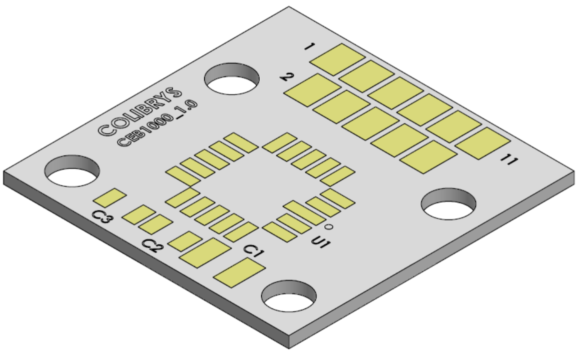
TECHNICAL NOTE

DESIGNED FOR ACCURACY, BUILT FOR TRUST

TS1000T Ceramic Evaluation Board (CEB1000_1)

These ceramic evaluation boards for the high-temperature TS1000T-series accelerometers are optimized evaluation boards designed to allow users to quickly and easily evaluate these high-performance accelerometers over their entire temperature range in laboratories conditions. They are designed for one single-axis TS1000T accelerometer and its 3 decoupling capacitors.

Why a ceramic board?
The TS1000T-series accelerometers are high-performance sensors designed to operate over a wide temperature range with minimal bias residual error and excellent long-term stability. The stresses induced by coefficient of thermal expansion (CTE) mismatch between the sensor package and the substrate can significantly degrade the device's performance, especially during extreme temperature excursions. Therefore, Colibrys has created a ceramic evaluation board to match the TS1000T package CTE of 7 ppm/°C.



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1 Ceramic Evaluation Board

1.1 Electrical schematic

The ceramic evaluation board (CEB_1000_1) is designed to receive one single-axis TS1000T accelerometer and its proximity decoupling capacitors: C1, C2 and C3 as shown in Figure 1. These capacitors are mandatory for the proper operation and full performance of the device. The ceramic board electronic schematic is shown below.

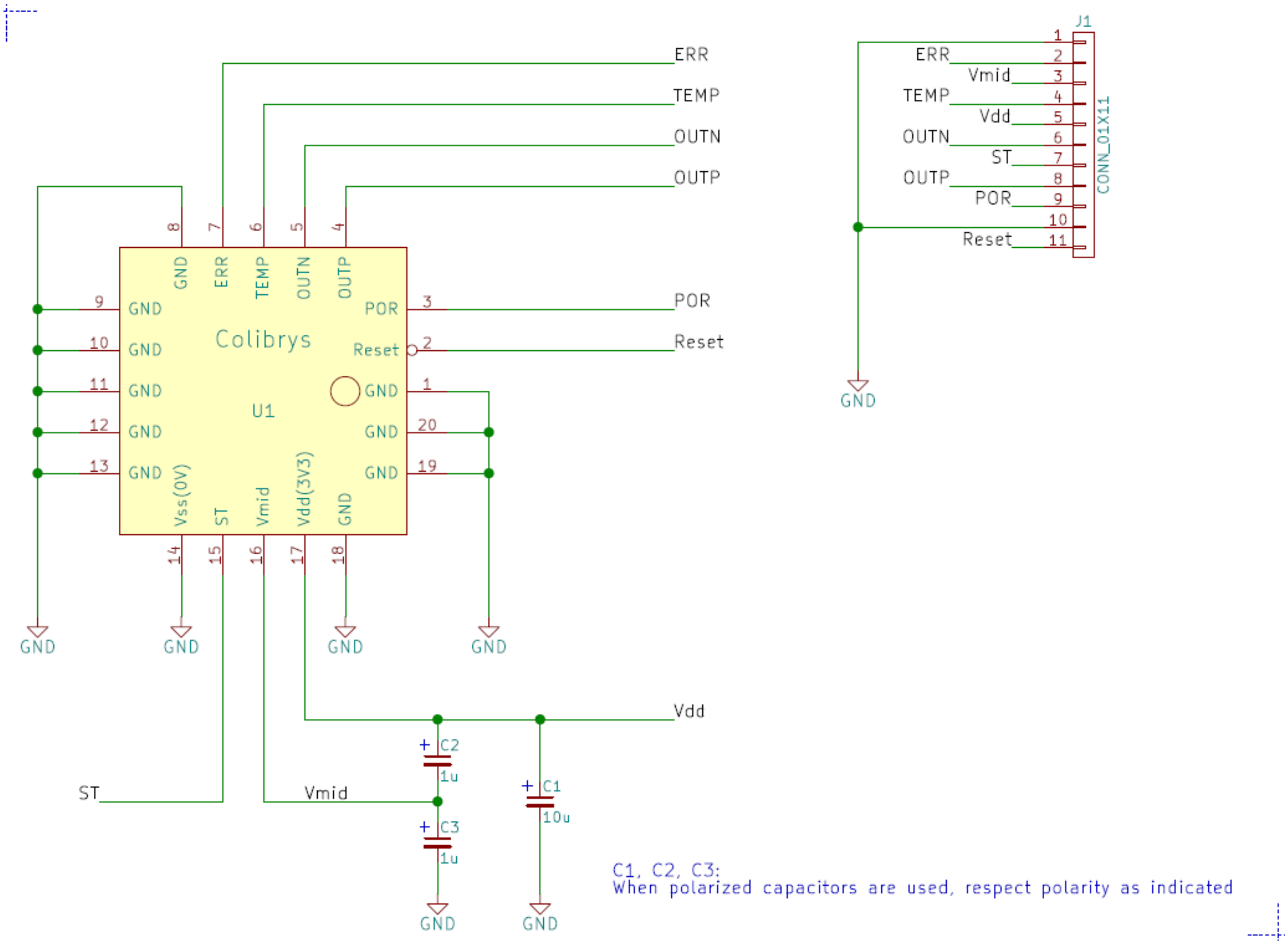


Figure 1: Board electrical layout

1.2 Interface Pinout

The Table 1 below describes the pin name and interface for the connecting pads J1 (pads on the ceramic)

Pin Nr	Pin name	Connector	Description
1	V_{SS} (0 V)	J1	Must be connected to ground plane (GND)
2	ERR	J1	Error signal (flag)
3	V_{MID}	J1	Internal ASIC reference voltage. For decoupling capacitors only
4	TEMP	J1	Temperature sensor analog output
5	V_{DD} (3.3 V)	J1	+3.3 Vdc Analog power supply
6	OUTN	J1	Negative differential output
7	ST	J1	Self-test activation, active high
8	OUTP	J1	Positive differential output
9	POR	J1	Power-on Reset signal (flag)
10	V_{SS} (0 V)	J1	Must be connected to ground plane (GND)
11	RESET	J1	System reset signal, active low

Table 1: Interface Pinout

1.3 Mechanical Layout

The mechanical layout of the ceramic evaluation board is shown in Figure 2. All components are soldered on the top surface and the board can be mounted using the 4 x Ø3.40 mm through holes provided (see the assembly recommendations section below for more information on board mounting).

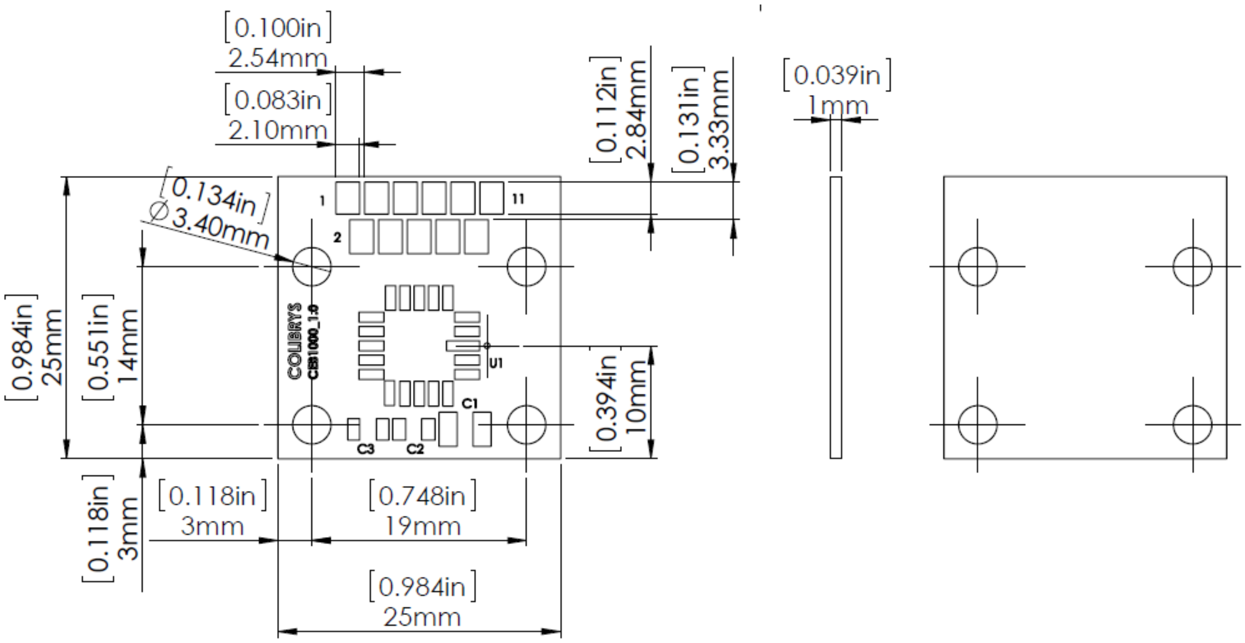


Figure 2: Board mechanical layout

2 Integration

2.1 SMD recommendation

As shown in Figure 3, the ceramic evaluation board was designed to hold one accelerometer and 3 decoupling capacitors. A recommended BOM is listed in Table 2.

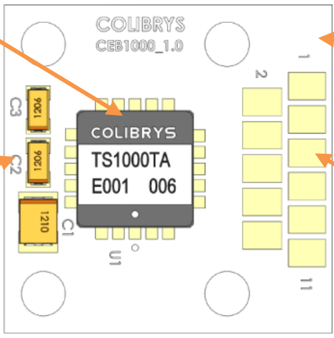


Figure 3: Sketch of the ceramic evaluation board with a TS1000T accelerometer and its decoupling capacitors

2.2 BOM

Item	Qty	Name	Description	Value	Tol.	Footprint	MFG	Part Number
1	1	NA	CEB1000_1 ceramic board	N/A	N/A	N/A	Colibrys	576 10001
2	1	U1	Accelerometer TS1000T	N/A	N/A	LCC20	Colibrys	376 10502 (2g) 376 10505 (5g) 376 10510(10g)
3*	1	C1	Capacitor	10 µF	10 %	1210	AVX Corporation	THJB106K016RJN
4*	2	C2, C3	Capacitor	1 µF	10 %	1206	AVX Corporation	THJA105K025RJN

***Note** : Item #3 & #4 are not supplied by Colibrys.

Table 2: Bill of material

3 Assembling and soldering

In order to obtain the best device performance, special care must be paid to the soldering of surface-mount MEMS sensors. This section give specific recommendations for an automated reflow process and a manual soldering process. For both processes, the sensors must be properly mounted to avoid mechanical stress by ensuring a proper solder thickness after soldering. The following elements must be considered:

- The solder paste must be as thick as possible in order to decouple board-related strains
- The solder paste thickness should be as uniform as possible to minimize solder-related strains

The automated reflow is *highly recommended* as it will give more uniform process.

3.1 Automated process (recommended)

The TS1000T is compatible with Sn/Pb and Pb-free soldering process and is RoHS compliant. Figure 4 show typical reflow temperature profiles. IPC/JEDEC J-STD-020D recommends a maximum ramp-up of 3 C/s and a maximum ramp-down of 6 C/s.
Note: the exact profile will depend on the solder paste used.

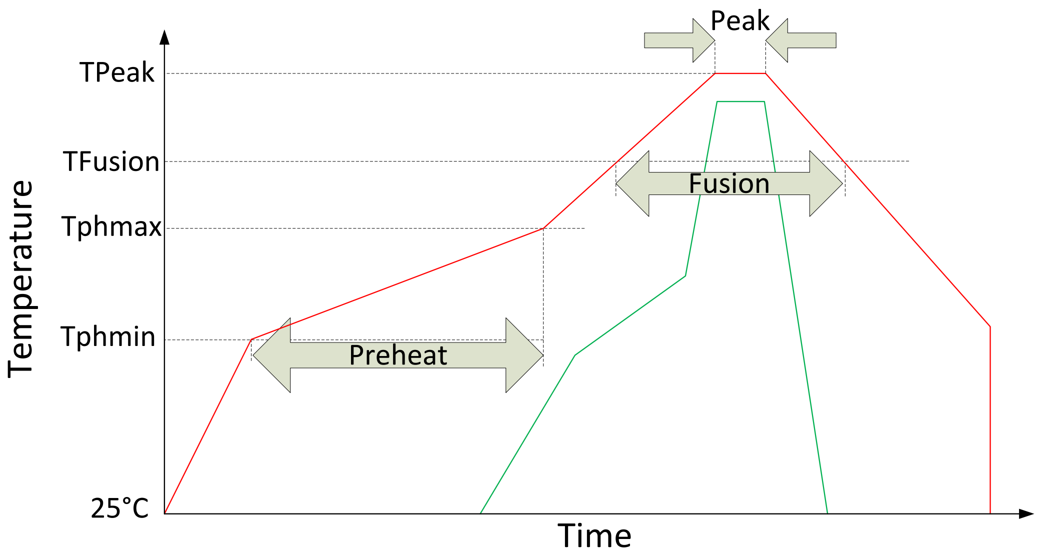


Figure 4: Soldering Temperature Profile

Phase	Sn/Pb		Pb-Free	
	Duration [s]	Temperature [°C]	Duration [s]	Temperature [°C]
Preheat	60-120	Min : 100 Max : 150	60-180	Min : 150 Max : 200
Fusion	60-150	183	60-150	217
Peak	10-30	235-240	20-40	245-250

Table 3: Typical soldering temperatures and times

Note: Ultrasonic cleaning of the ceramic evaluation board is strictly forbidden once the MEMS accelerometer is mounted in order to avoid damage to the MEMS.

3.2 Manual soldering

Colibrys recommends an automated reflow process.
However manual soldering has been tested for lab purposes by Colibrys and is presented below.
Note: Using a manual process could results in additional strains on the MEMS that can be detrimental to the product performance.

The process flow is

- Setup: heat plate and dispenser
- Clean the CEB Surface
- Dispense solder paste
- Placement of components
- Reflow
- Cool down

The material used is listed below:

- Solder paste of alloy SnSb8,5 like the ECORELTM FREE HT 245-16
- Heat plate set to surface temperature of 210°C (-5°C / +10°C)
- Manual paste dispenser tip diameter 0.58mm
- Timer

3.2.1 Set up

3.2.1.1 Solder paste dispenser

The picture shows the manual paste dispenser unit used for this demonstration and the syringe (empty) fitted with a tip and pressure tube piping. Once a pedal is pressed the unit establish a pressure (set to about 2bars) during a preset timer (here 4.3 sec).

Figure 5: dispenser control panel

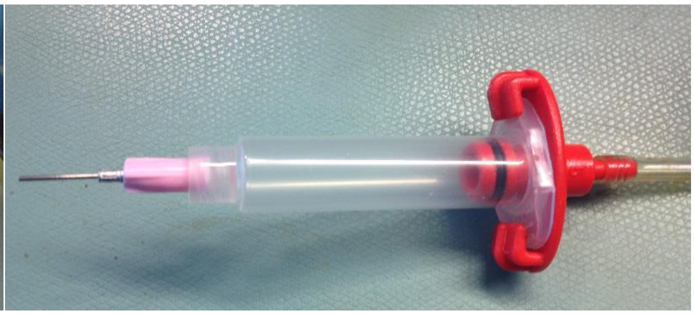


Figure 6: dispenser syringe with tip

Try and adapt to find the convenient setting to deposit required dose of paste. The setting will depend on the type of material and the consistence of the paste used.

3.2.1.2 Heat plate

Conventional Heat plate can be used.

Set the control to get a regulated surface temperature of +210°C $^{+10°C/-5°C}$.

To verify the temperature is correct a small dose of soldering paste can be dropped on the heated plate. The flux starts to be activated followed by the solder melting that forms a small sphere.

Once the setting is found, switch off the plate and allow time to cool down

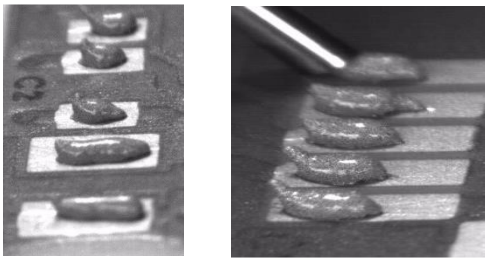
Figure 7: illustration of a suitable heat plate

3.2.2 Cleaning

The CEB surface is cleaned with particular care to the contact pads.

3.2.3 Dispense the solder paste

On a clean ceramic substrate, dispense solder paste on all contact pads, but the J1 pads 1 to 11 are left free of paste.



Hint:
the paste shall cover half of the pad length for the LCC package from mid position toward the outside and almost the entire pad for the other components as shown on the picture sequence

Figure 8: Solder paste on contact pads

3.2.4 Placement

Note: MEMS accelerometer can be damaged by electrostatic discharge (ESD). Handle with appropriate precautions and placement should be done in accordance with strict ESD control

Place the MEMS accelerometer and the 3 decoupling capacitors on the substrate taking care to manipulate them using the adequate tools (vacuum pen to be preferred for the MEMS).

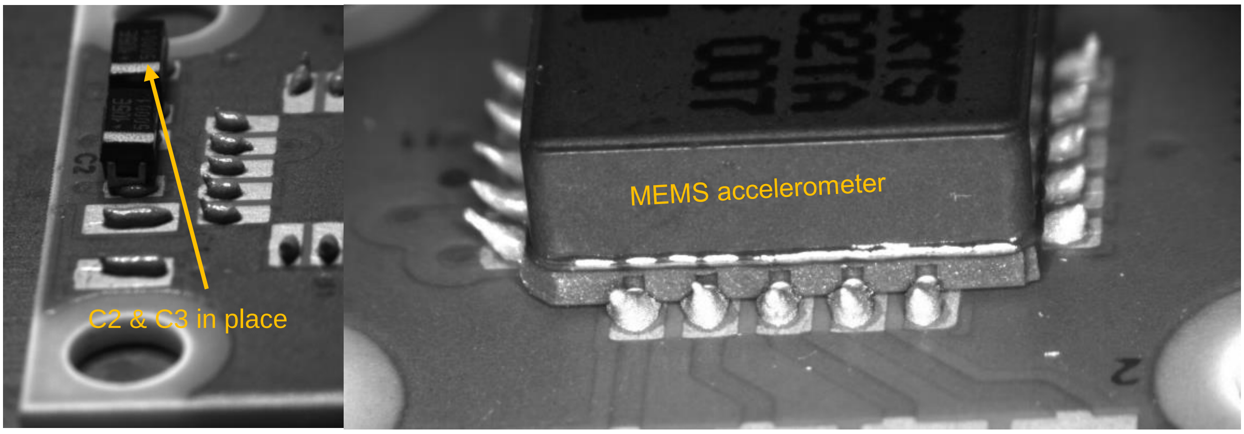


Figure 9: components are placed on the contact pad and slightly pressed down

Once this is done and components are placed and aligned (see picture above), the reflow process can be carried out.

3.2.5 Reflow

3.2.5.1 Heating up

The populated ceramic substrate is at room temperature. Carefully place the ceramic on the plate and switch the heater on using the pre setted conditions . The temperature around the pads rapidly increase and solder paste volatiles get removed and the flux get activated.

That is the moment to start the timer.

After few seconds the temperature reach the solder melting point.

When the flux is evaporated and no more bubbles are observed the substrate can be removed from the heat plate, but do not exceed 60sec.

Please note that these conditions are specific to a manual soldering with a heat plate.

Pictures of reflow sequences on heating plate

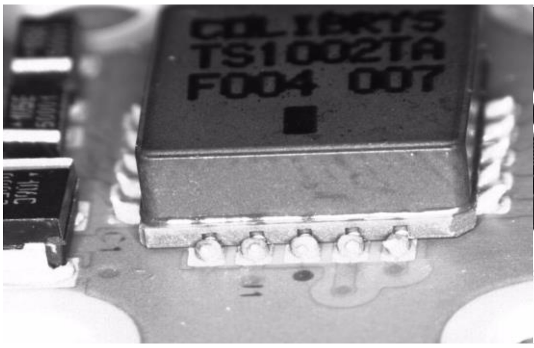


Figure 10: PCB on heat plate

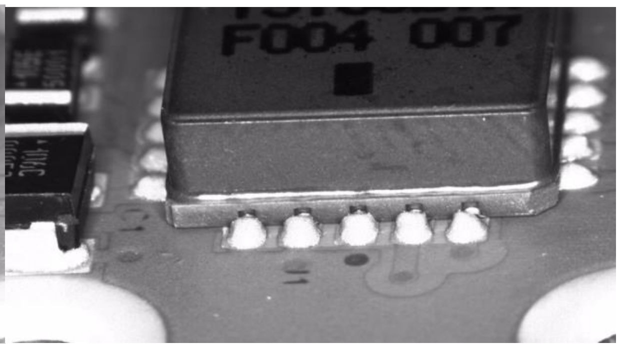


Figure 11: Flux start to bubble

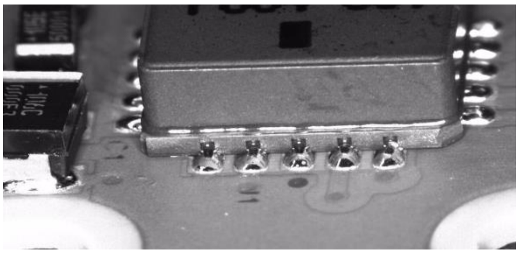


Figure 12: pads are well covered with melted solder

3.2.6 Cool down

After removing the CEB off the heat plate, place it on a surface to allow a slow cool down

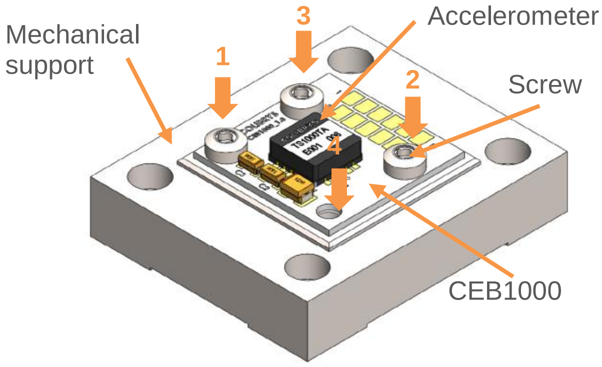
Note: Ultrasonic cleaning of the ceramic evaluation board is strictly forbidden once the MEMS accelerometer is mounted in order to avoid damage to the MEMS.

4 Assembly Recommendation

We recommend mounting the ceramic evaluation board to your mechanical support using only 3 of the 4 through holes to prevent redundant constraints in the board. The 4th hole can be used if required, but care should be taken to minimize stresses in the board that may adversely affect sensor performance. We further recommend using a low CTE material such as titanium (8.6 ppm/°C) or Kovar (5.5 ppm/°C) for your support to minimize CTE mismatch with the ceramic board (7 ppm/°C). Spacers between the ceramic board and your mechanical support are also recommended to further decouple the board from the support and reduce their contact area. Excessive roughness or poor flatness in the surfaces in contact with the ceramic board (i.e., fasteners and spacers) can lead to stress concentrations during temperature excursions that may damage the board. Our engineering mechanical support have been machined with a surface roughness Ra 1.6µm and flatness of 0.01mm.

4.1 Mechanical Assembly

If the board is attached using screws, we recommend pre-tightening them in a criss-cross pattern as numbered in Figure 13, before final tightening. We do not recommend a specific torque value for tightening, but special care should be paid to prevent damage to the ceramic board.



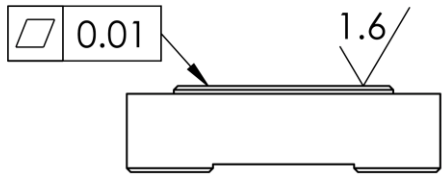


Figure 13: Ceramic Evaluation Board mounting (left) and mechanical reference surface (right)

4.2 Potting Recommendation

Ensure that there is no resin, such as epoxy potting material, touching the MEMS accelerometer package as it may induce additional stresses on the accelerometer.

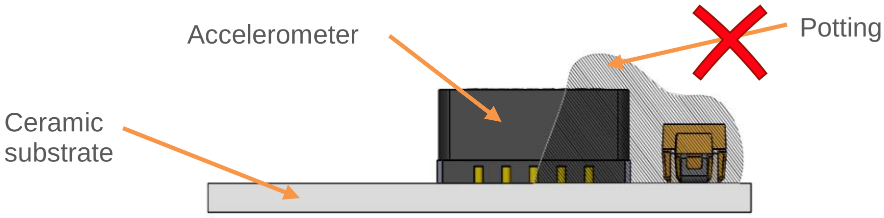


Figure 14: Ensure potting materials does not touch the accelerometer

5 Electronic Design - for sensor tests

In order to obtain the best device performance, special care must be paid when selecting the proximity analog electronics used with the accelerometer, i.e. the reference voltage source and the output signal buffers (see the block diagram in Figure 15).

Furthermore, optimal acceleration measurements are achieved using the differential device output (OUTP–OUTN). If a single-ended output is required, it must be generated from the differential output in order to remove the common-mode noise. Using a single device output (OUTP or OUTN) will result in degraded performance.

5.1 Block Diagram

The block diagram below illustrates the power supply management, the accelerometer's internal electronic blocks (including decoupling capacitors) and the output signal conditioning. This document focuses on an accelerometer ceramic board that includes the TS1000T and the decoupling capacitors. Recommendations for the power supply and output signal conditioning are listed in the TS1000T datasheet and they can be implemented on a separate board, or all together on a custom-designed board, depending on the application requirements.

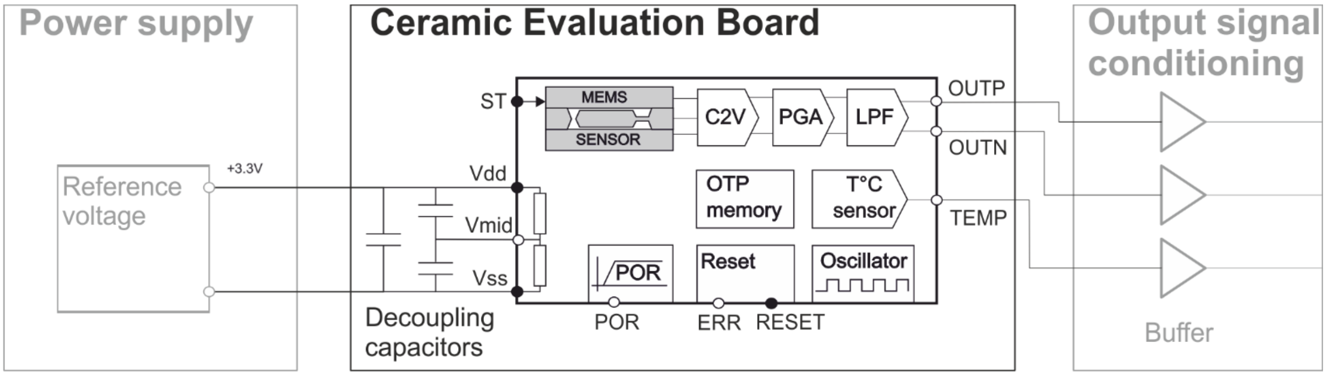


Figure 15: Accelerometer block diagram

Colibrys proposes, as an example, the following analog electronics that are compatible with the +175 °C temperature range of the TS1000T sensors.

5.2 Power Supply

The accelerometer output is ratiometric to the power supply voltage and its performance will directly impact the accelerometer bias, scale factor, noise and thermal performance. Therefore, a low-noise, high-stability and low-thermal-drift power supply is recommended. Key performances are:

- Output noise < 1 µV/√Hz
- Output temperature coefficient < 10 ppm/°C

To further improve the output stability, the power supply voltage signal (V_{DD}) can be used to compensate output drift/noise due to V_{DD} variations thanks to the ratiometric nature of the output.

The electronic circuit within the accelerometer is based on a switched-capacitor architecture clocked at 200 kHz. Therefore, high-frequency noise or spikes on the power supply beyond the device's bandwidth can generate lower-frequency aliases within the bandwidth and affect the output signal quality.

5.3 Output Signal Conditioning

The output buffers must be correctly selected in order to match the TS1000T output impedance and signal bandwidth. If an analog-to-digital converter is involved, we recommend using a component with an external voltage reference derived from the sensor power supply (V_{DD}). Such an implementation inherently accounts for the ratiometric nature of the accelerometer's outputs.

5.4 Typical electrical schematic

Colibrys suggest a typical electrical schematic in the Figure 16 based on the above recommendations. Customers should validate and test their design implementation to confirm system functionality.

The output signals of the CEB1000 board are buffered using high temperature OPAmps (ie the INA128-HT) with unity gain. The 3.30VDC power supply is fed using a high temperature voltage reference of 2.5VDC (ie AD225HRZN) buffered with a high temperature OPAmp (ie OPA211-HT) with a gain of 1.33.

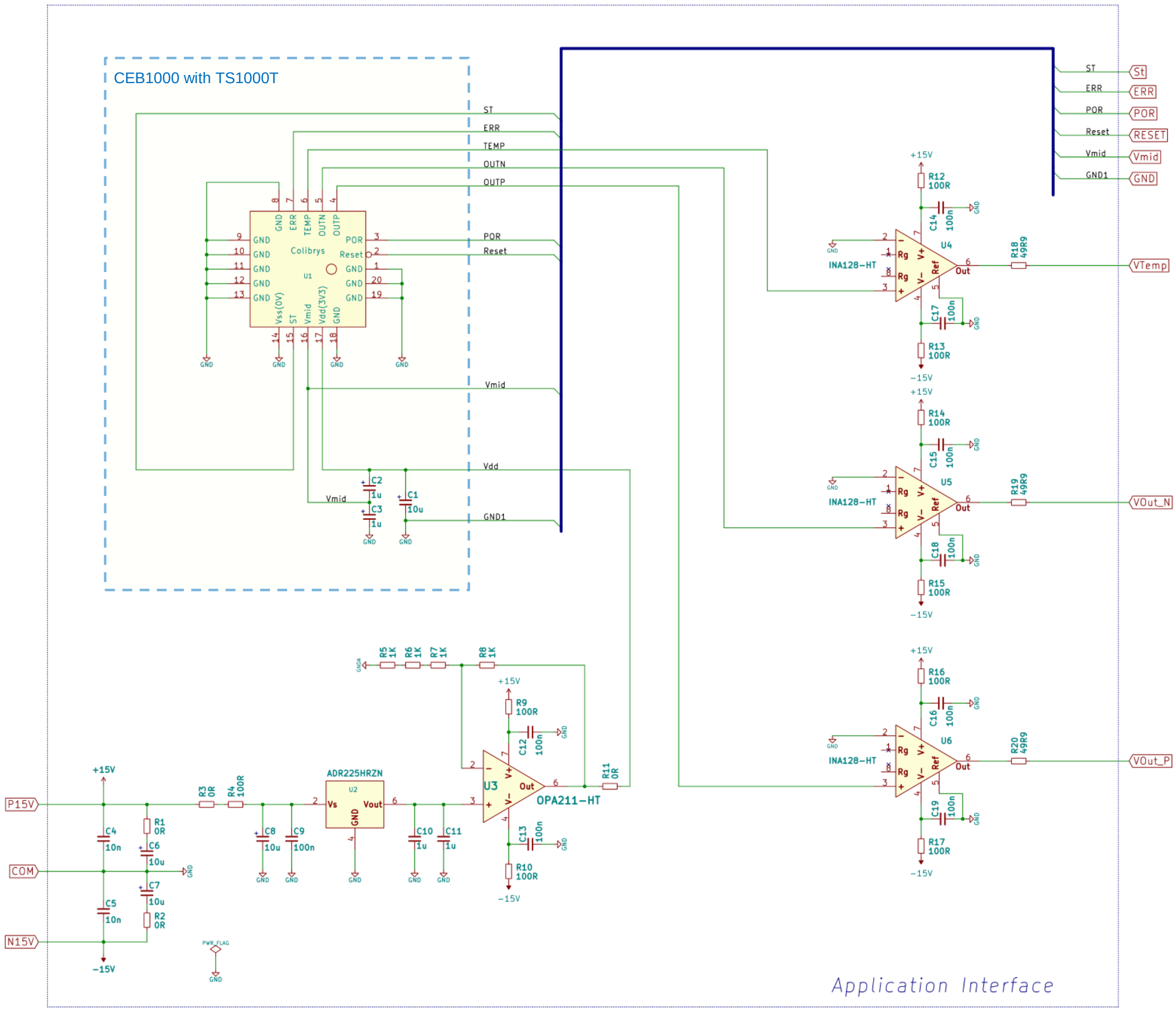


Figure 16: Suggested electrical schematic for CEB1000 board with TS1000T

When a single-ended output signal is mandatory for the application, the accelerometer output signal must be generated from the 2 differential output signals (OUTP & OUTN).

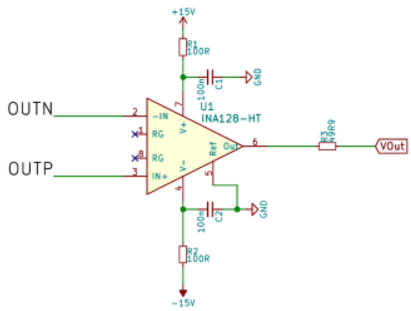


Figure 17: Suggested differential to single ended output conversion circuit