AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

UT SALT, status and next steps

Marek Idzik on behalf of AGH-UST

Faculty of Physics and Applied Computer Science
AGH University of Science and Technology

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Outline

- Status of SALT2.5 – what do we know/understand ?
- Next steps

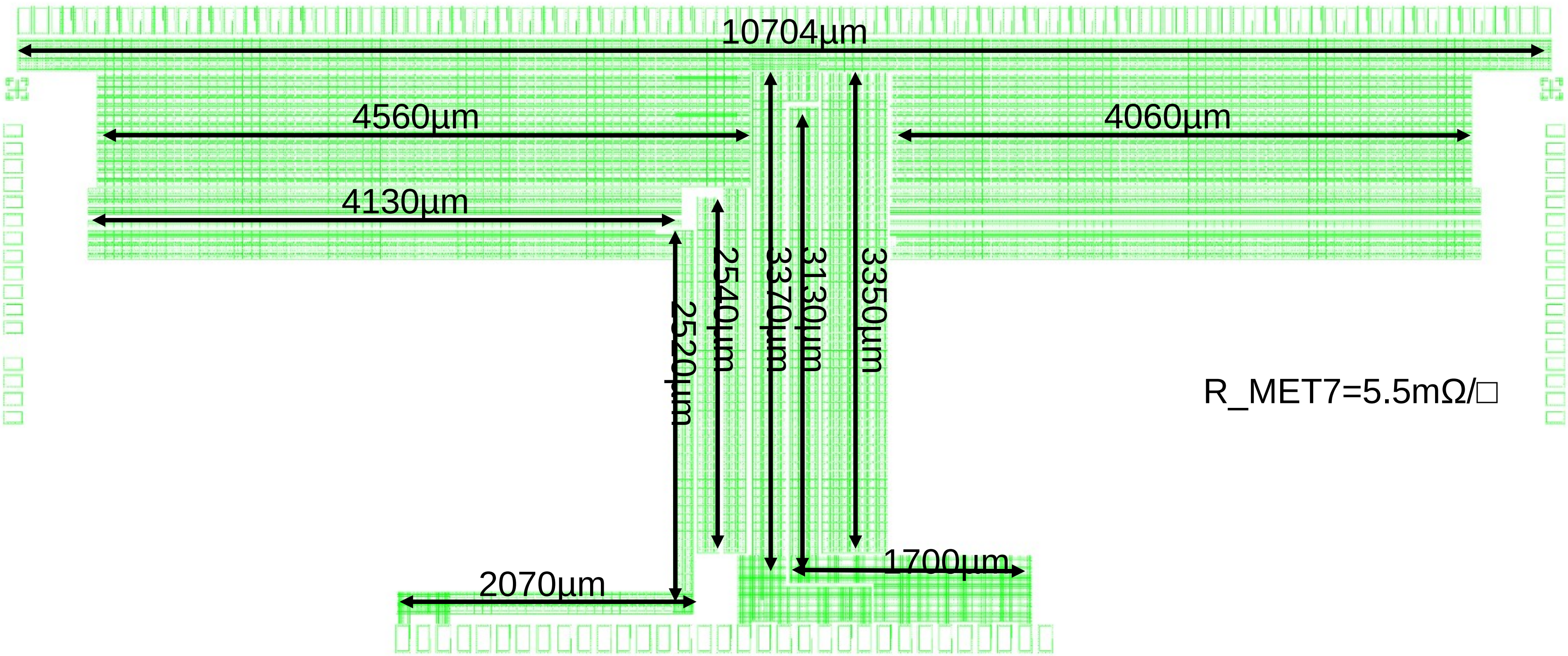
Status of SALT 2.5

- Measurements show that the chip does not fulfil yet the specs:
  - **Main issue – baseline shifts/oscillations** when sensor is connected.
- From measurements/simulations few weak points in the design found:
  - After extraction a possible stability issue in Krummenacher circuitry was found (Jan Kaplon) – we have checked in simulations that adding ~600k resistor between input-gnd solves the issue – we have done it experimentally for side channel, but oscillations are still there
  - Leakage currents – 1st simulations with leakage added does not change results, confirmed with measurements at low temperature
  - Calibration circuitry is not separated enough from the digital part
  - DLL needs some tuning
- The weak points found **DO NOT explain baseline shifts/oscillations** !
- We have proposed and simulated inductive effects (and theirs coupling) which, for the first time, may explain the effects measured in SALT 2.5

Status of SALT 2.5
Why inductive effects ?

- We have verified in simulations the sensitivity of the SALT2.5 response to different parameters (resistances of paths, bond inductances, decoupling capacitances,…) but we were not able to reproduce the measurements
- It was verified in measurements that input capacitance C=2pF
  - implemented internally DOES NOT deteriorate the SALT2.5 performance,
  - connected externally (sensor) DOES deteriorate it
- We know that we have very good ground in the present PCB board. If so, we conclude that the ground in SALT2.5 is bad
- This bad ground in SALT2.5 is generated by something which was not taken into account in simulations (also after extraction)
- Simulations take into account “R”, “C” parasitics but NOT “L” !
- So we started to think about “L” and “Lcoupling”…

Status of SALT 2.5
Power grid to estimate L and Lcoupling



R_MET7=5.5mΩ/□

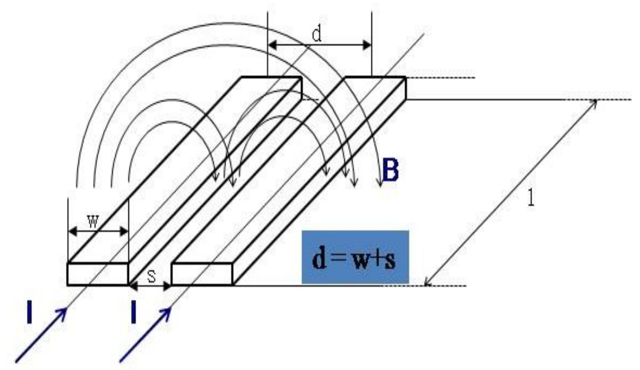
* By horizontal/vertical we mean vertical/horizontal in this figure. In this figure we rotated SAL2.5 by 90 degree to fit it to the slide.

Status of SALT 2.5
Effects of internal inductances

- The main effect of internal inductances/Lcoupling may come from:
  - long (~2.5mm) horizontal lines placed in parallel
  - long (~1cm) vertical power/gnd network lines
- First order estimation of critical lines (like ADC_supply or Preamp_gnd) inductance gives about ~1.5nH for each.

- First order estimation of Lcoupling factor for 1st neighbor line is >50%, for 2nd neighbor >25%. It is really large!
- Some of these Lcouplings partially cancel (effect of signal line and its return) so the effective Lcoupling will be lower.

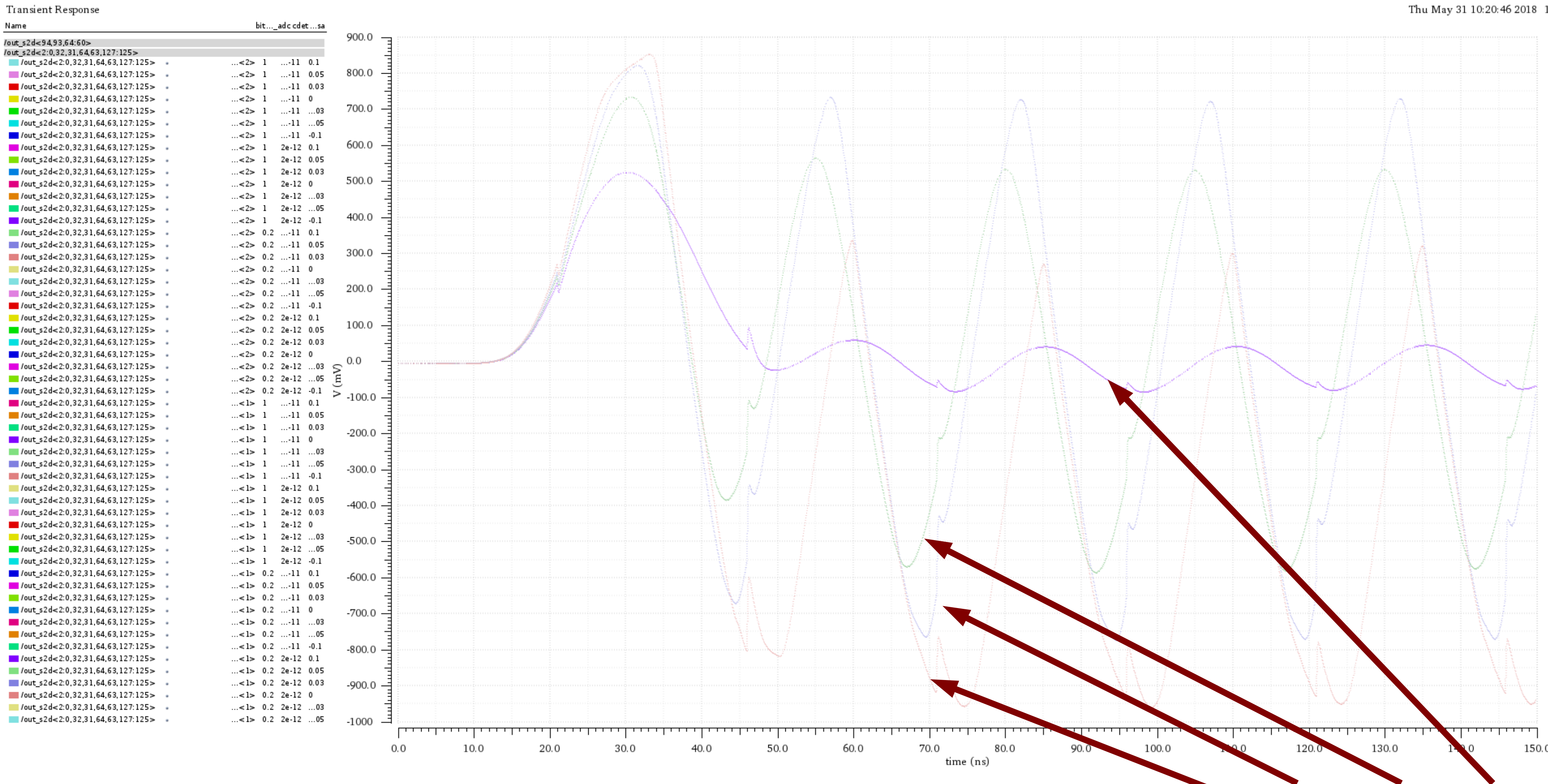
Since some of the flux generated in one line is "coupled" to the adjacent line, "mutual" inductance is introduced between the two lines.



$$M = \frac{\mu_0}{2\pi} l \left(\ln\left(\sqrt{1+\left(\frac{l}{d}\right)^2} + \frac{l}{d}\right) - \sqrt{1+\left(\frac{d}{l}\right)^2} + \frac{d}{l}\right)[H]$$ Dimensions in m

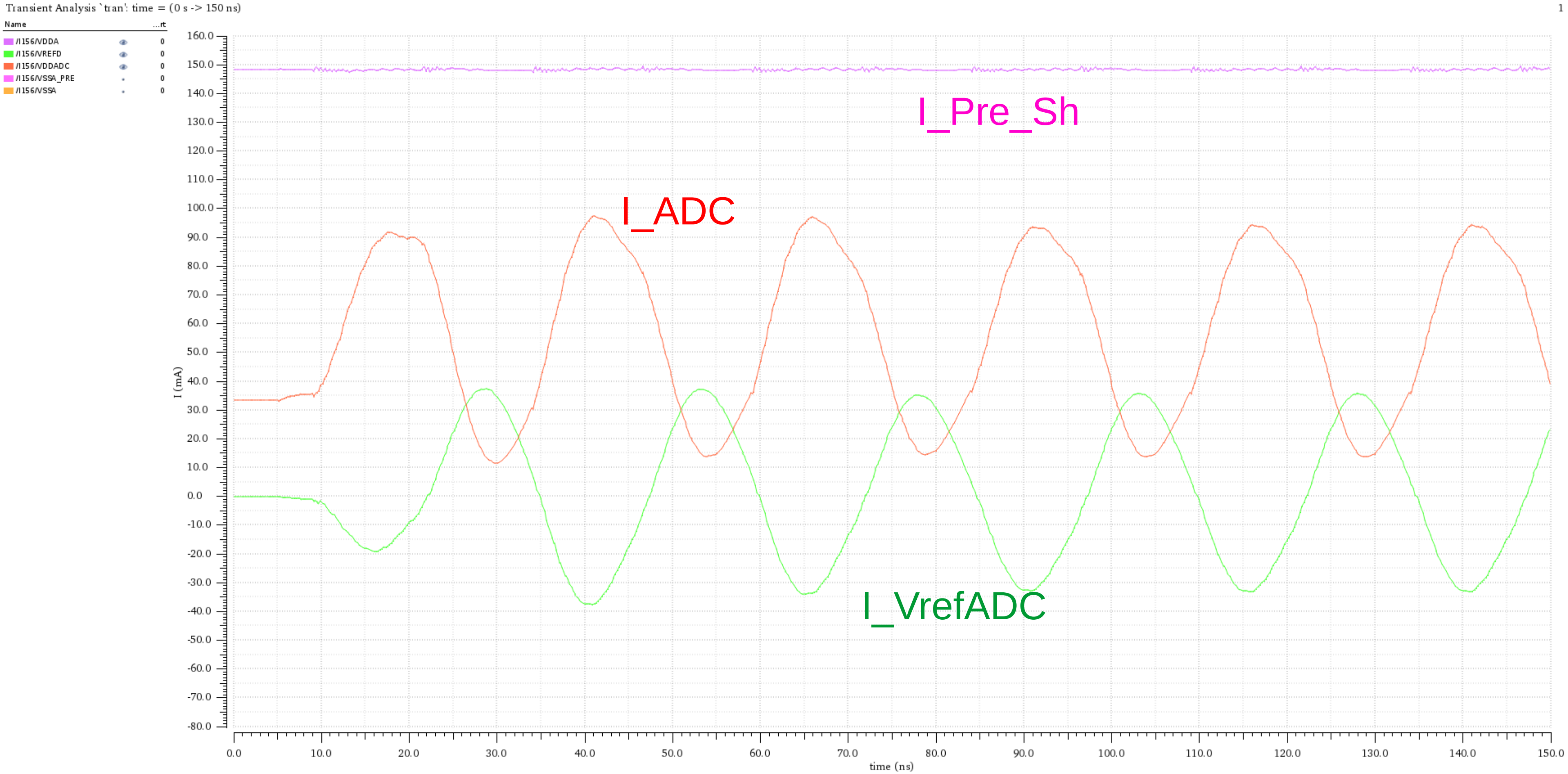
Mutual inductance can be positive or negative depending on current direction.

Status SALT 2.5
Analog out vs Lcoup (ADC_supply, Preamp_gnd)



- Internal “L” of ADC_supply and Preamp_gnd 2nH. Lcoup 0.1,0.05,0.03,0.0
- For the first time we see oscillations in simulations !

Status of SALT 2.5
Why we see the effects of internal L/Lcouplings while others do not ?



- I_ADC current changes by ~90mA during 25ns period !
- Effect caused by Lcoupling is proportional to current derivative !

Next steps
Measurements/simulations to be done

- Assuming that we understand the main source of problem, we should be able to explain (simulate) different measurements performed in Syracuse, Milano and Kraków:
  - For existing measurements we can explain the mechanism of oscillation generation. But we should understand also more detailed results obtained for different ground configurations,
  - New measurements should be done to prove the idea, e.g., how many ADCs need to be switched OFF to get satisfactory performance (baseline level&oscillations, pulse shape for both polarities,…), other measurements to prove/disprove the idea need to be proposed…
- In conclusion, we need to be strongly convinced that we can solve the problem.

Next steps
Assuming that we understand the problems...

- Main goal is to eliminate baseline shifts/oscillations:
  - Decrease fluctuations of ADC current (power consumption will increase by <=0.5mW/channel)
  - Improve power/gnd network to decrease “L” and “Lcouplings”
- Remove stability issue related to Krummenacher circuitry:
  - If we remove the Krummenacher circuitry the baseline dispersion will increase but the SEU hardness will improve
- Improve separation between digital/analog domains in calibration circuitry
- DLL tuning

Going to this stage should be accepted by the UT

Next steps
Schedule

- Optimistic
  - In next ~2 weeks we agree that we understand SALT performance
  - In such case there is a chance to prepare submission by end of July
- More realistic
  - More time is needed for measurements&simulations
  - It is not possible to give exact time needed to prepare submission, but in 1st estimation additional 2 months would be needed

Thank you for attention