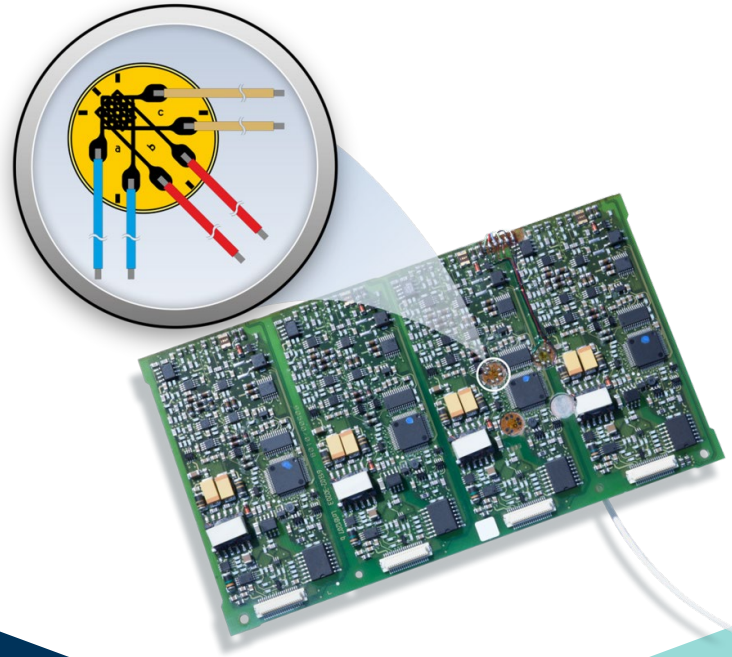
Strain and Strain Rate Measurement on PCBs

APPLYING THE IPC/JEDEC 9704



Malte Grieme

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Agenda

WHAT ARE WE GONNA TALK ABOUT

1. Why are strain measurements performed on PCBs?

2. How to measure strain on PCBs?

3. Where to measure strain on PCBs?

4. How to do data analysis?

Why are strain measurements performed on PCBs?

During the manufacture of PCBs

- Bending strain during the installation
- Breakage during mounting SMD, SMT, THD, THT and PIH fitting
- Stress cracks and dislodging of solder points with ball grid arrays (BGA)

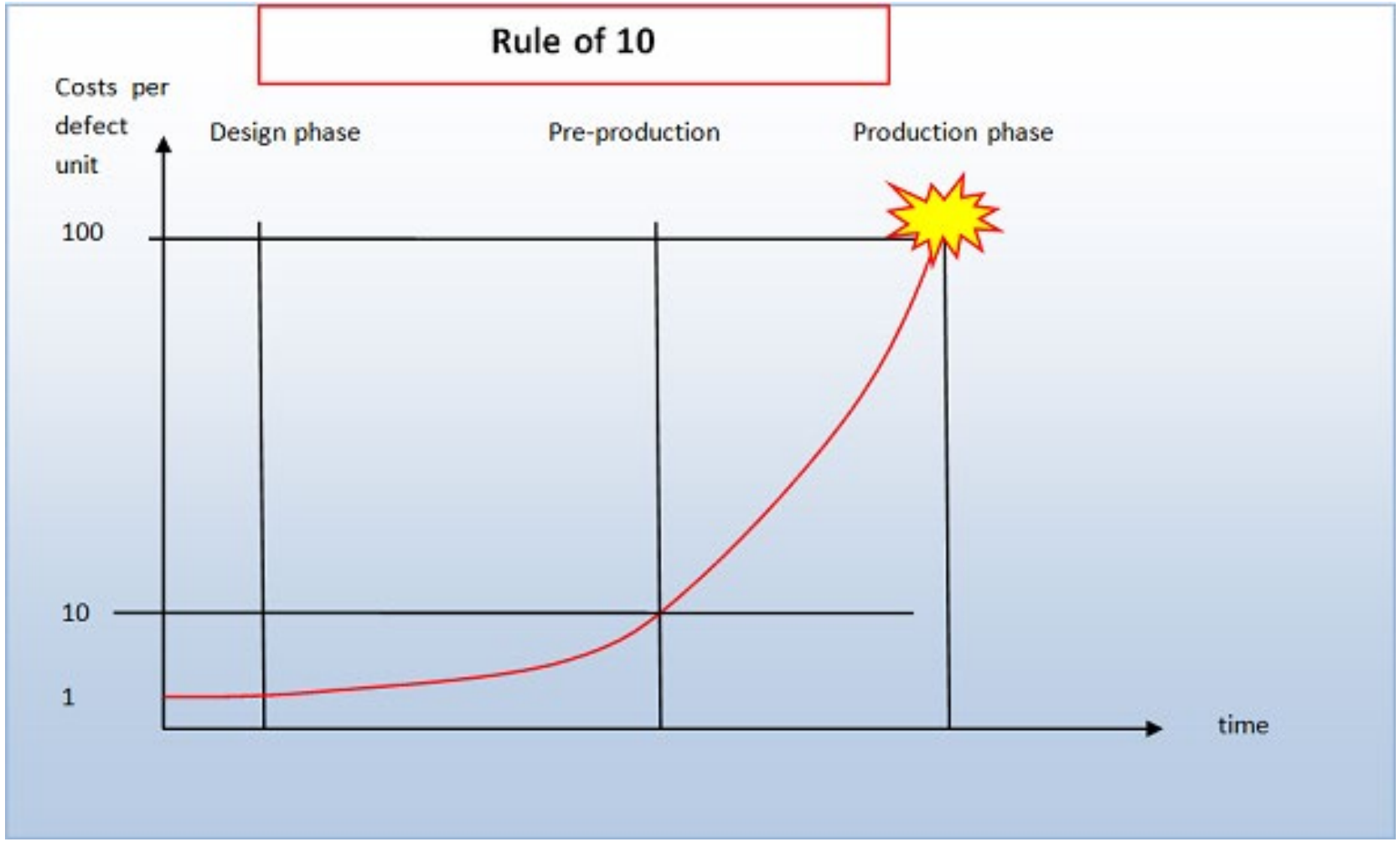
During the manufacture of PCBs

- Transient strain peaks during separation (determination of critical strains/shear strains during separation)
- Elevated mechanical stress (strain)
- Broken SMD capacitors due to high bending stress in other steps of the process
- Hard touchdown of the test probes during the ICT

During transport and operation

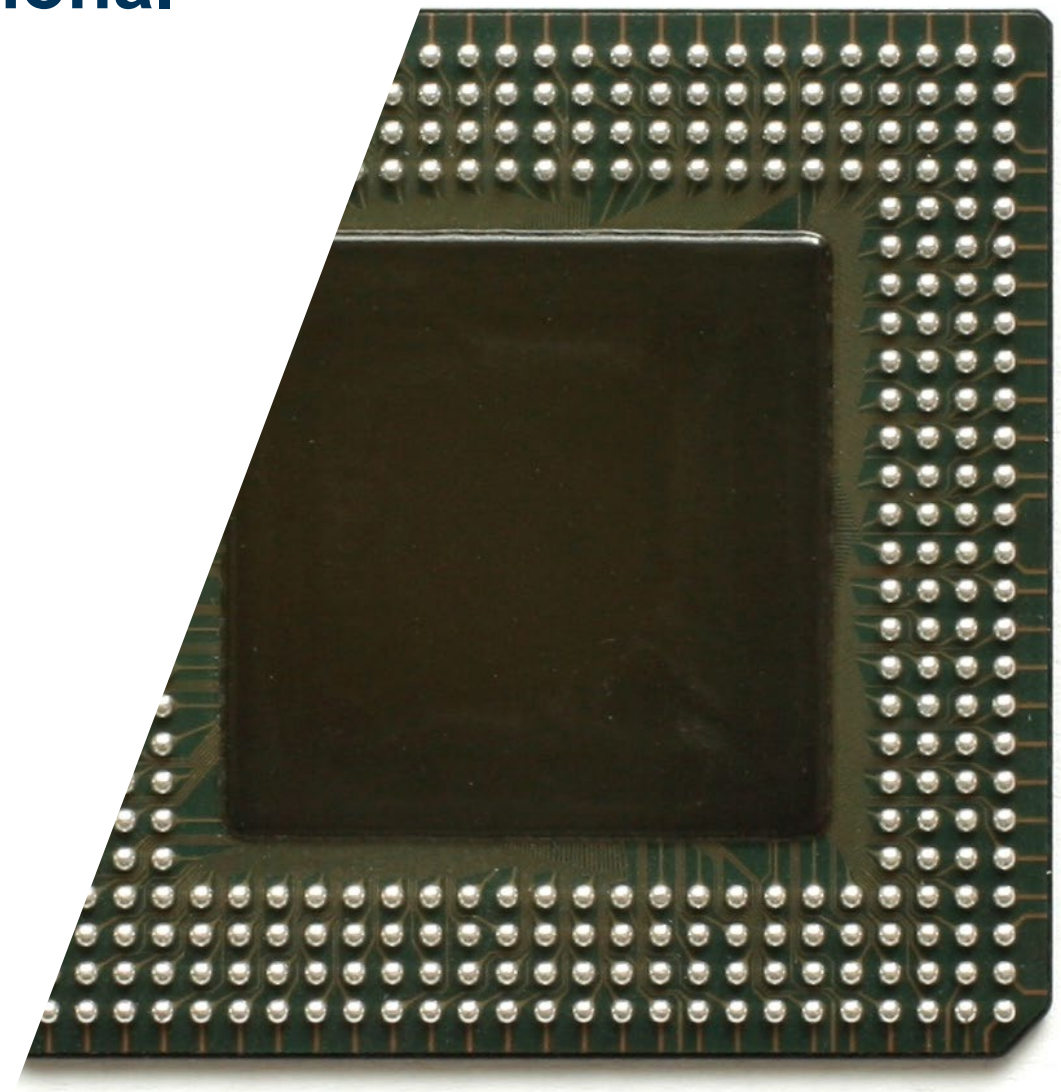
- Mechanical load (static)
- Vibration and splicing (dynamic)
- Thermal effects resulting in cracks caused by thermal expansion (differing α values of housing, heat sink, printed circuit board, and electronic components)

Rule of 10



Extended Requirements and International Standards for PCB Testing

- Use of lead-free solder (RoHS conformity, EU guideline) that is more sensitive in relation to mechanical load and tends to crack earlier (flexure-induced damage)
- More compact construction elements such as ball grid arrays (BGA) instead of surface-mounted devices (SMD)
- Stiffer contacts that lead to higher mechanical tension



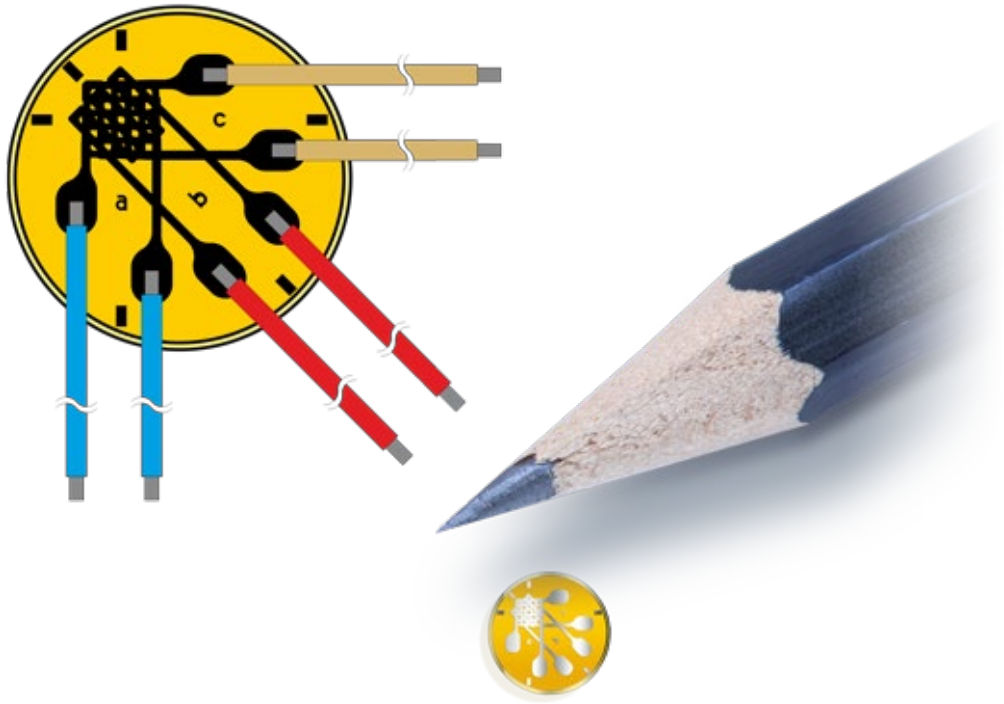
How to measure strain on PCBs?

Why strain gauges?

- Numerical simulation methods such as FEA are limited in their scope since they are based on mathematical model approaches.

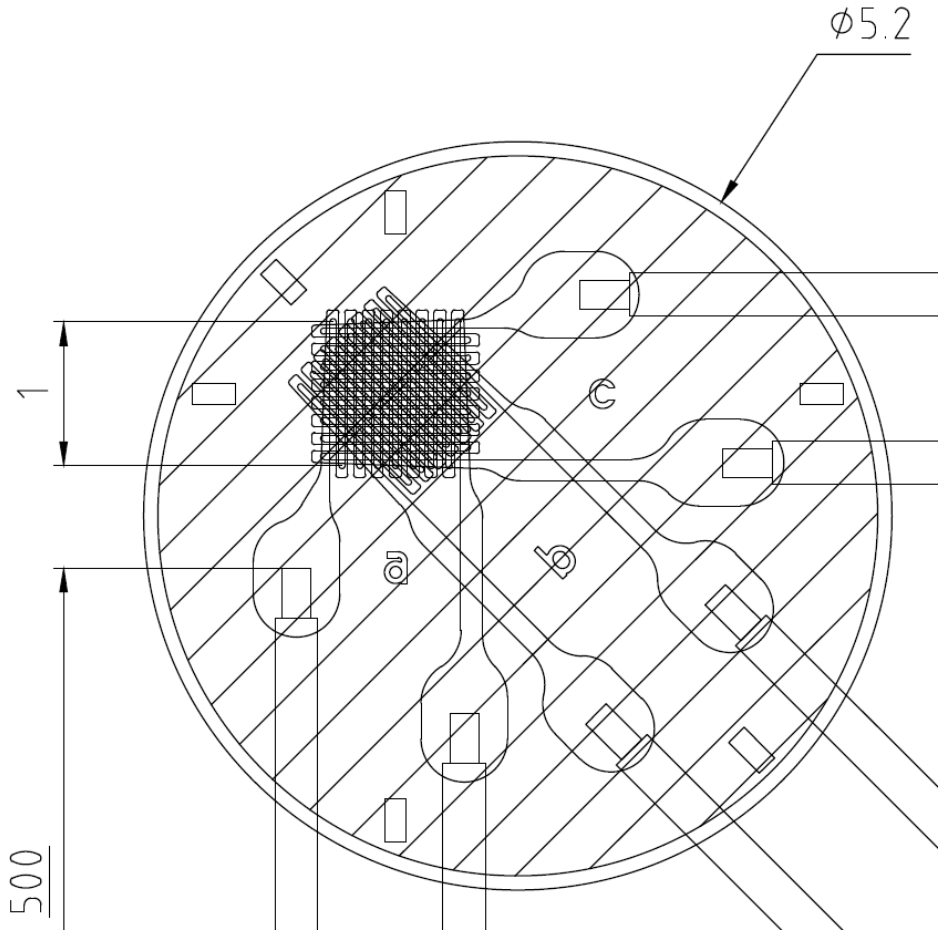
- CTs and X-rays are not sufficiently adequate to check the influence of the mechanical impact and are, on top of that, expensive methods to employ

- **Therefore, strain gauges are designated to measure the deformation of the PCBs to an extremely accurate degree.**



What are the requirements for the strain gauge?

- Three element stacked (0/45/90) rosette
- 1.0 to 2.0 mm², nominal, gage sensor size
- Lead wires attached
  - 30 AWG lead wire preferred
- Coefficient of Thermal Expansion (CTE) is not critical as long as the gauge factor is stable in the temperature range.



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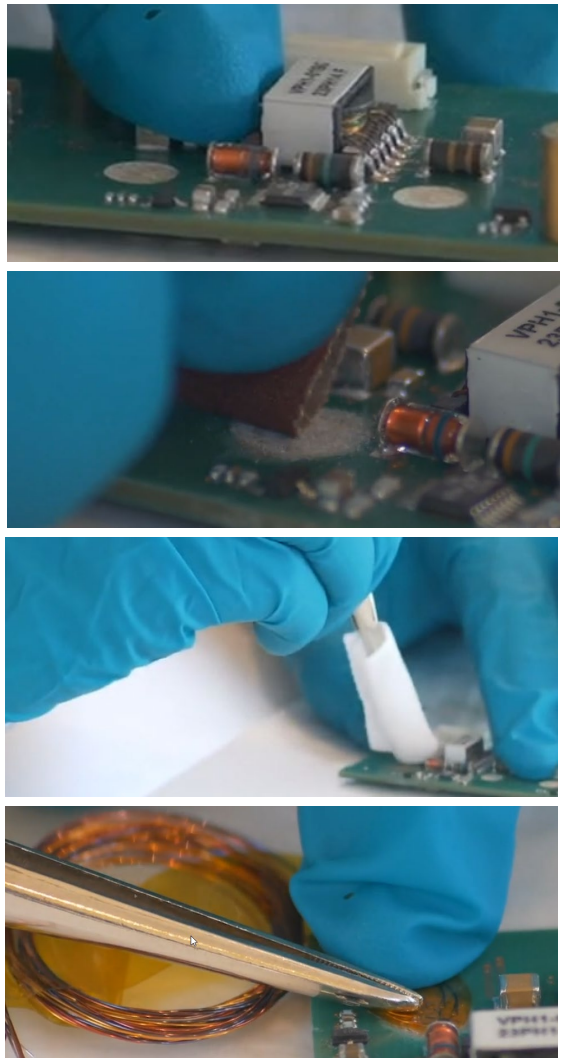
How to install the strain gauge onto a PCB?



- The installation point should have a surface that ensures good adhesion between strain gauge and PCB.

1. Removal of the uppermost lacquer layer by means of face milling cutter
2. further roughening of the surface with sandpaper if necessary
3. Clean the adhesive surface with a suitable cleaner (chemically pure) -> RMS1
4. Bonding of the strain gage by using Z70 fast adhesive

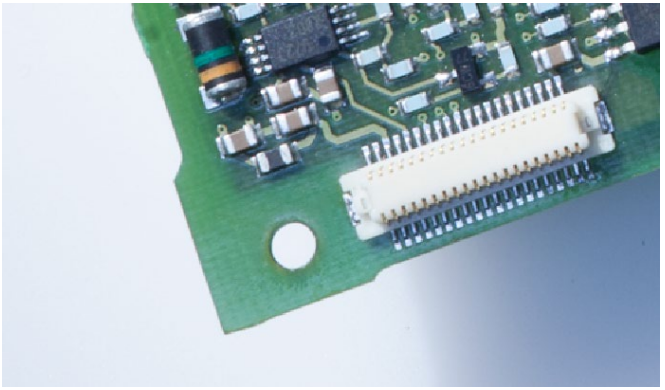
- On our website you will find a video tutorial

Where to measure strain on PCBs?

How to select the measurement points?

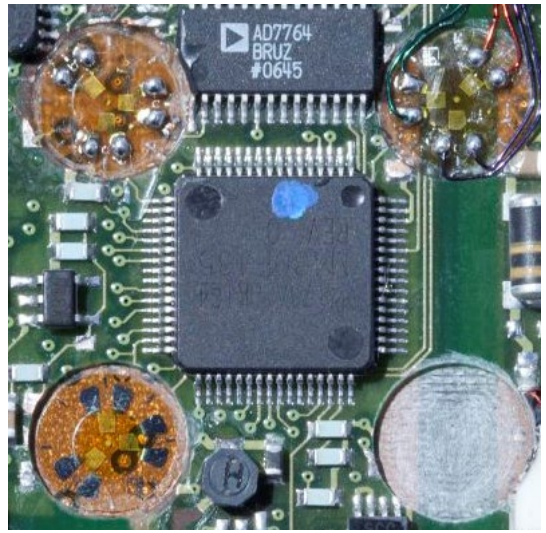
- Tension status on PCBs is mostly unknown and mechanically complex

- Measurements on PCBs are set at areas where the risk of failure is estimated to be especially high such as:
  - **Corners:** Corners can be mechanically critical if they are fixed.
  - **Stiff regions of the board** (e.g. the ones close to capacitors): Bigger elements lead to increased stiffness of PCBs.
  - **Regions close to interconnects** (solder-joint failures): Solder points are weak points in terms of yield strength.



How to select the measurement points?

- Components and devices:
  - In generell: User and supplier agree on components and measuring points
  - Recommendations:
    a. Area Array Components:
       I. Evaluate any package body > 27x27mm and pitch component > 10mm
       II. If a lot of components are present, take the 3 worst ones.
       III. Let experience values flow in, where weak points are.
       IV. All four corners should be measured, if possible
       V. 6-10mm next to BGA solder points (grids should be in parallel with solder rows)
    b. Non-Area Array Components:
       I. MLCC are critical and should be considered to measure (not more than 1mm away from the edge)

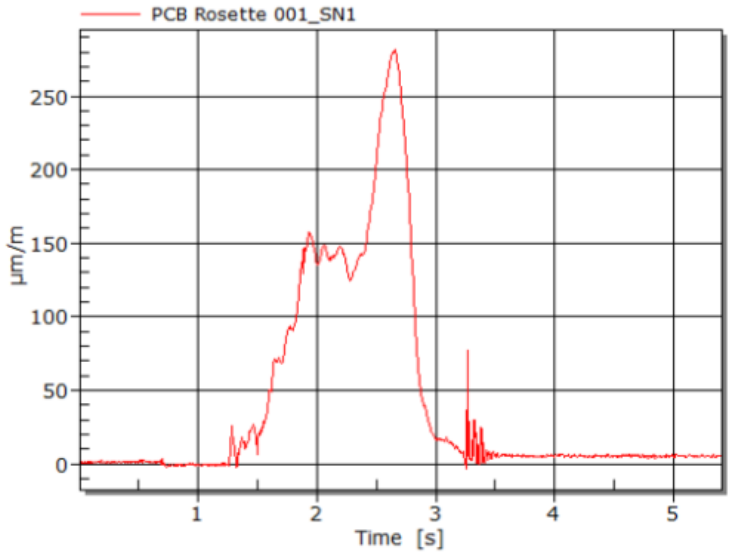


How to do data analysis?

Maximum allowed strain

- In general: users and suppliers agree on limit values.
- Some manufacturers of critical components specify limit values for their parts.

$$\varepsilon_1 = \frac{\varepsilon_A + \varepsilon_C}{2} + \frac{1}{\sqrt{2}}\sqrt{(\varepsilon_A - \varepsilon_B)^2 + (\varepsilon_C - \varepsilon_B)^2}$$



- Requirements for the Measurement equipment:
  - Minimum allowed measurement frequency 500 Hz. Recommended is 2 kHz
  - Sampling resolution of 12 to 16 bits
  - Suitable low pass filters are recommended.

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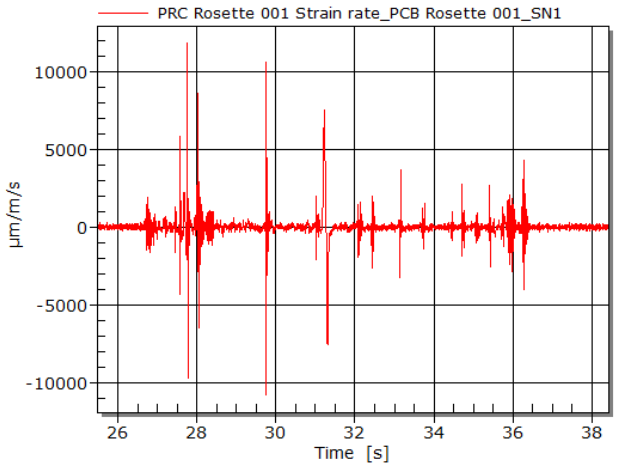
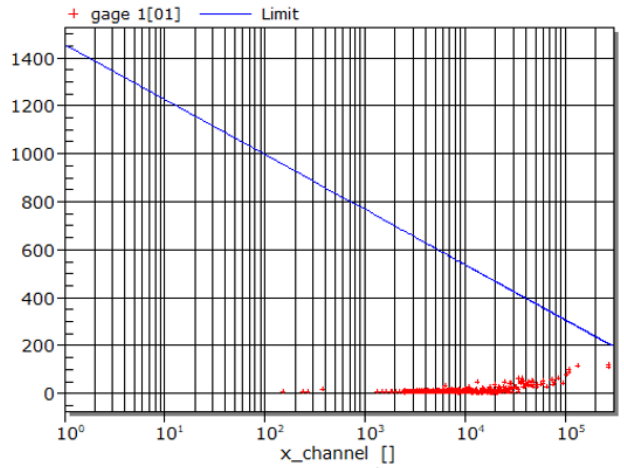
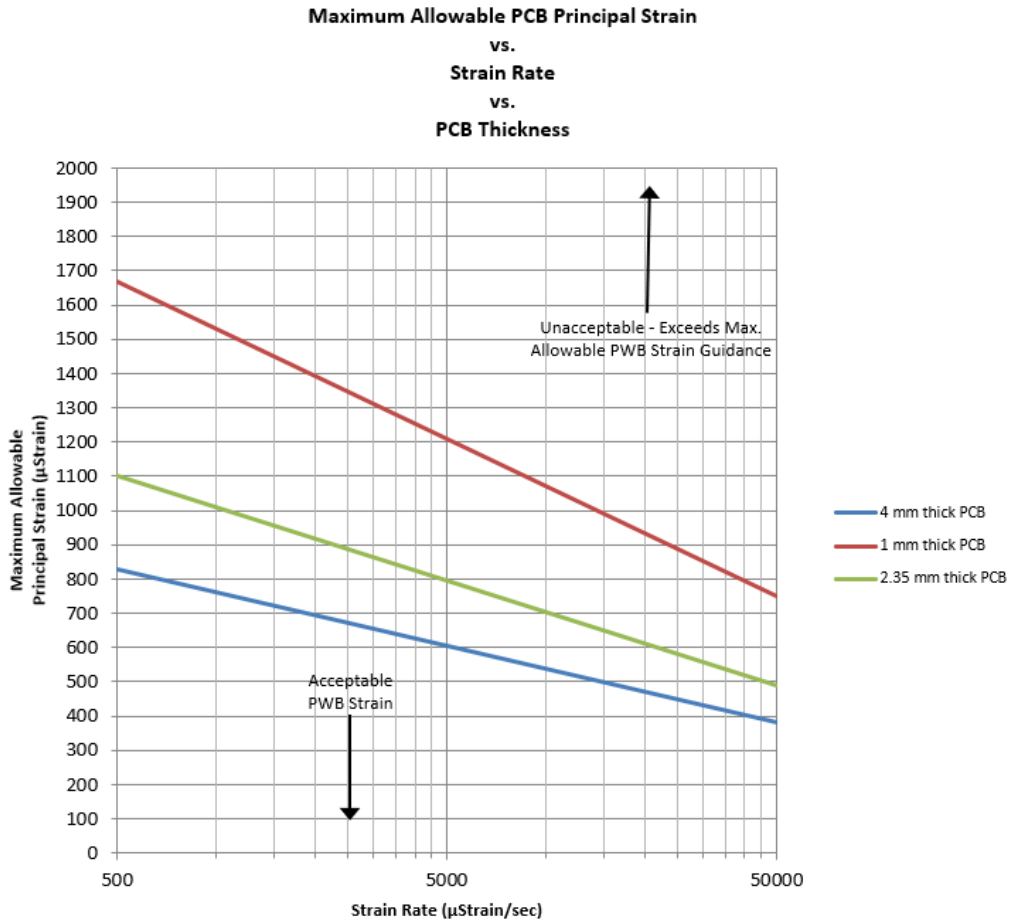
Strain rate

- The strain rate means that the lifespan of a PCB is impacted not only by the pure value of the maximum principal strain but also by the speed of changing the strain (impulse).

- Boundary lines as a function of the strain rate and the board thickness (IPC / JEDEC-9704A)







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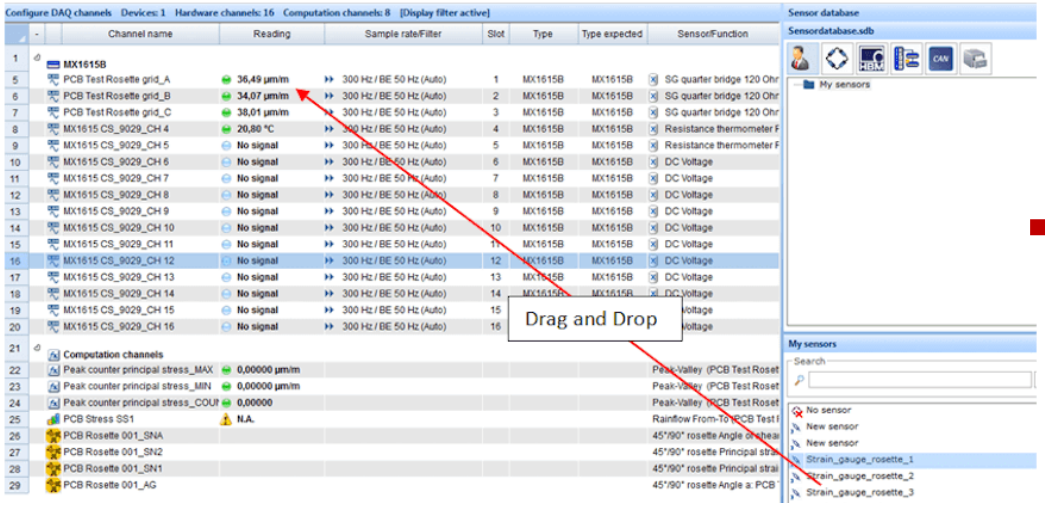

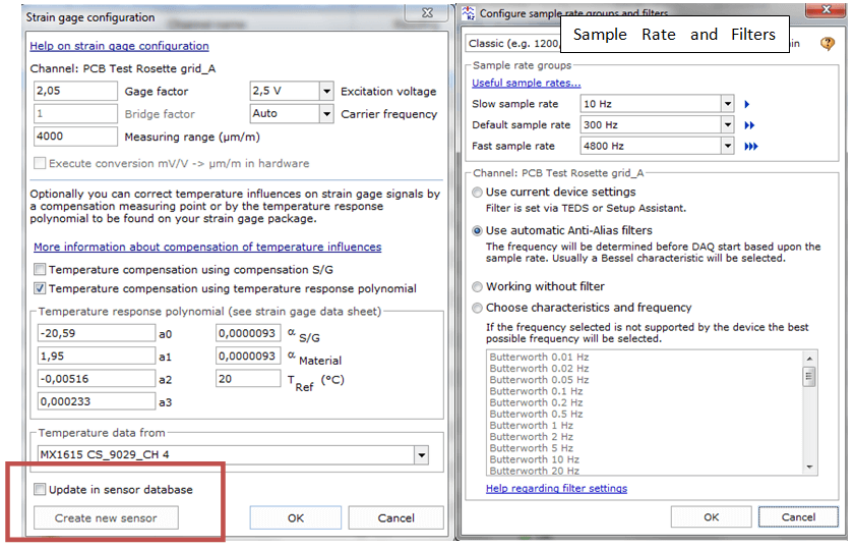

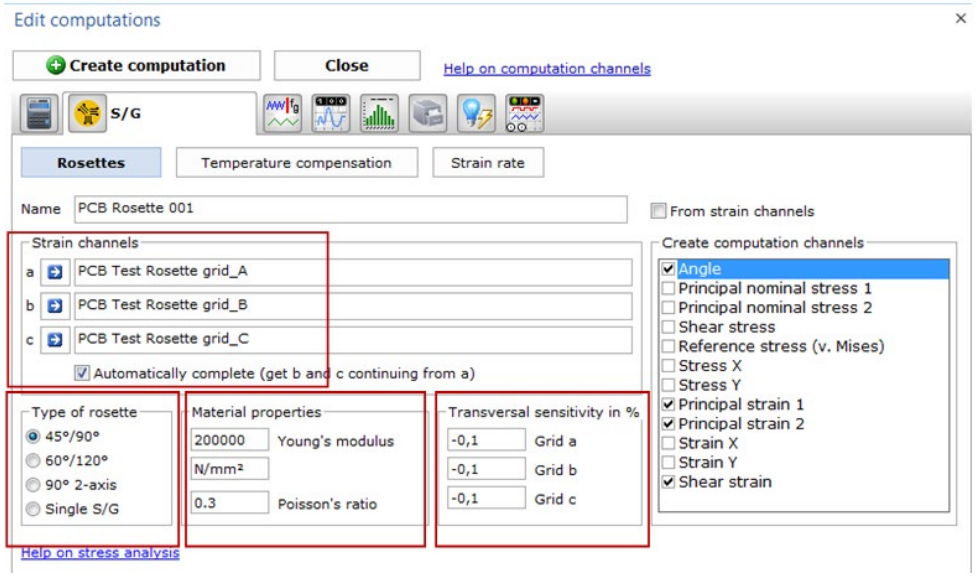

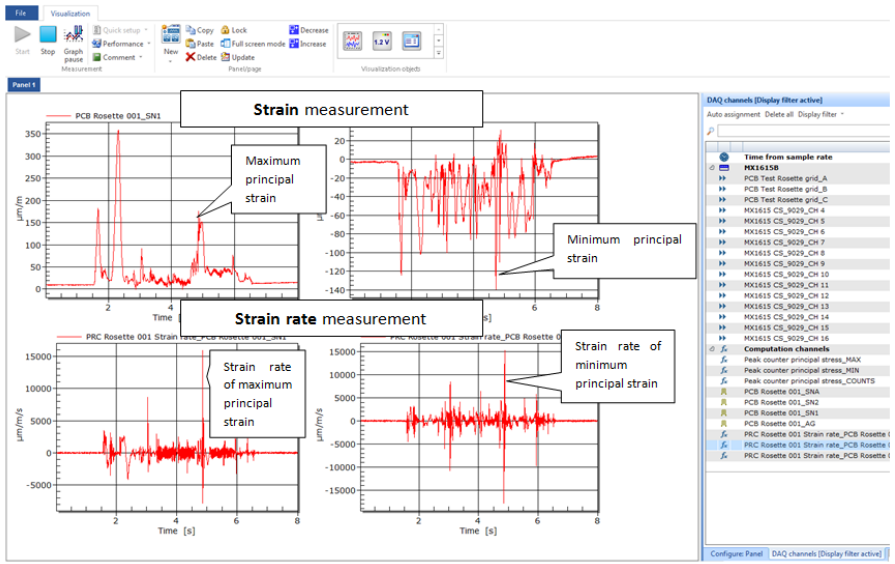

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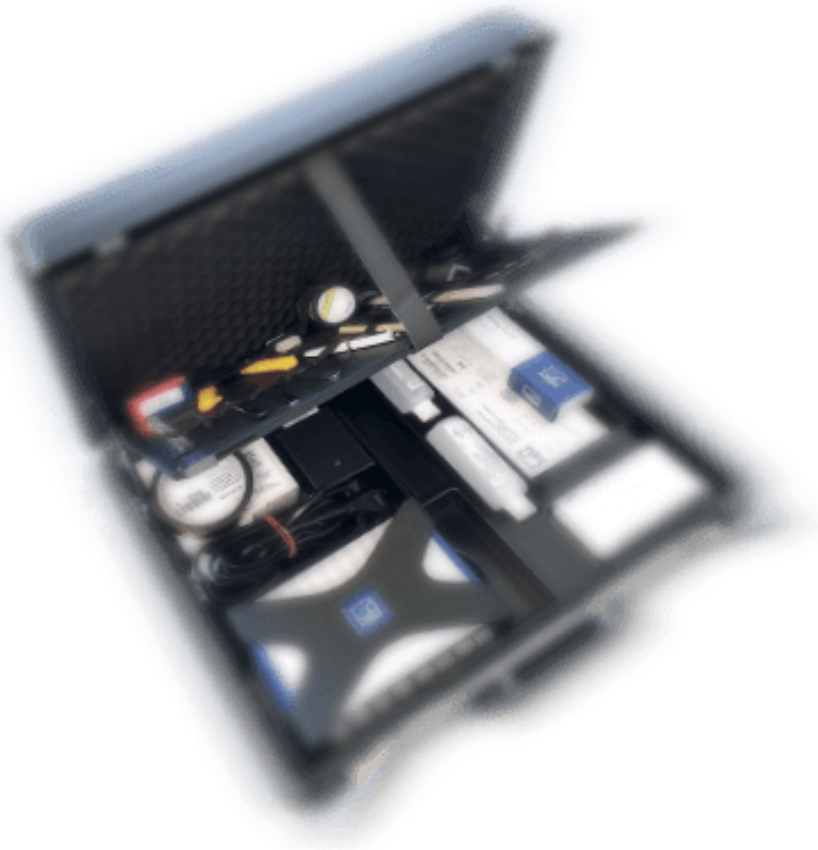
All in one solution



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Further Information

HOW WE CAN HELP YOU.

General strain gauge knowledge database:

www.hbm.com/strain-fundamentals

Special application PCB testing:

https://www.hbm.com/en/7698/how-to-measure-strain-rate-on-printed-circuit-boards-pcbs/

Trainings:

https://www.hbm.com/en/7172/seminar-pcb-testing-with-strain-gauges/

On-site service:

helpme@hbkworld.com

Thank You

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Do you have a question for the Presenter? Visit the Guest Speakers Virtual booth within the next hour for an interactive Q&A session.