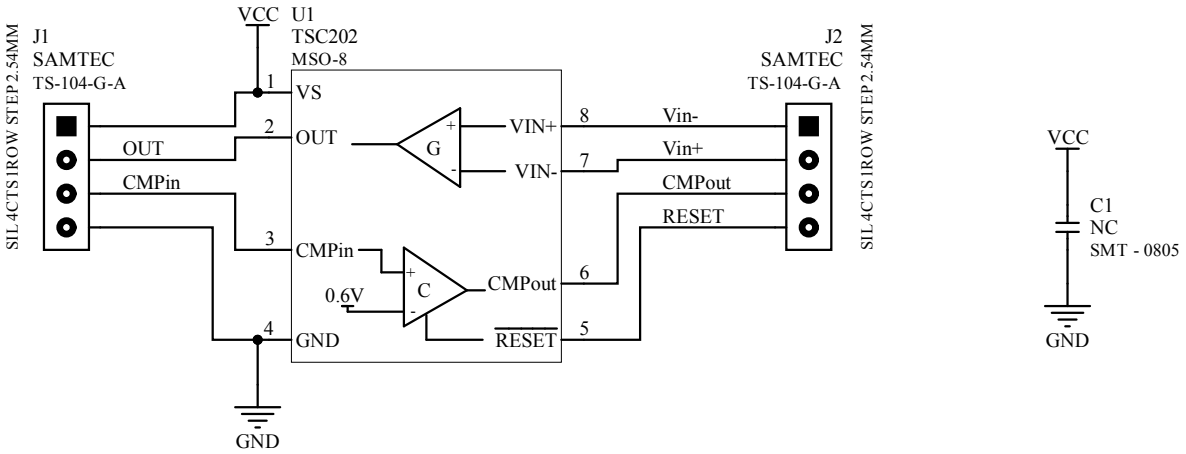


Figure 17. STEVAL-AET34V1B (daughter board) circuit schematic

The STEVAL-AET34V1B board is not available for separate sale.



5 Bill of materials

Table 1. STEVAL-AETKT3V1 bill of materials

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	1	Table 2. STEVAL-AET31V1B		Main board	ST	Not available for separate sale
2	1	Table 3. STEVAL-AET32V1B		Daughter board	ST	Not available for separate sale
3	1	Table 4. STEVAL-AET33V1B		Daughter board	ST	Not available for separate sale
4	1	Table 5. STEVAL-AET34V1B			ST	Not available for separate sale

Table 2. STEVAL-AET31V1B bill of materials

The STEVAL-AET31V1B 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	100nF, SMT - 0805, 100V, ± 10%	CAPACITOR	WURTH ELEKTRONIK	885012207128
2	1	C2	1µF, SMT - 0805, 100V, ± 10%	CAPACITOR	KYOCERA AVX	08051C105K4T2A
3	1	C4	NC, SMT - 0805	CAPACITOR (not assembled)	Any	Any
4	3	Cc1, Cc2, Cd	NC, SMT - 0603, 100V mini	CAPACITOR (not assembled)	Any	Any
5	1	J1	SIP 1X4 MALE, SIP 1x4 STEP 2.54mm, 250V, 3A	CONNECTOR - HEADER	WURTH ELEKTRONIK	61300411121
6	2	J2, J3	SIP 1X2 MALE, SIP 1x2 STEP 2.54mm, 250V, 3A	CONNECTOR - HEADER	WURTH ELEKTRONIK	61300211121
7	1	J4	SIP 1X1 MALE, SIP 1x1, 250V, 3A	CONNECTOR - HEADER	WURTH ELEKTRONIK	61300111121
8	1	J5	TERMINAL BLOCK, 2 WAYS STEP 5.08mm, 20 A	CONNECTOR - TERMINAL BLOCK	CAMDENBOSS	CTBP0708/2
9	2	Ju1, Ju2	BLACK COLOR, STEP 2.54mm, 250V, 3A	JUMPER	WURTH ELEKTRONIK	60900213521
10	4	M-01, M-02, M-03, M-04	8MM, D 8 MM	ANTI SLIP PAD	M3	SJ5076

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
11	12	PAD1, PAD2, PAD3, PAD4, PAD5, PAD6, PAD7, PAD8, PT1, PT2, PT3, PT4	1.04 MM HOLE, 5A	MINI SOCKET	TE CONNECTIVITY	5050935-2
12	2	R1, R2	SMT - 0603, 1A, 125mW	RESISTOR	PANASONIC	ERJH3G0R00V
13	2	R3, R4	1K, AXIALI 0.4, 200V, 250mW, ± 5%	RESISTOR	TE CONNECTIVITY	CFR16J1K0
14	1	R5	SMT - 0805, 1.5A, 250mW	RESISTOR	WALSIN	MR08X000 PTL
15	1	R6	100K, SMT - 0603, 75V, 100mW, ± 1%	RESISTOR	VISHAY	CRCW0603100KFKEA
16	1	R7	4K7, SMT - 0603, 75V, 100mW, ± 5%	RESISTOR	VISHAY	CRCW06034K70JNEA
17	1	Rs1	SMT - 3637	RESISTOR - SHUNT (not assembled)	Any	Any
18	1	Rs2	METAL BAND STEP 11.43MM	RESISTOR - SHUNT (not assembled)	Any	OAR1 - R020FI
19	1	S1	434121025816, 6mm x 3.8mm, 12V, 50mA	SWITCH	WURTH ELEKTRONIK	434121025816
20	1	U1	TSC200	High voltage, current sense amplifier with open drain comparator and ref	ST	TSC200

Table 3. STEVAL-AET32V1B bill of materials

The STEVAL-AET32V1B 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	SMT - 0805	Capacitor - Ceramic - Boitier (not assembled)	Any	Any
2	2	J1, J2	4CTS, SIL 4CTS 1ROW STEP 2.54MM	CI CONNECTOR - BREAKABLE MALE-MALE BARS	SAMTEC	TS-104-G-A
3	1	U1	TSC200 MSO-8	High voltage, current sense amplifier with open drain comparator and ref	ST	TSC200

Table 4. STEVAL-AET33V1B bill of materials

The STEVAL-AET33V1B 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	SMT - 0805	Capacitor - Ceramic - Boitier (Not assembled)		
2	2	J1, J2	4CTS, SIL 4CTS 1ROW STEP 2.54MM	CI CONNECTOR - BREAKABLE MALE-MALE BARS	SAMTEC	TS-104-G-A
3	1	U1	TSC201, MSO-8	High voltage, current sense amplifier with open drain comparator and ref	ST	TSC201

Table 5. STEVAL-AET34V1B bill of materials

The STEVAL-AET34V1B 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	SMT - 0805	Capacitor - Ceramic - Boitier (Not asembled)		
2	2	J1, J2	4CTS SIL, 4CTS 1ROW STEP 2.54MM	CI CONNECTOR - BREAKABLE MALE-MALE BARS	SAMTEC	TS-104-G-A
3	1	U1	TSC202, MSO-8	High voltage, current sense amplifier with open drain comparator and ref	ST	TSC202

6 Kit versions

Table 6. STEVAL-AETKT3V1 versions

PCB version	Schematic diagrams	Bill of materials
STEVAL$AETKT3V1A (1)	STEVAL$AEKT3V1A schematic diagrams	STEVAL$AEKT3V1A bill of materials

1. *This code identifies the STEVAL-AETKT3V1 evaluation kit first version. The kit consists of the STEVAL-AET31V1B mother board whose version is identified by the code STEVAL$AET31V1BA, the STEVAL-AET32V1B daughter board whose version is identified by the code STEVAL$AET32V1BA, the STEVAL-AET33V1B daughter board whose version is identified by the code STEVAL$AET33V1BA and the STEVAL-AET34V1B daughter board whose version is identified by the code STEVAL$AET34V1BA.*

7 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:

(1) 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

(2) 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 not cause harmful interference to licensed radio stations and that this product accept 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	Revision	Changes
13-Sep-2024	1	Initial release.

Contents

List of tables

List of figures