Investigation status of amplitude jumps on Libera electronics

Borut Repič

WWW.I-TECH.SI

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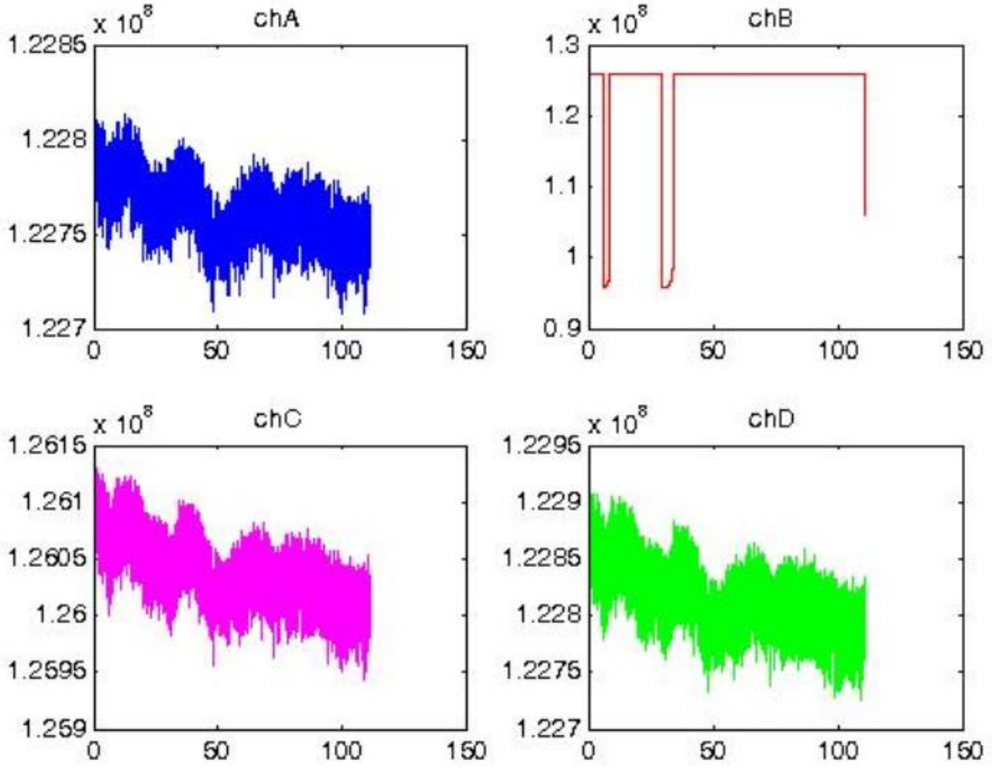
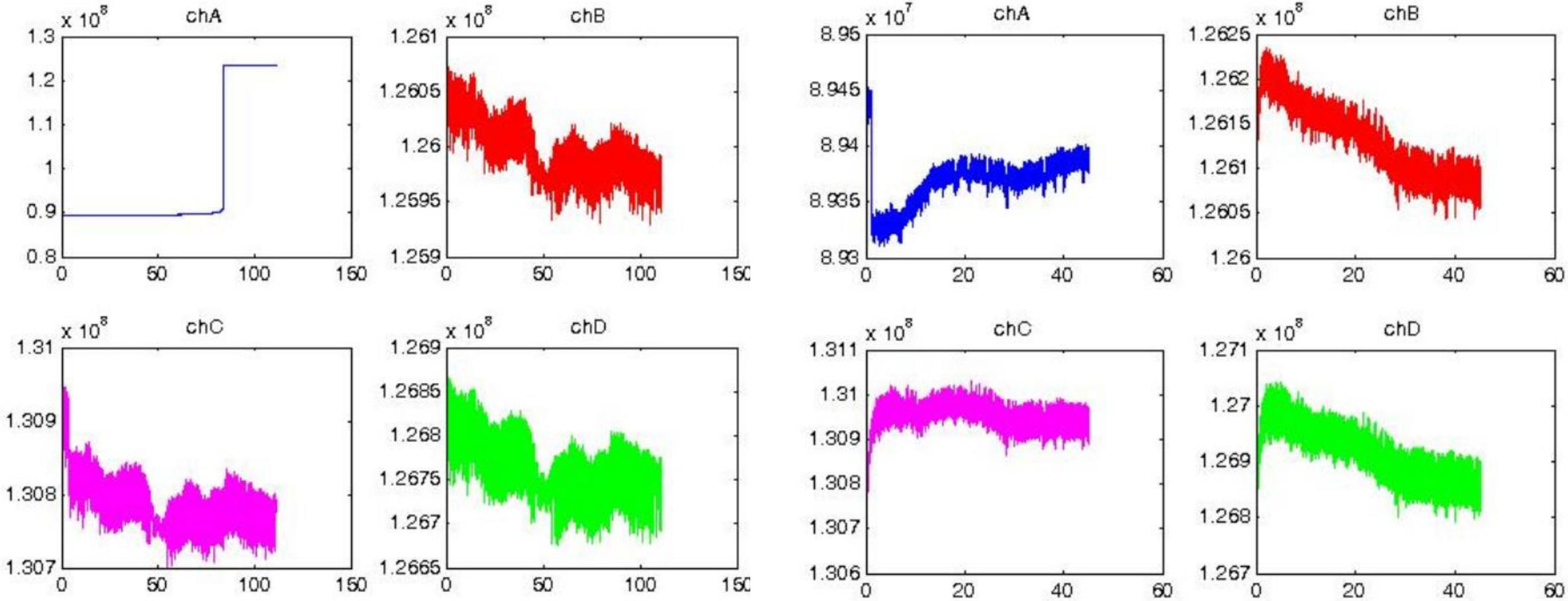
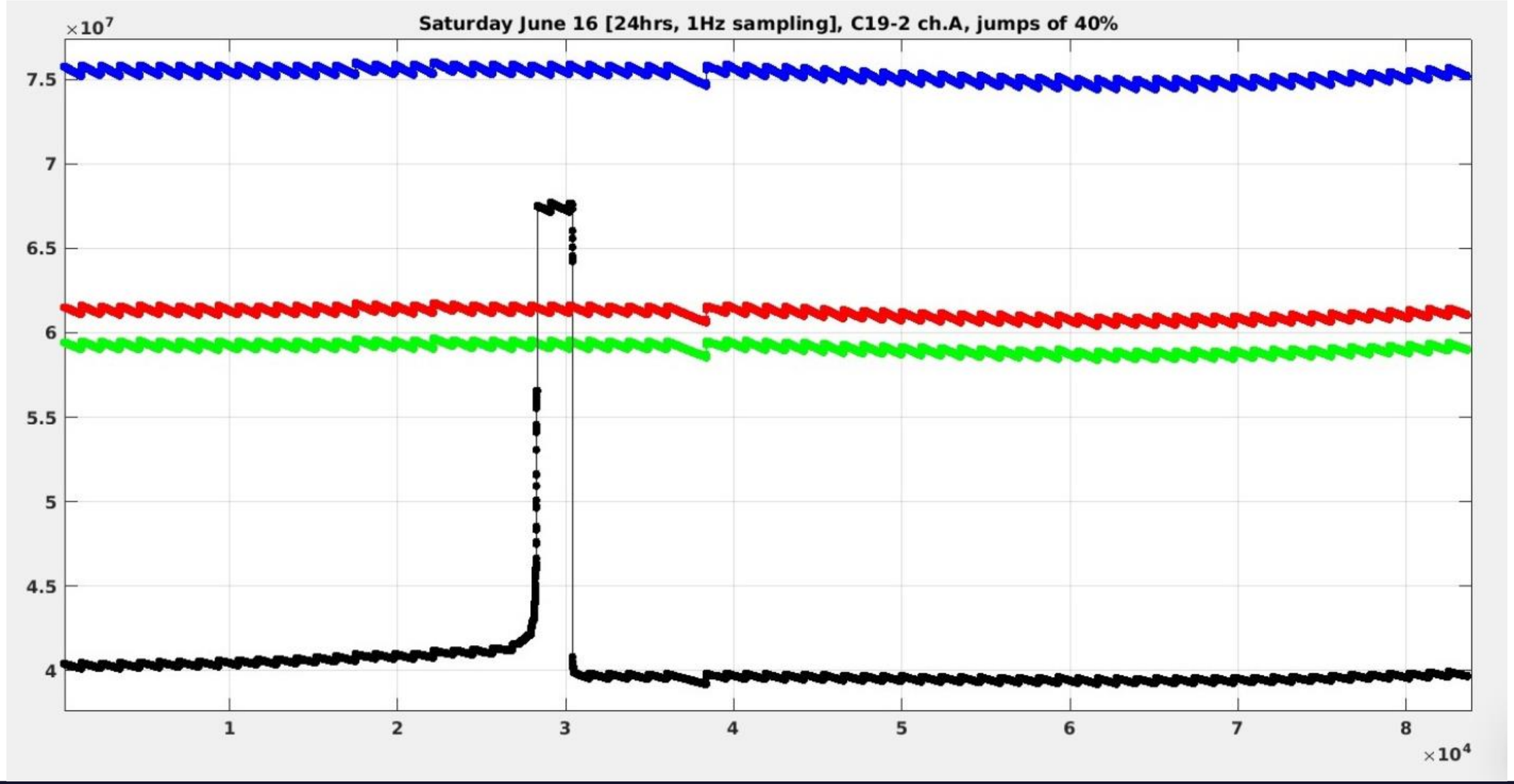
Overview of the issue

Over a year ago ESRF reported unexpected occasional jumps of button amplitude on LB!

- exclude software (DSC, attenuators)
- reproduction of the behavior in our test lab.
- not always the same channel
- Amplitude and duration of the jumps differs from instrument to instrument




x 10^8
chA
1.3
1.2
1.1
1
0.9
0.8
0
50
100
150
x 10^8
chB
1.261
1.2605
1.26
1.2595
1.259
0
50
100
150
x 10^8
chC
1.31
1.309
1.308
1.307
0
50
100
150
x 10^8
chD
1.269
1.2685
1.268
1.2675
1.267
1.2665
0
50
100
150
x 10^7
chA
8.95
8.945
8.94
8.935
8.93
0
20
40
60
x 10^8
chB
1.2625
1.262
1.2615
1.261
1.2605
1.26
0
20
40
60
x 10^8
chC
1.311
1.31
1.309
1.308
1.307
1.306
0
20
40
60
x 10^8
chD
1.271
1.27
1.269
1.268
1.267
0
20
40
60


Saturday June 16 [24hrs, 1Hz sampling], C19-2 ch.A, jumps of 40%
×10^7
7.5
7
6.5
6
5.5
5
4.5
4
1
2
3
4
5
6
7
8
×10^4

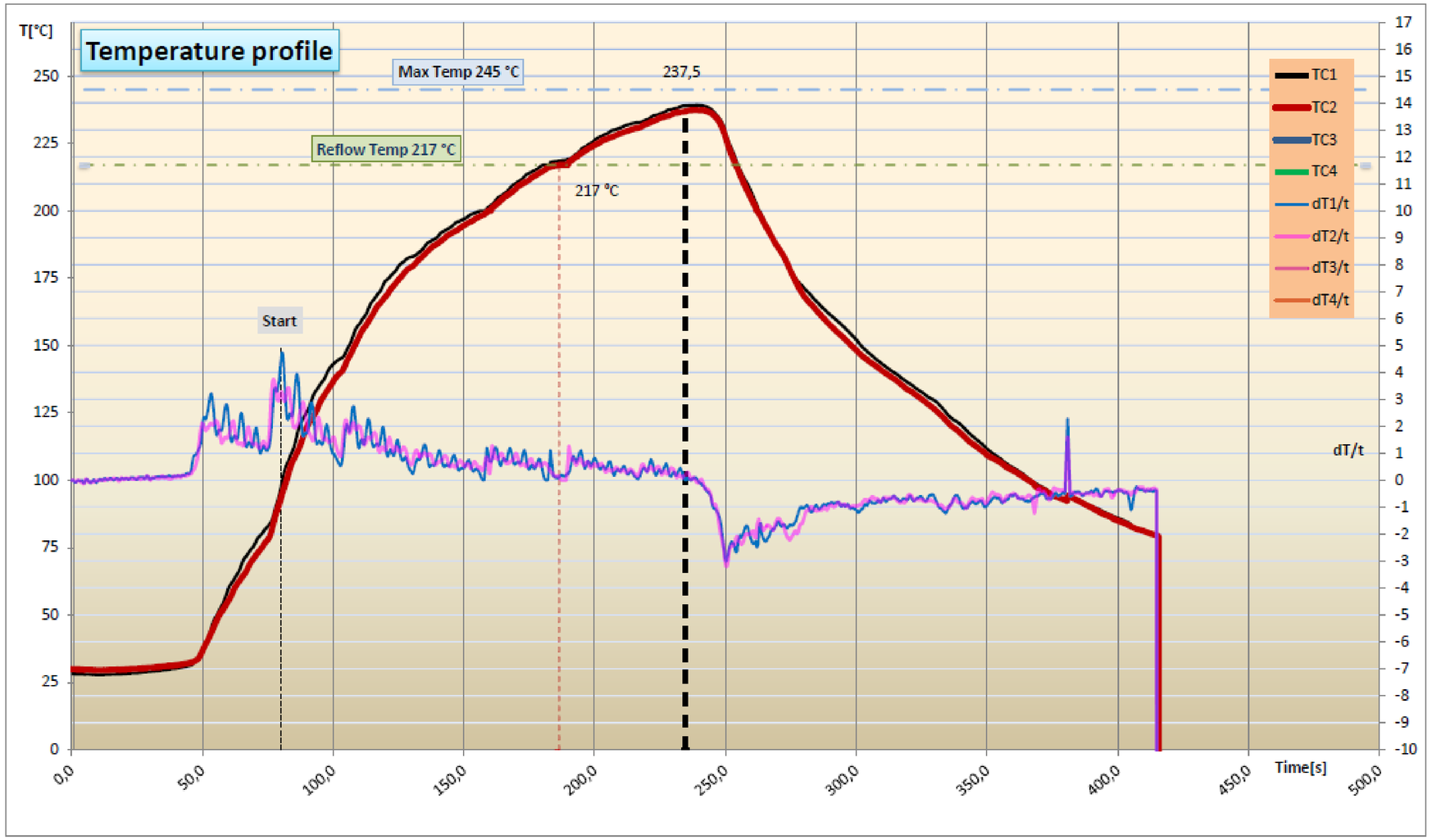
Investigation steps of the issue

- How to reproduce the problem?
- Since the occurrence is very rare and hard to reproduce on single unit we did a lot of long term tests with low success.
- Move the testing to environmental chamber.
- Variation of temperature 0-40°C and relative humidity 20-80%. No correlation observed.
- We could not find any straight forward way to reproduce the problem.

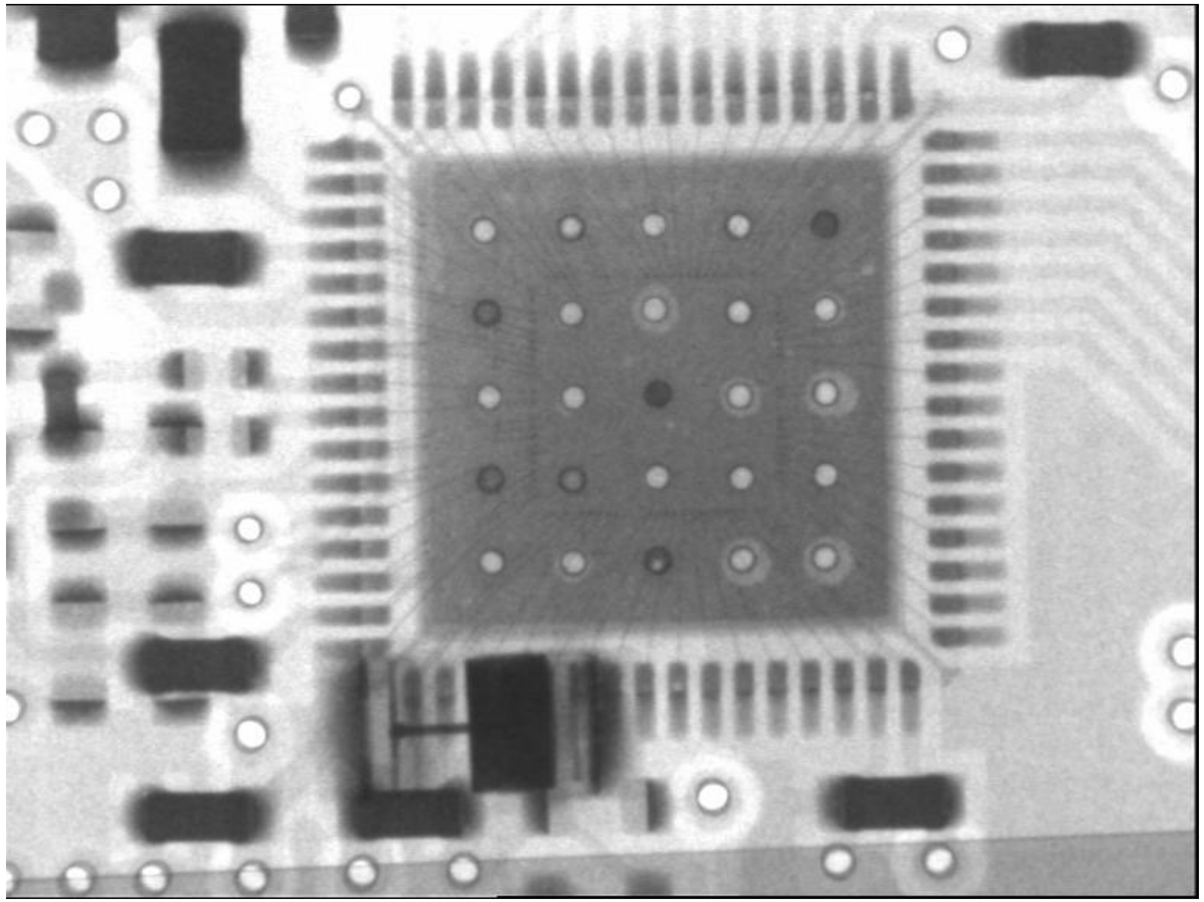
<u>Main questions to be answered at the beginning:</u>

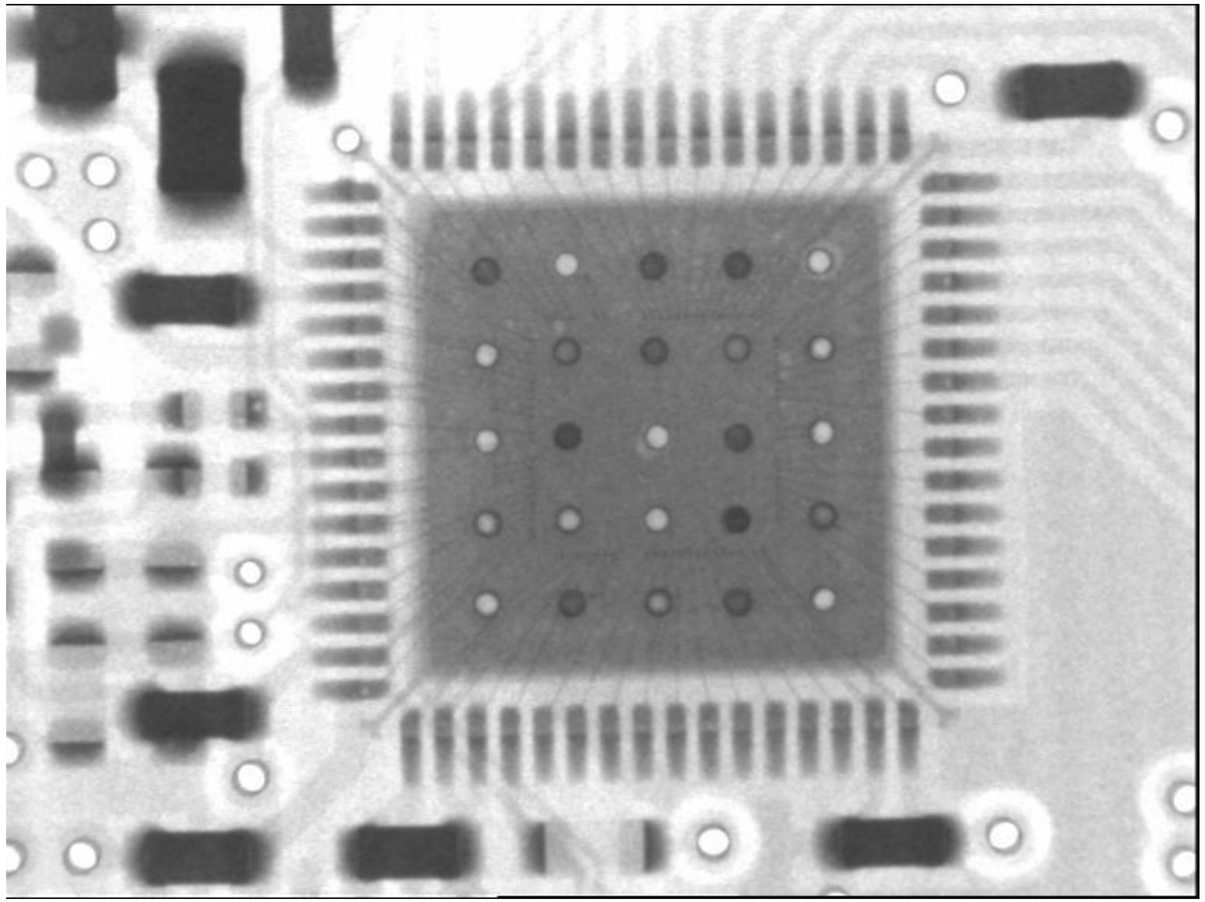
- What is the reason for this behavior
- Is it a production problem (solderability, reflow profile)? or
- Component failure (component manufacturer or circuit design)?

Reflow profile

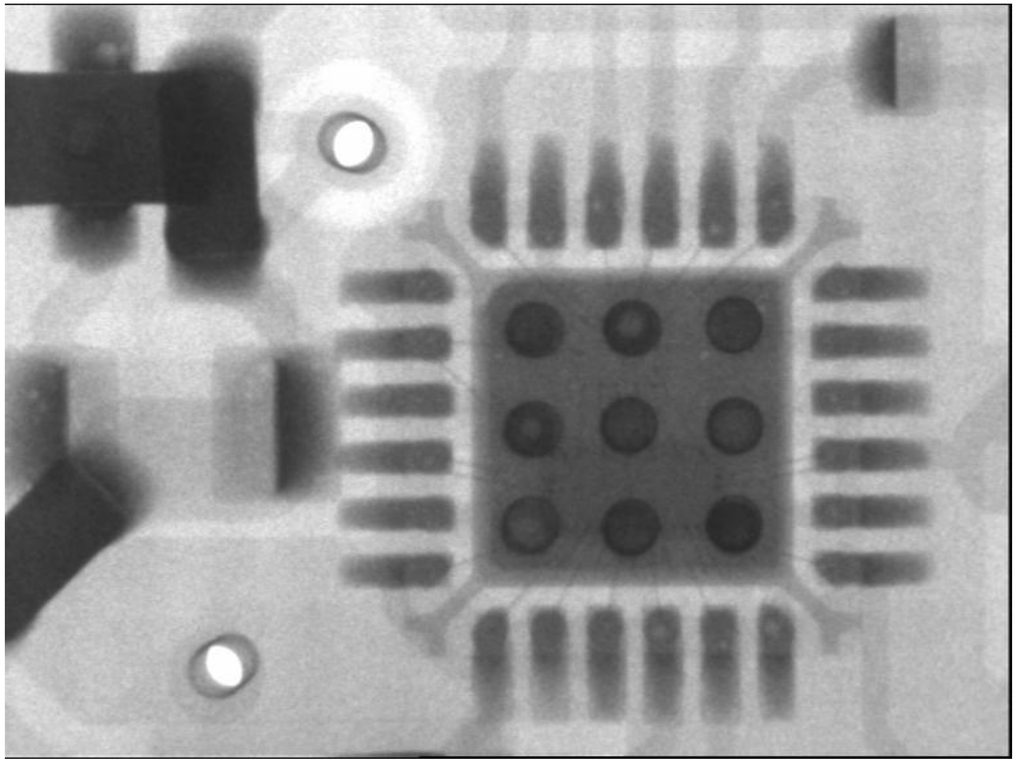


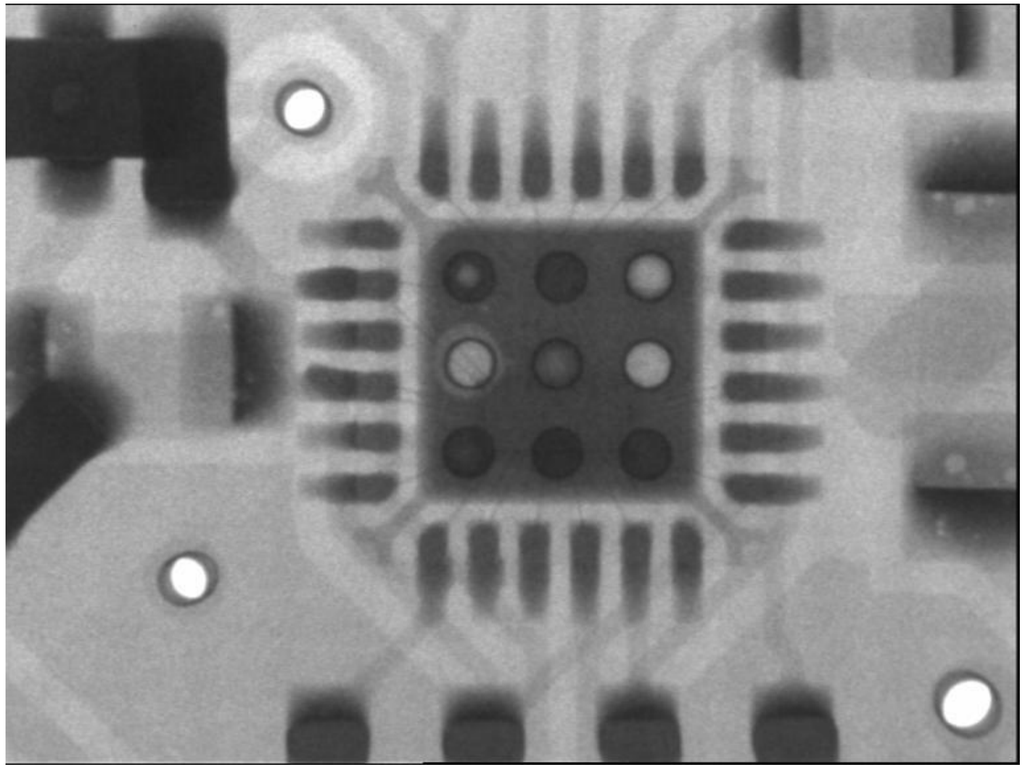
Xray inspection - ADCs



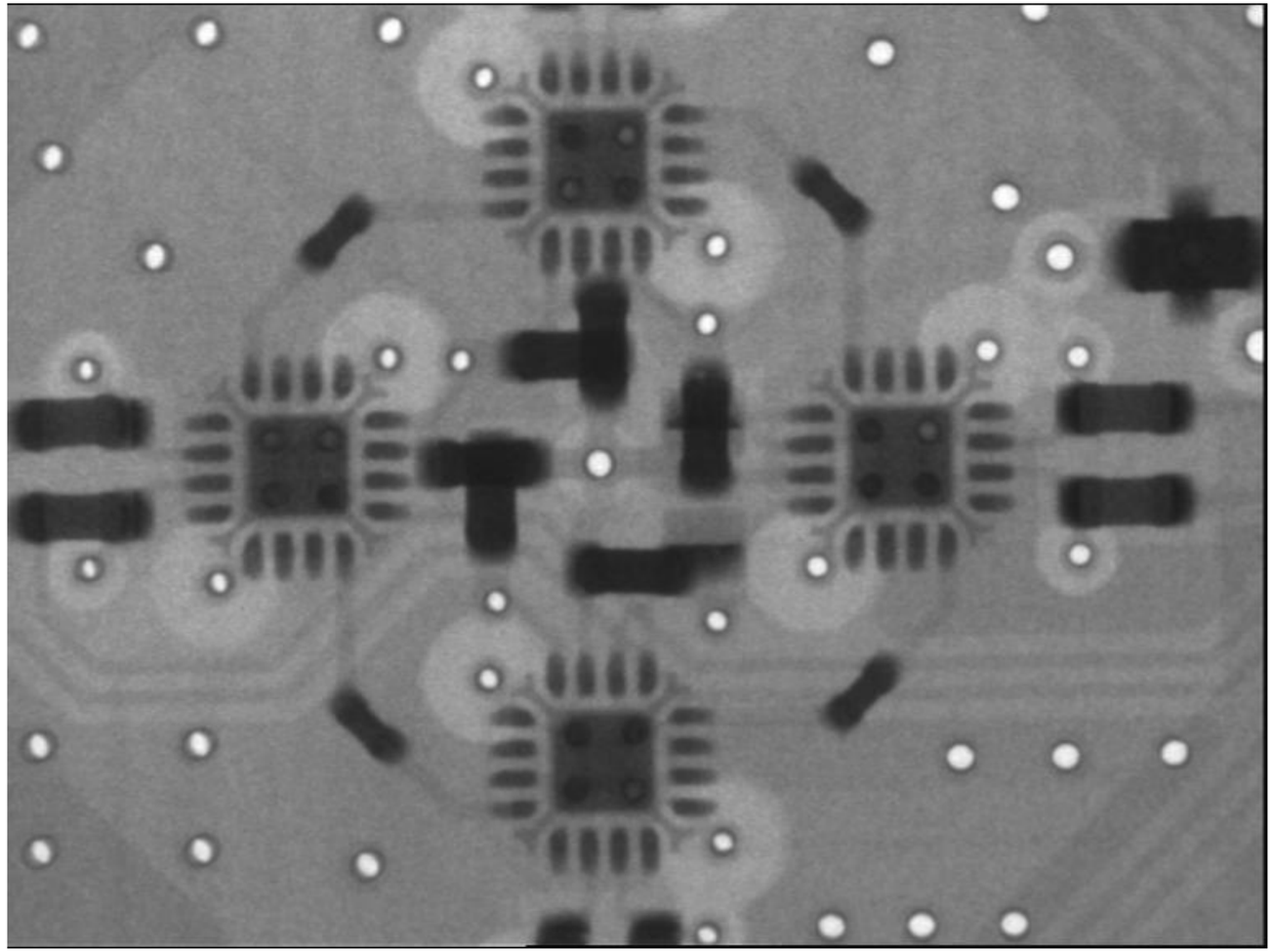


Xray inspection - attenuators

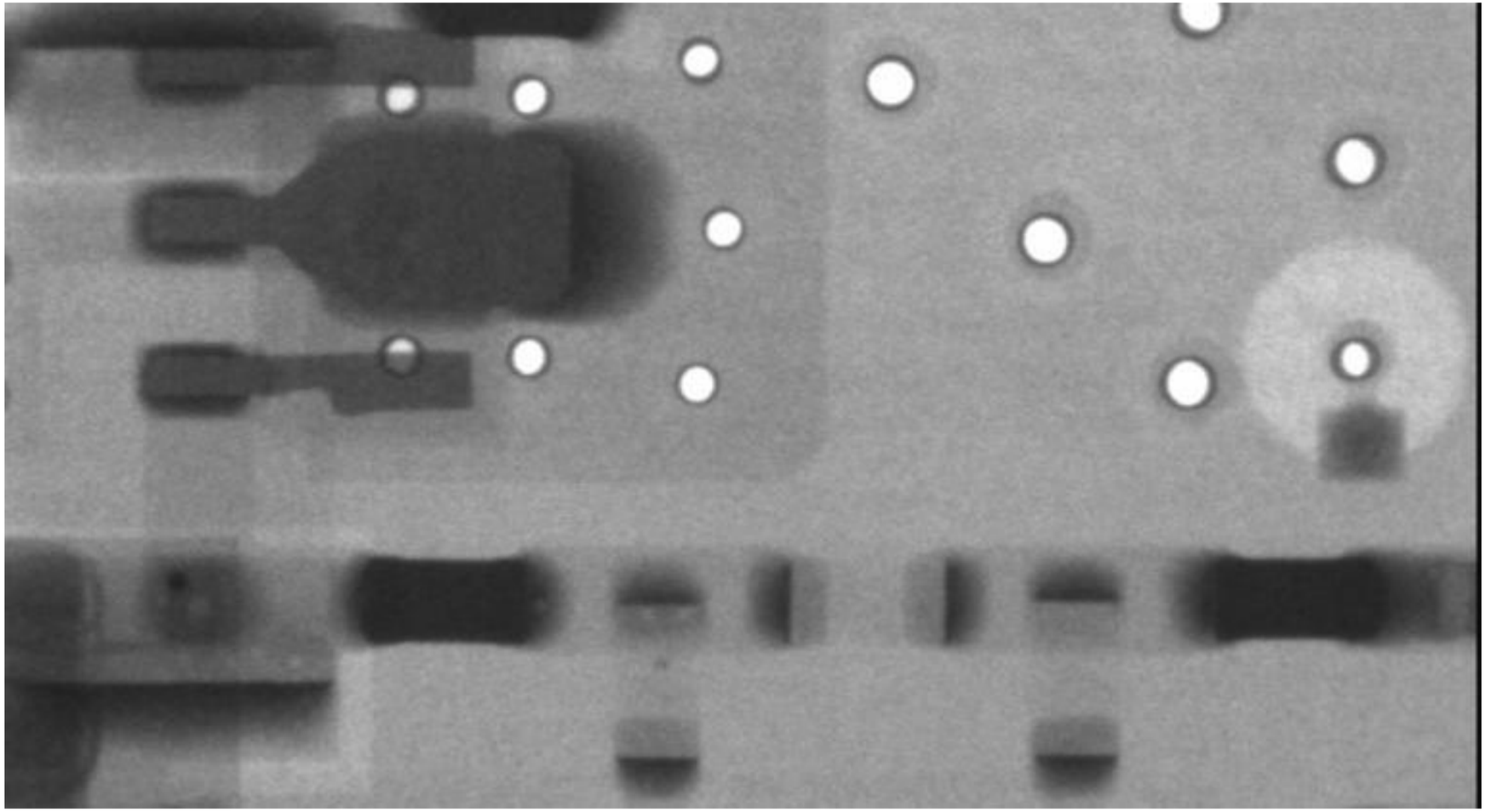




Xray inspection – switch matrix



Xray inspection – switch matrix



Component failure investigation

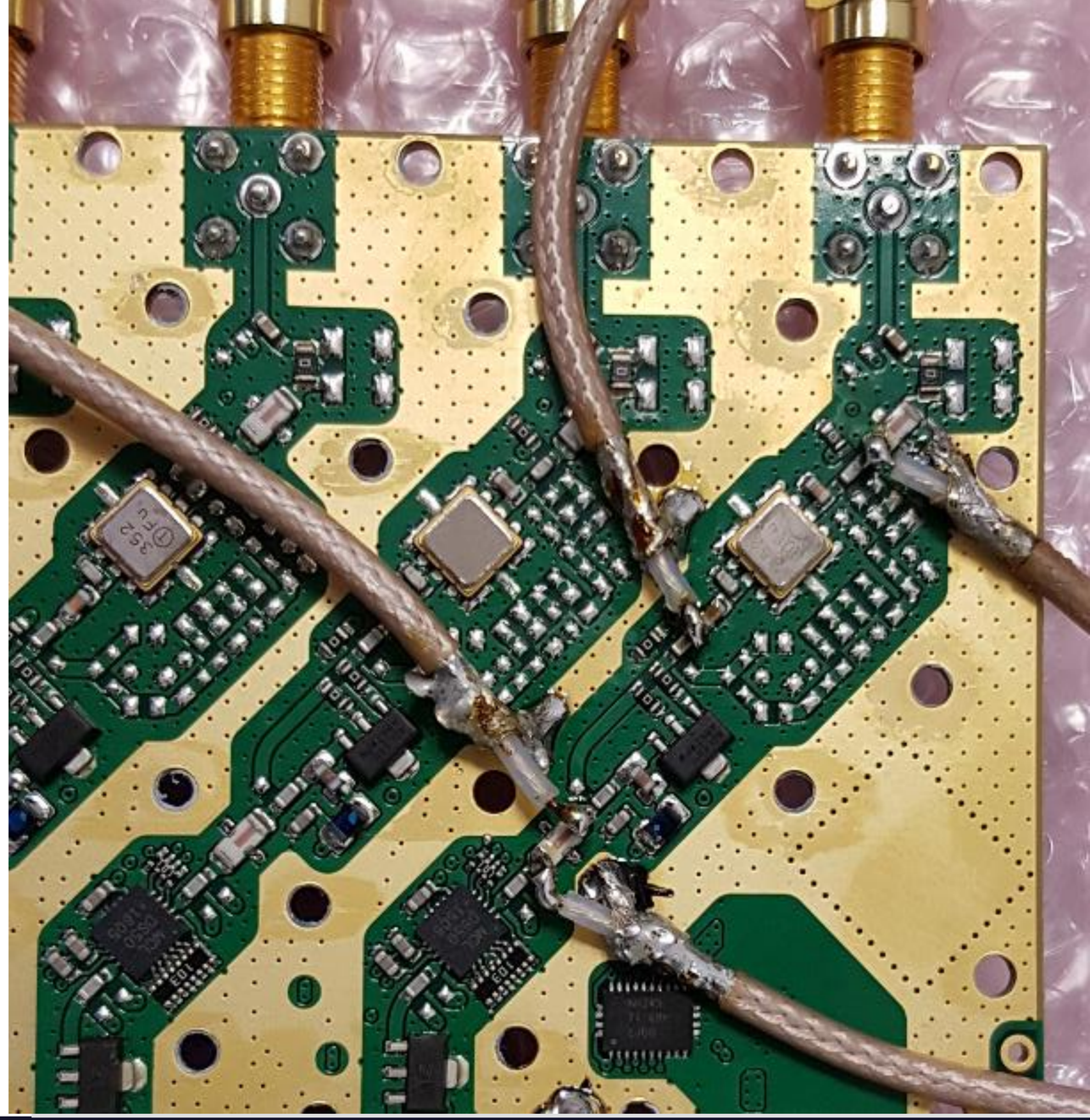
SAW filters are declared to work bellow 10 dBm.

We tried to make the filters defective with applying high power to their input.

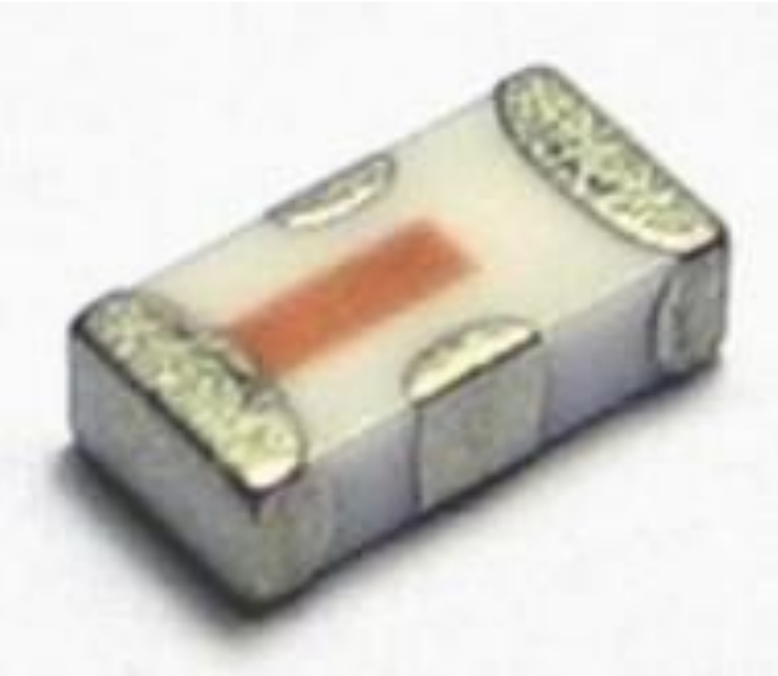
No success!

Attaching multiple RF power probes along the signal path to identify critical component.

Low pass filters LFCN from Minicircuits which are commonly used to suppress harmonics of amplifiers were identified as root cause.



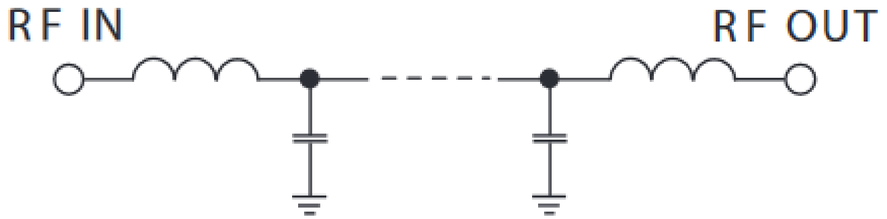
LFCN low pass filter



Product documentation says:

- 7th order LTCC low pass filter
- High power handling - 8W (+39 dBm)
- Small footprint 3.2 x 1.6 mm
- Wide operating temp range -45-85°C
- Temperature stable

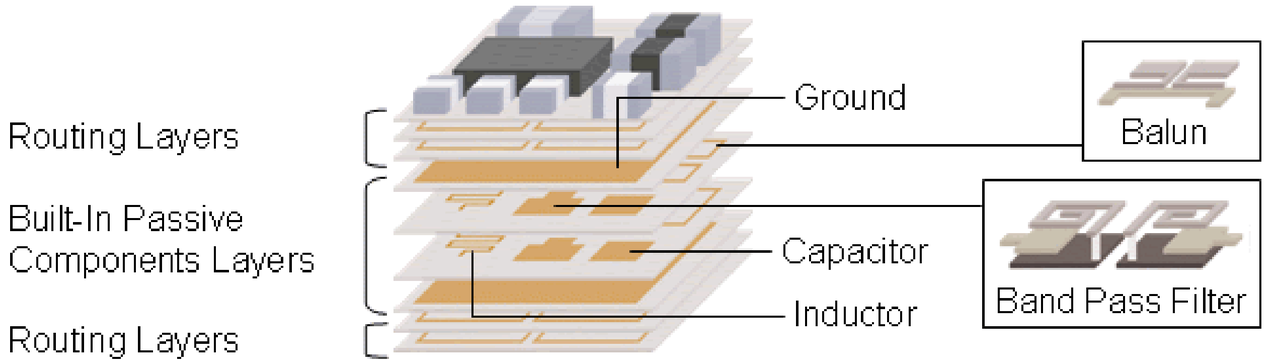
Electrical Schematic



(1) In Application where DC voltage is present at either input or output ports, coupling capacitors are required.

What is LTCC?

A typical LTCC (Low Temperature Co-fired Cermaic) structure consists of multiple dielectric layers; screen-printed or photo-imaged low-loss conductors; embedded baluns, resistors and capacitors; and viaholes for interconnecting the multiple layers.



LFCN on Libera

- Each channel 3-4 filters ➔ 12-16 pcs/board
- Faulty component was identified on the board.
- Failures found at different positions within signal path.
- RMA towards Minicircuits was opened
- Reflow profile, operating enviroment, electrical conditions, washing solvents, coating …

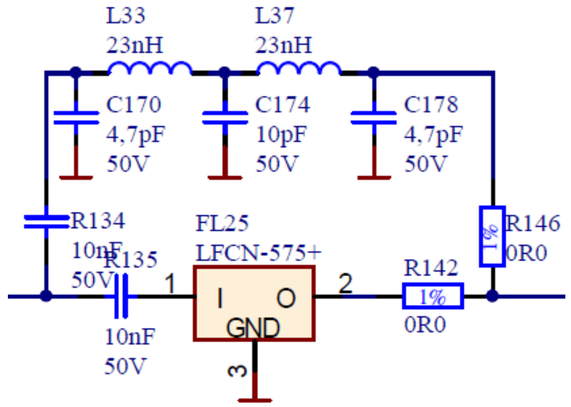
  were checked. All within specs!

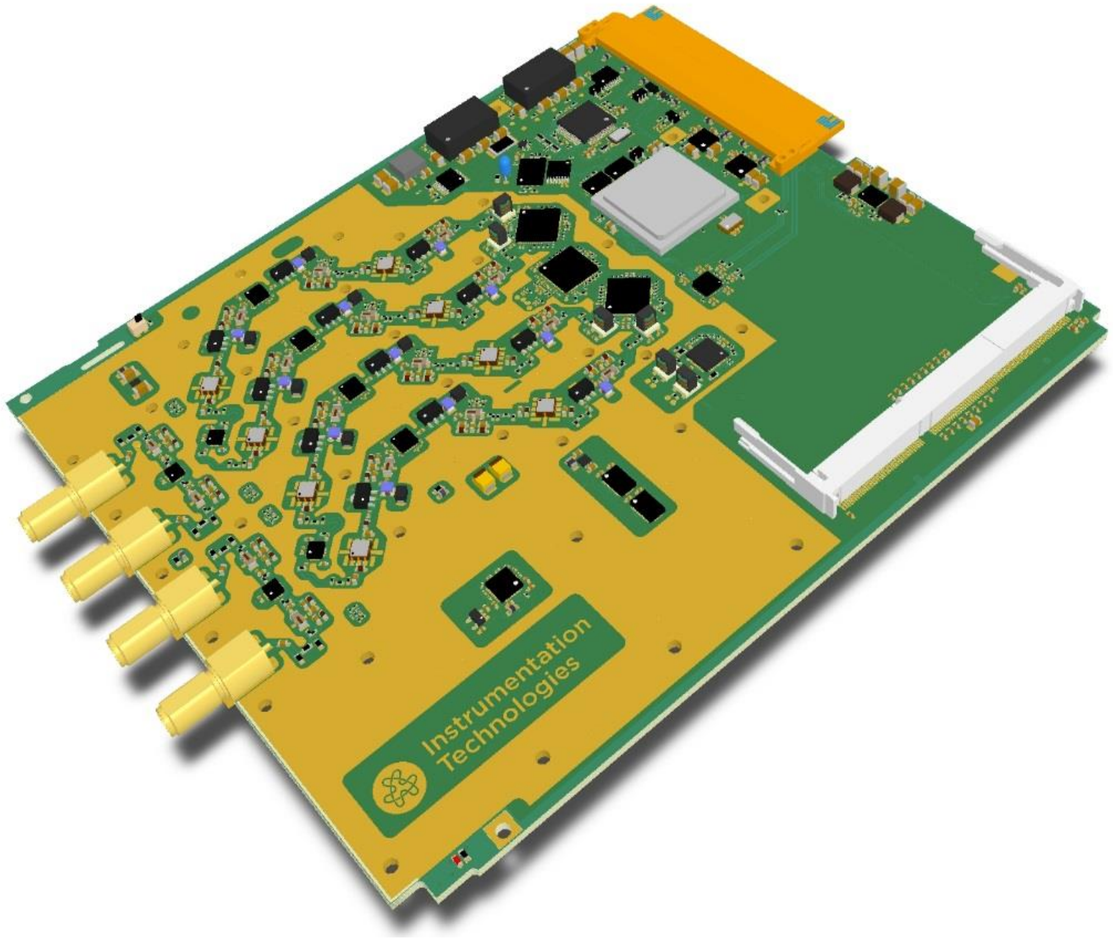
LFCN test results

- We found this issue on different boards (with different frequencies), assembled at different EMS plants.
- After such component was resoldered, the problem disappeared → cold joints X
- All faulty samples we got so far were too old (>3 years) for Minicircuits to accept them for analysis.
- Currently we have fresh samples behaving in the same way.
- Impedance behavior discovery
- We just sent complete board (soldering effect) to Minicircuits for analysis.

Preventive actions on new BPM module for Platform B

- AMC form factor
- Latest Xilinx 16 nm FPGA: Kintex Ultrascale+ (XCKU3P)
- Large data buffers (SODIMM DDR3 slot)
- Switching or direct signal routing (maximum isolation)
- Merging Spark resolution & Brilliance + stability
- LFCN as an option to lumped 5th order low pass (pros & cons)
- No comparable alternative to LFCN on the market





Summary

- Order of magnitude ~50 out of 3000 BPMs (50 out of 40.000 LFCNs)
- Issue confirmed on different frequency models of LFCN
- Exchange of the component which was proven as reliable (pros & cons)
- After the problem was initially discovered we have added long term test (>16h) of every board to standard FAT procedure
- 300+ Engineer-days invested in discovering the issue.
- Simple repair procedure.
- Next steps strongly depend on Minicircuits response

Thank you!

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