Examples & Lessons Learned
from various SET Evaluations

Stanley Mattsson

RUAG Aerospace Sweden

stanley.mattsson@ruag.com

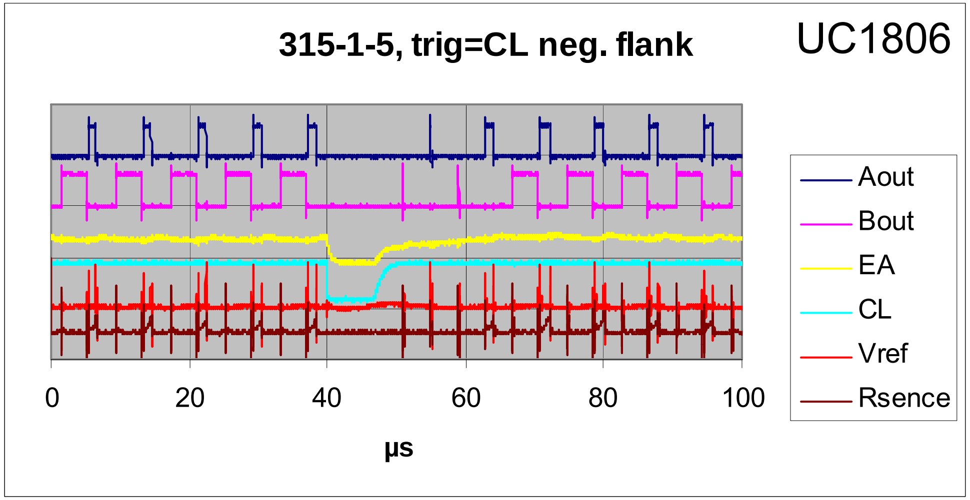
Outline

- Examples & Lessons Learned of SET Testing of Linear Devices
  - Test Set-up
  - Trigger Requirements
  - High Flux
  - Examples of Lessons Learned

SET & Linear Devices

- Generally 2 Levels of Complexity
- Simple devices - no specific test design required
  - effect of load and mitigation techniques can be calculated
- Complex devices - Specific test design preferable
  - design critical, SET behaviour difficult to calculate

PWM UC1806 was tested in application like set-up for Rosetta - No Error

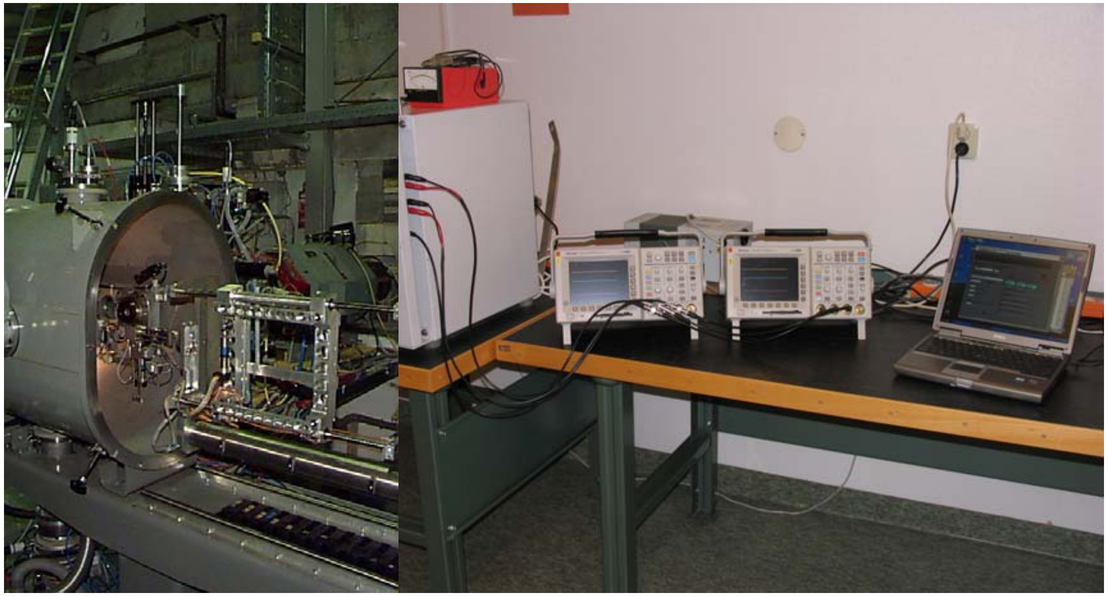


SET Measuring Set-Up

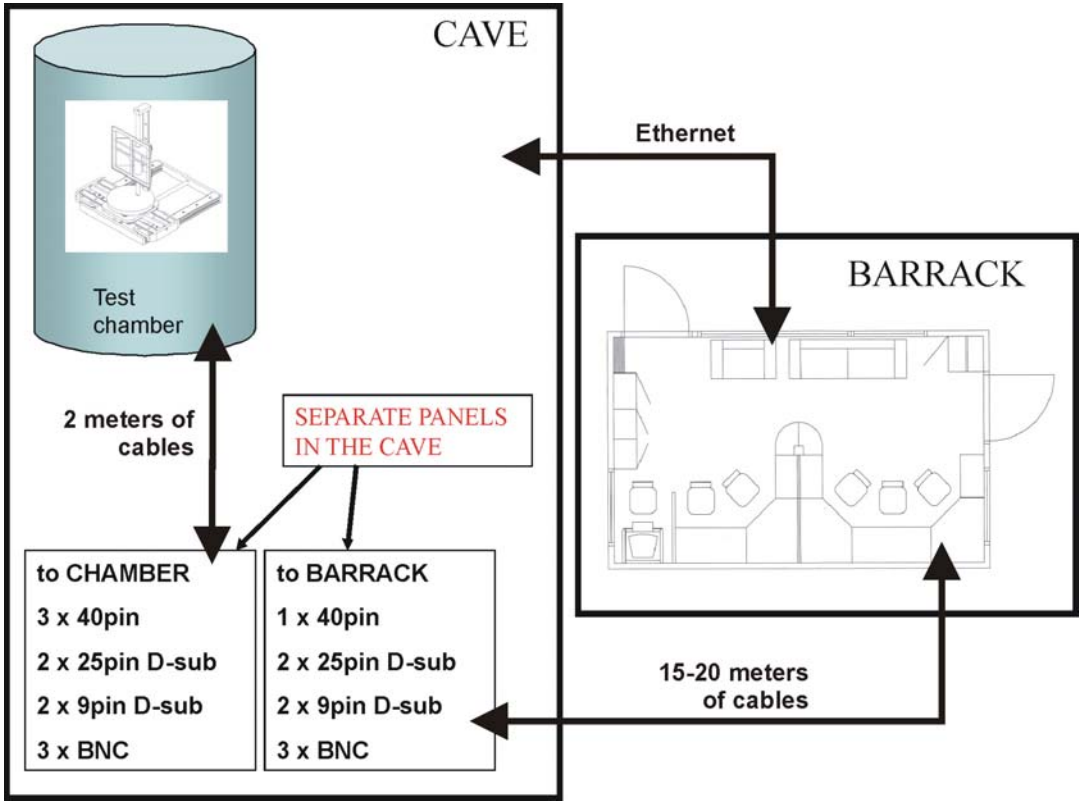
RUAG

- SET measurements of Linear Devices requires rather “simple” test Set-Up
  - Oscilloscope, Computer, Cables & Test boad
    - One Osc. for each trigger requirement
    - Increased complexity with many devices on the same test board

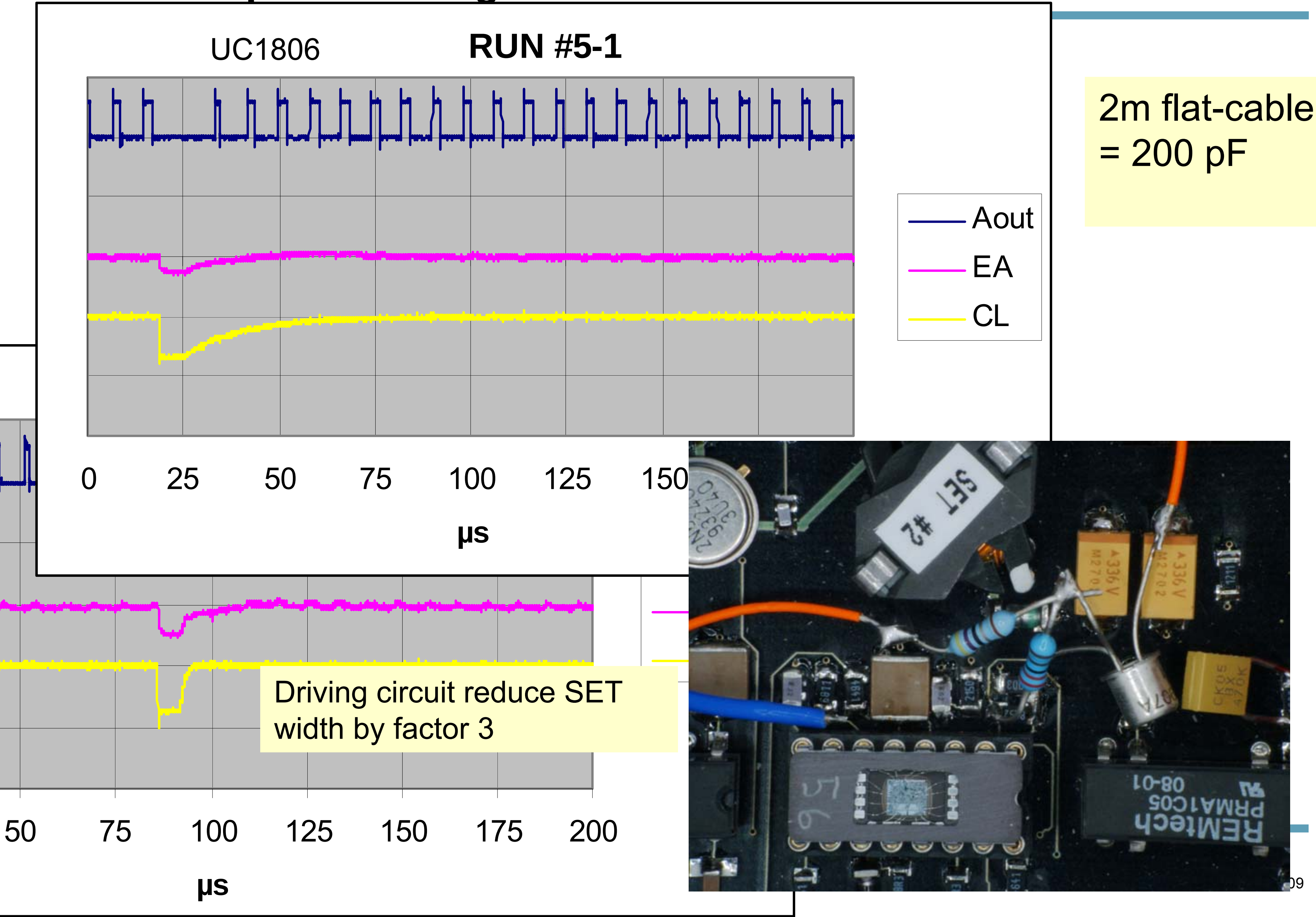
UCL Advantage ;
Test set-up close
to the test chamber



- SET testing at JYKL need precautions for the long cables



Pulse Shape & Cabling

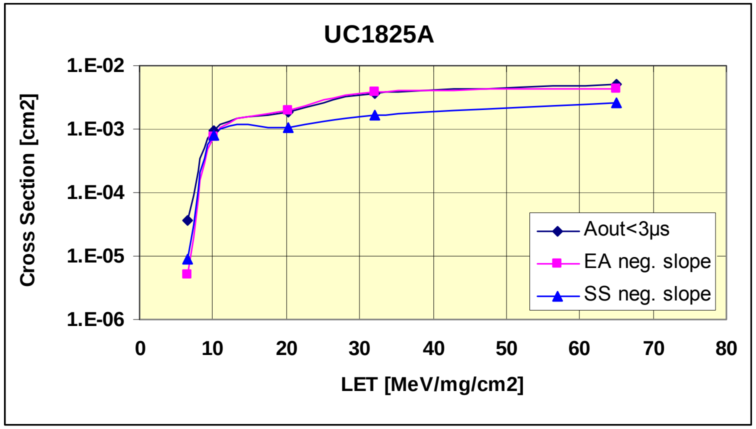


2m flat-cable = 200 pF

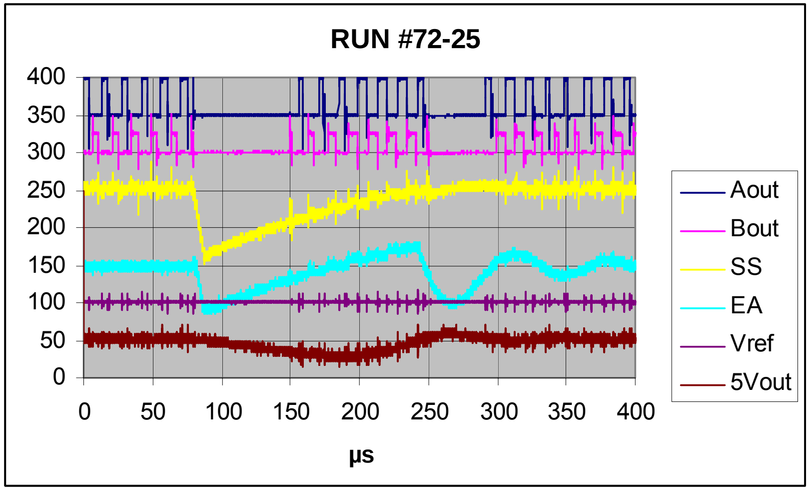
Driving circuit reduce SET width by factor 3

High SET Sensitivity

- Some complex Linear devices can show very long induced transients / errors
  - Soft Start
- Latch-Up tests may be confusing
- LU; 1e+7, flux; 1e+4,
- Soft-Start typical up to 50 upsets/s



Many Soft-Start upsets require more current for recovery of device



Data taken with 2m flat-cable+100pF to ground

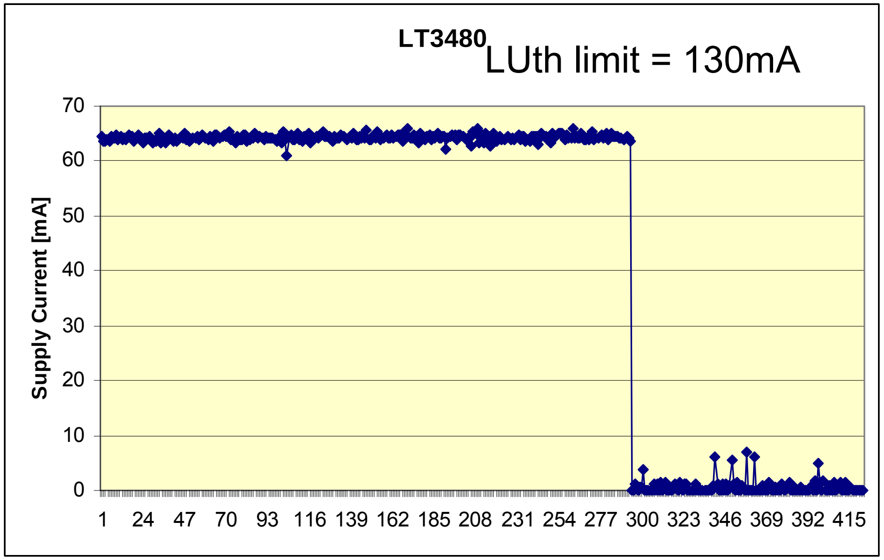
Increase of supply current

- LUth current limit@1.5x, device show LU

- Frequent SETs tend to increase the required start-up current

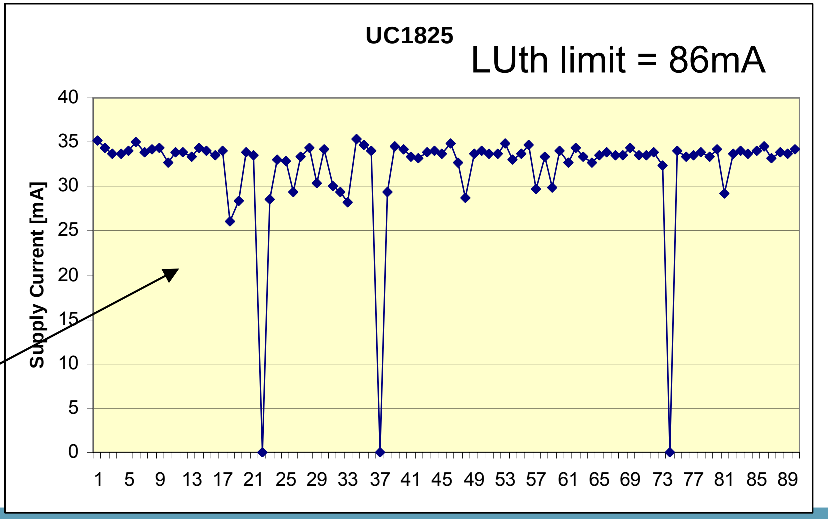
- LT3480 up to 2,5x normal current needed

- Low flux give better results



UC1825 indicate same behaviour
LUth limit = 134 mA → No LU (1e+7)

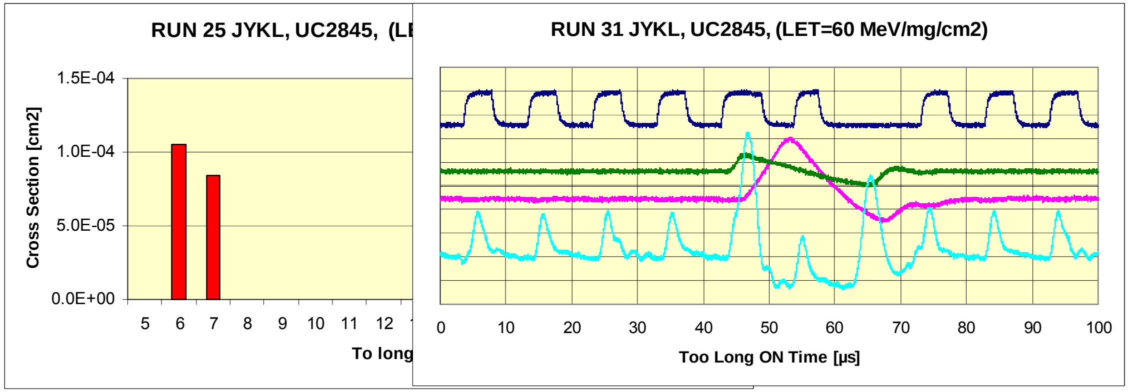
Reset of LU unit required to restart



High Flux & Confusing Data

UC2845

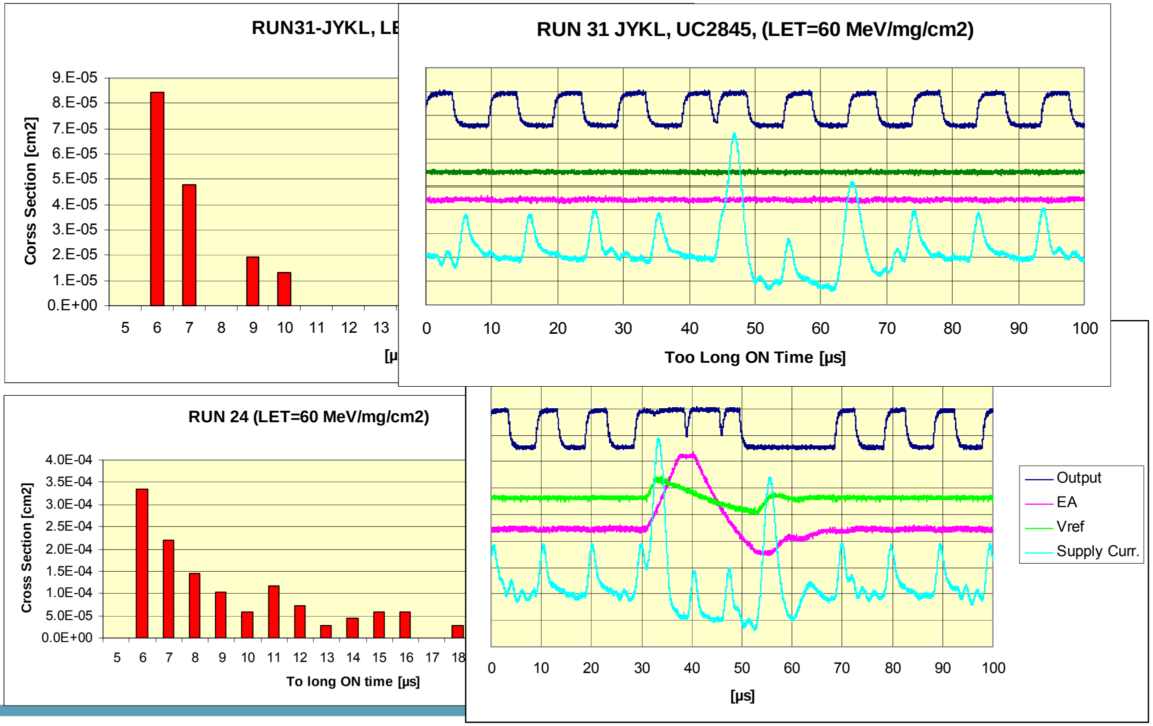
Low flux data 1e+2 ions/cm2



How flux data 1e+4 ions/cm2

UC2843

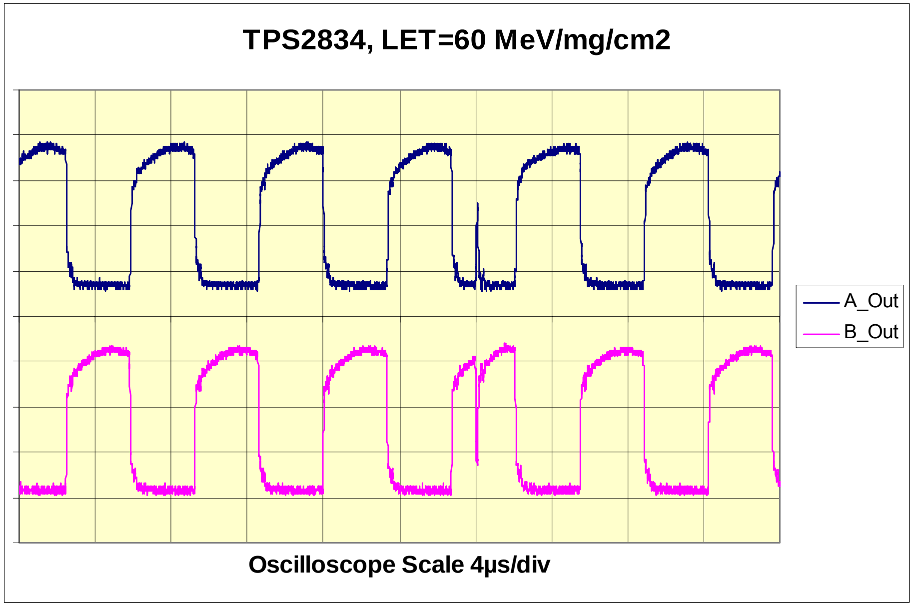
Low flux data 1e+2 ions/cm2

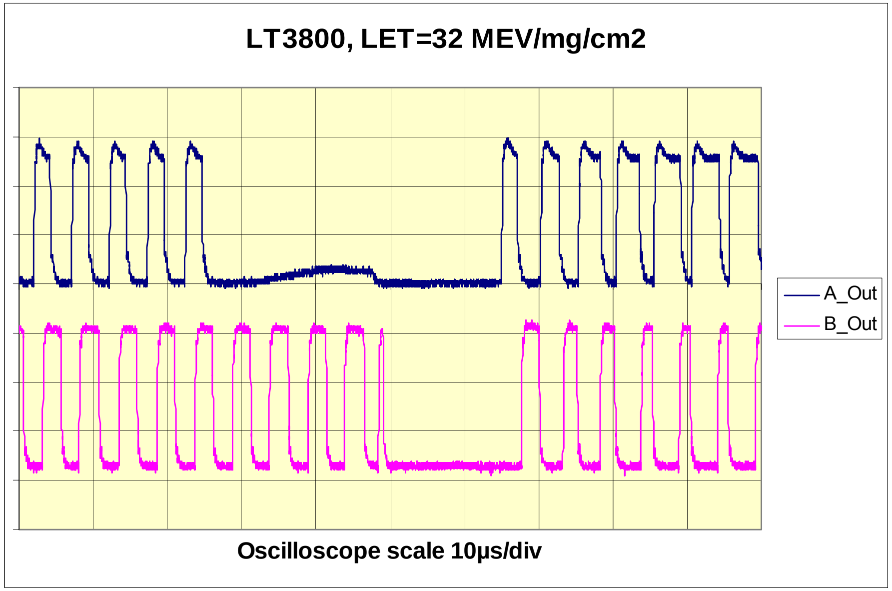


Trigger Requirements

- Some devices can be tricky to define right trigger requirements,
  - Conflict in collecting “All SET’s” and good statistics of “Critical SET’s”

Majority of all SET are Trivial,
Normal statistics ~ 100 SET/run,
Consider flux vs test set-up dead time





Hard and Soft Trigger Requirements

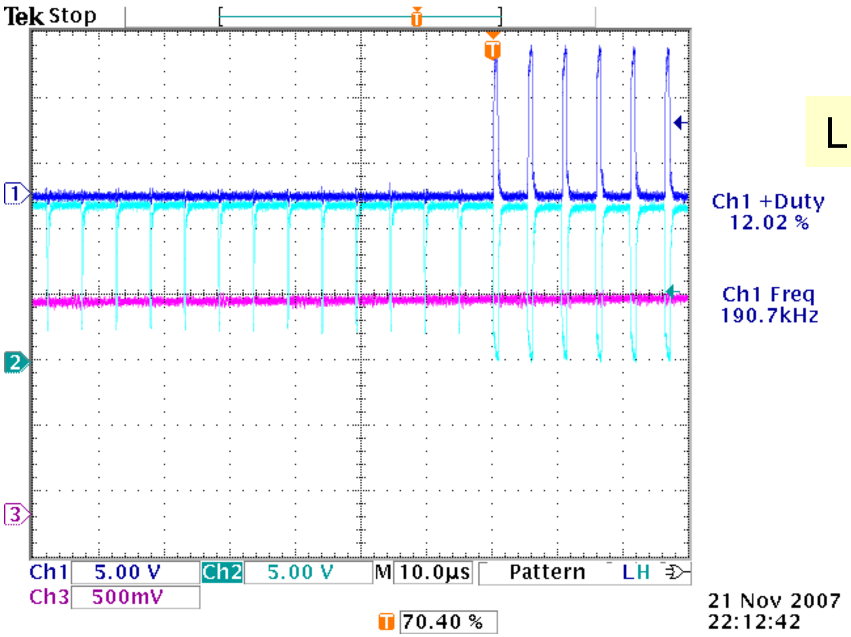
- Collecting ”Good to have” data may mask critical data

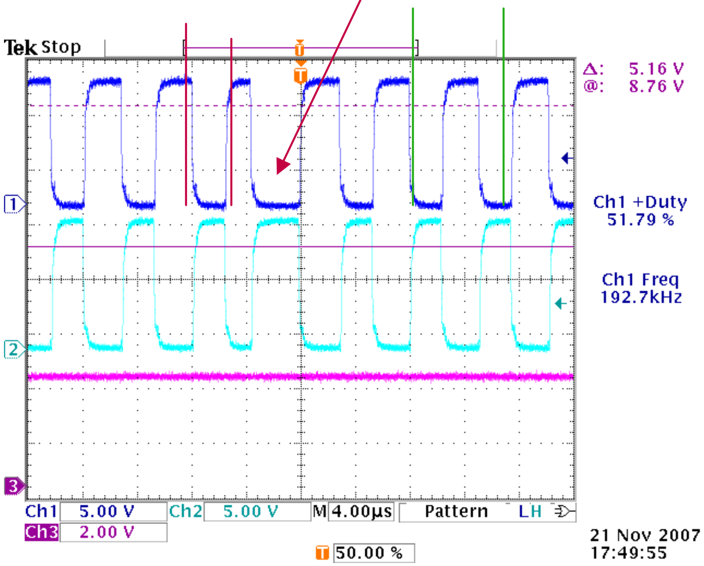
Too Tight Trigger Requirements
-Overload of trivial errors

- 1 missing pulse normally acceptable

Risk to have
Very low statistics of the real events

LM5026





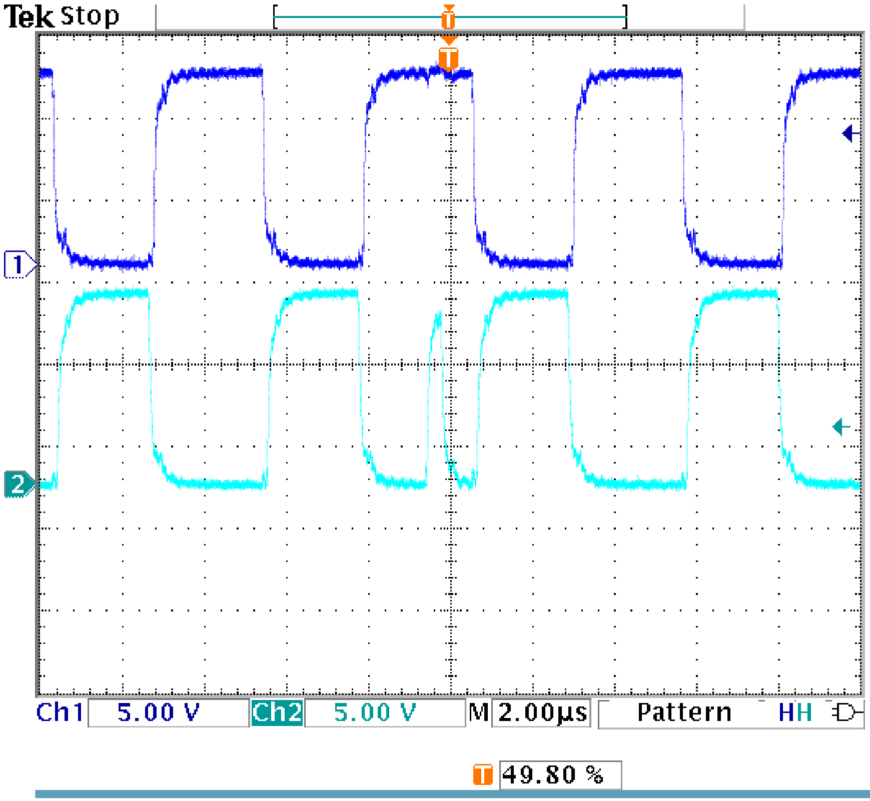
Hard and Soft Trigger Requirements

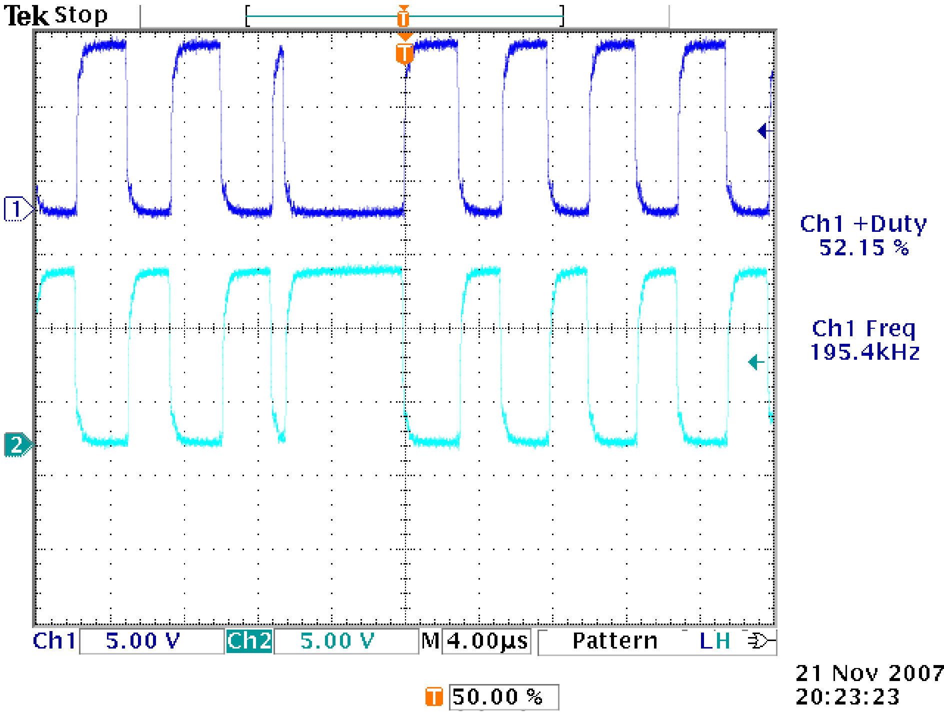
- Example of Critical Failure Mode

PWM with 2 complementary outputs, both used to drive MOSFETs,

Driving at the same time will result in shortage.

frequent type of transient, but not critical

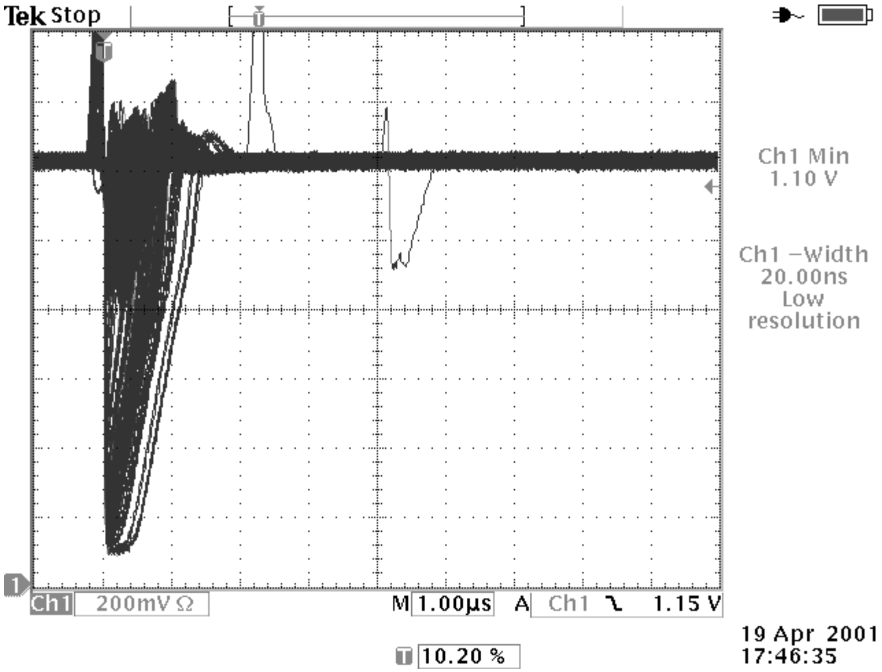




Design Knowledge Good to Have

In a large Tests Campaign

SET test of Voltage References showed transients down to zero volts



Most important results was the existence of positive pulses

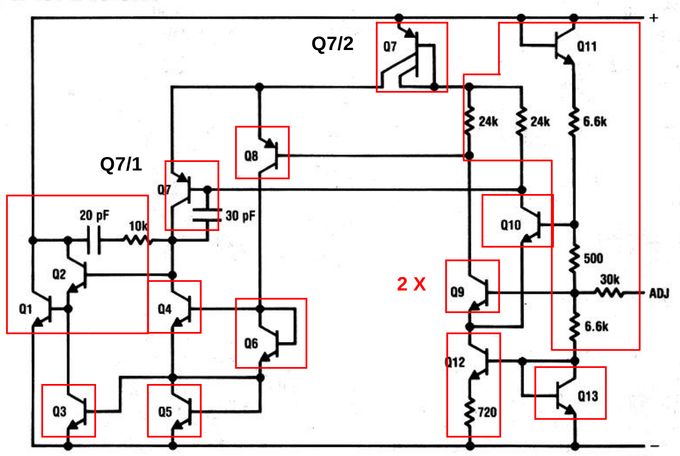
Because, 0.5V positive transient would trigger over-voltage protection causing power shut down

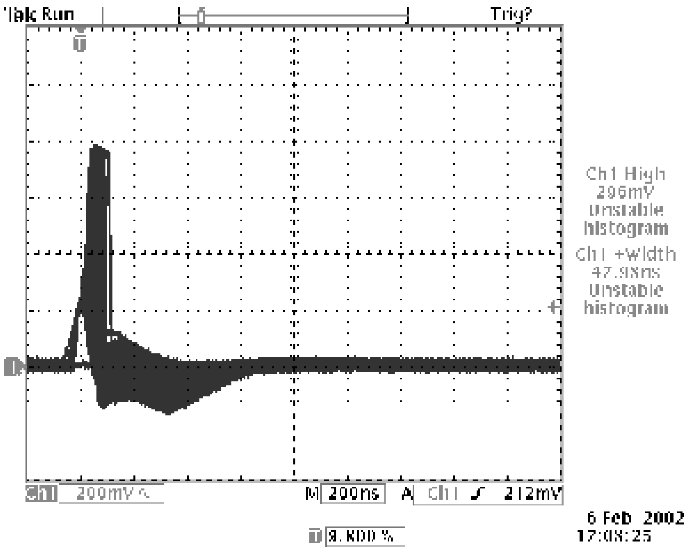
2 large test campaign was out concurred by some lab work

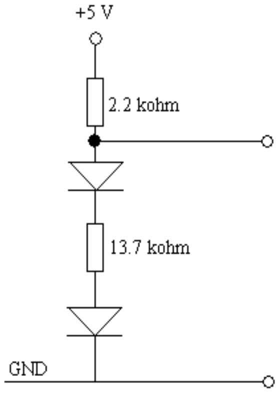
Design Knowledge Important

Positive Transient Pulses, 252-Cf

Voltage Ref LT1009, RH1009, 15pF







Worst case positive transient occurs when the shunt-transistor Q1 is cut off, giving a transient height of:

$V_{IN} - ((I_{BIAS} + I_{LOAD}) \times R) \approx \mathbf{4\ V}$

- Positive Transients Very Short (100 ns)

Lesson Learn on the importance of Critical Analysis

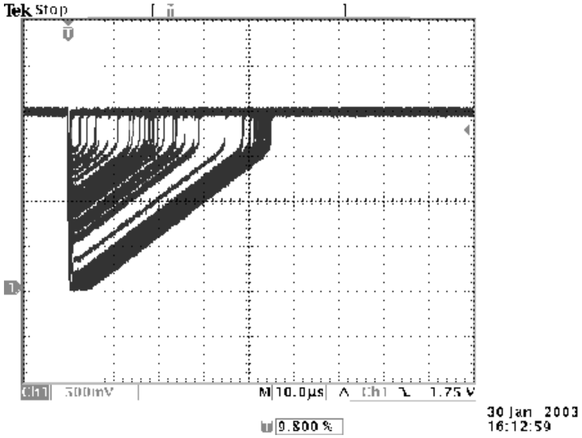
Unforeseen results taken as extra ordinary findings

Background RH1014

- In previous study on SET in Op Amps LM124 /TI, LM124A /NS and RH1014I /LT was tested.
- All device types have 4 Op Amps in one package,
  LM124's, one chip in each package
  RH1014, 2 dies of RH1013 in each package.
- One of the four Op Amps in each package was tested
- Results for LM124A 's

SET = 30-40µs

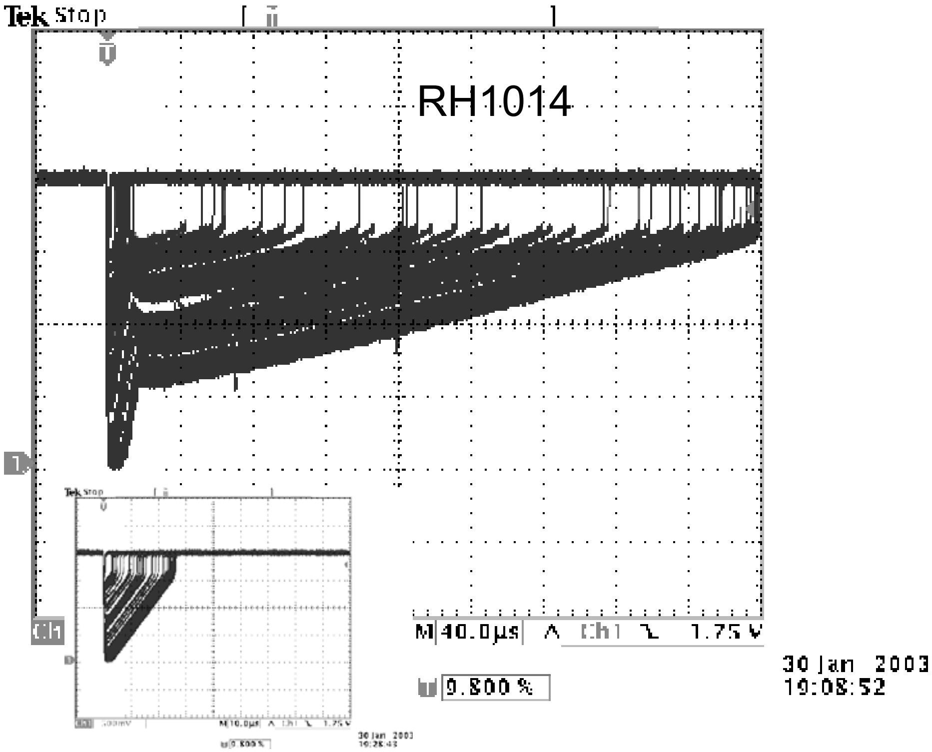
LM124A NS



Background RH1014

- RH1014 SET > 300µs
  - All types same bias set-up
  - Placed on the same test board
  - Performed in the same test

- S. Bruchner/NASA Tested RH1013 with laser,
- RH1013 and LM124A similar SET
- PROBLEM WITH THE TEST BOARD?

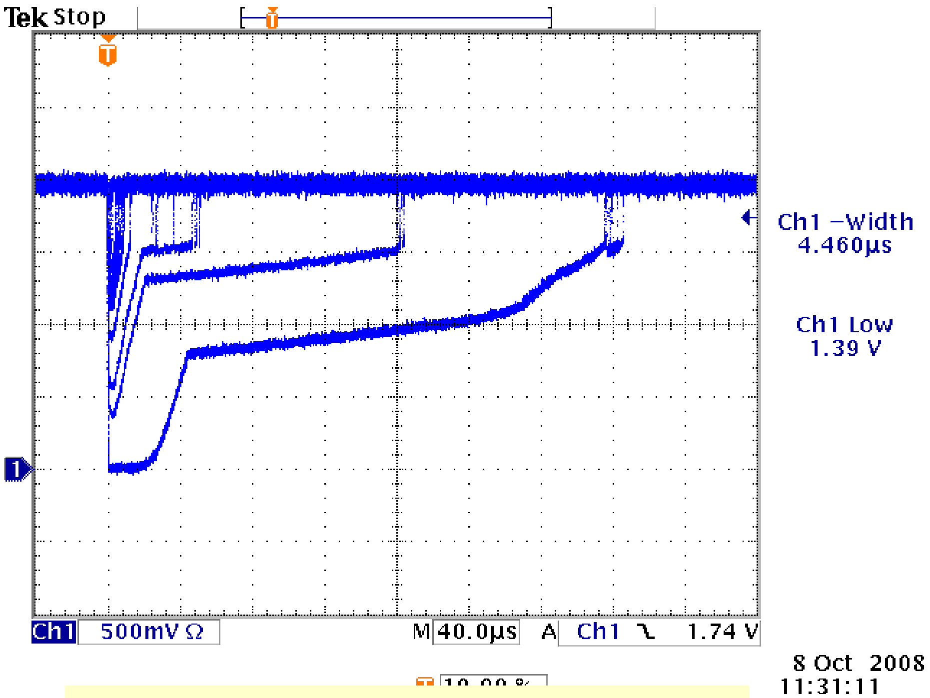


LM124 TI

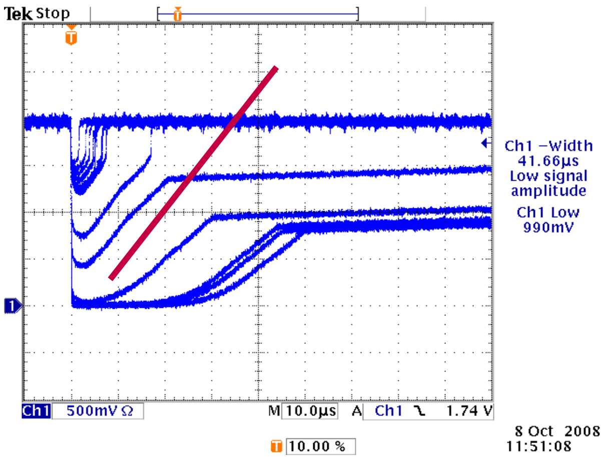
Test Board Verification

- Verification tests with original test board
  1) RH1014 original position - check of old results
  2) LM124 in original position – check of old results
  3) RH1014 in LM124 position – long pulses maintained?
  4) RH1013 in RH1014 position – same behaviour as RH1014?

Test Board Verification

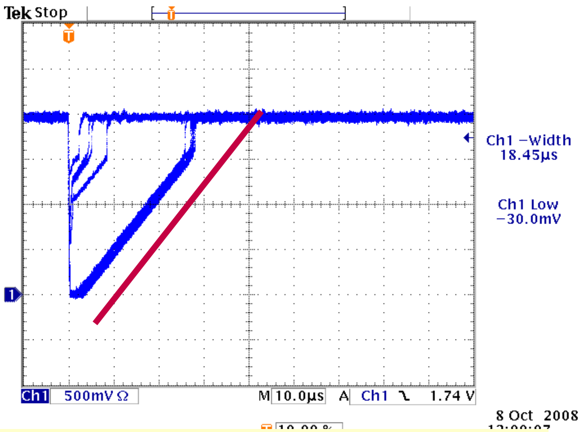


RH1014 in the normal position
Old results confirmed



RH1014 in LM124 position, 300µs

Test Board - OK

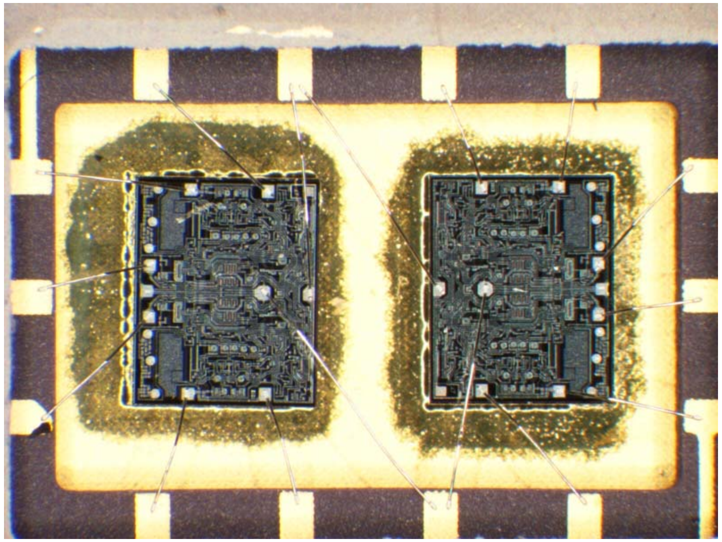


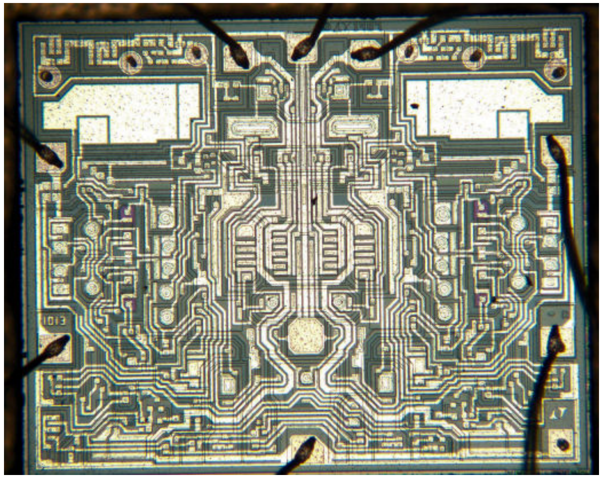
LM124 in RH1014 position, 30µs

RH1014 & RH1013 Identical

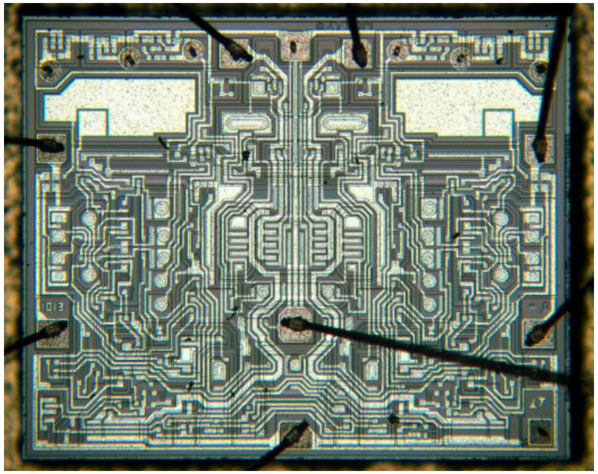
RH1014 - 2 dies of RH1013

The 2 dies have the same power pin





RH1013 die



RH1014 die

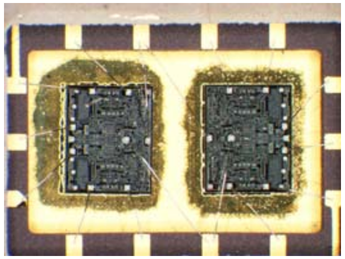
Deferens between RH1013 & RH1014, bonding of 1 power pin

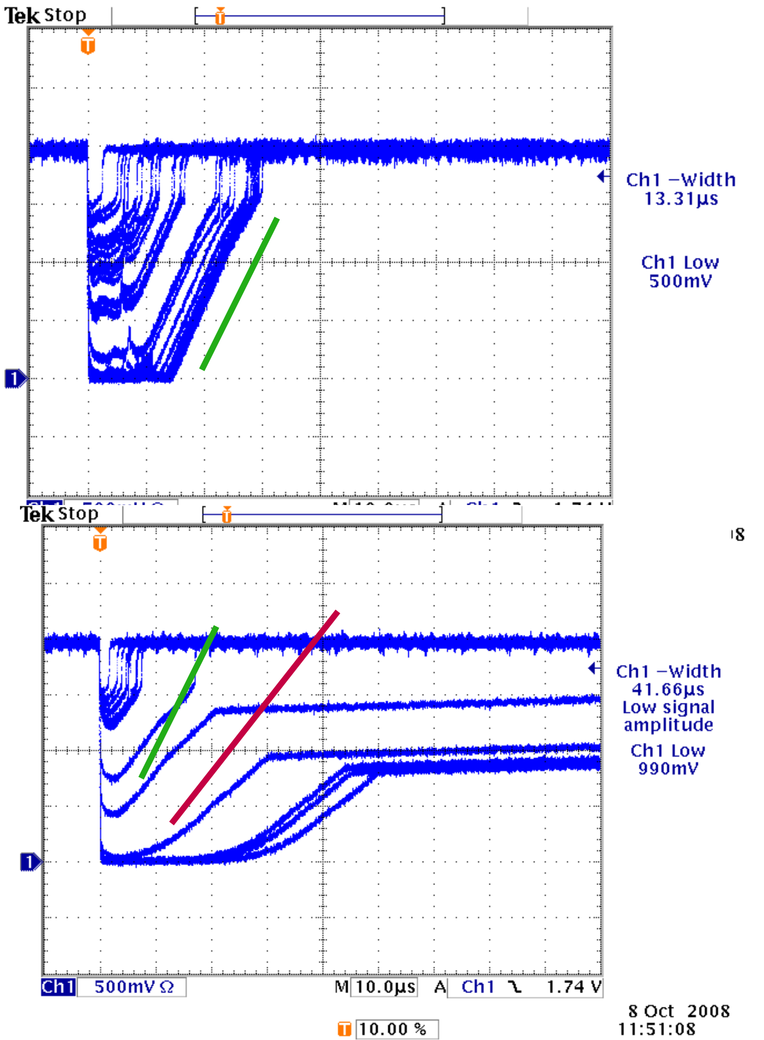
RH1013 resultat

RH1013 in RH1014 position
Pulses very similar to LM124

?

Is this a test induced effect ?





RH1014

NASA Laser Results

S. Bruchner /NASA tested RH1014 with laser,
Transients similar to RH1013,
NO LONG PULSES

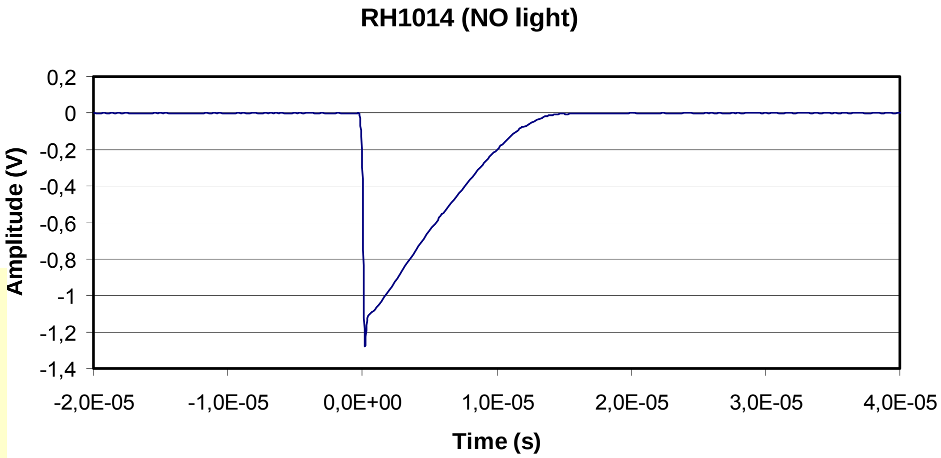
However,
RH1014 was found to be light sensitive in a small area of the chip,

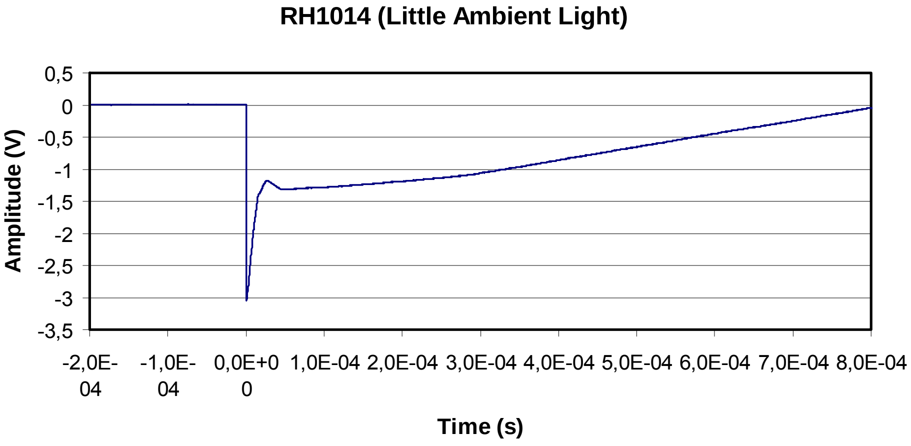
Transients generated from other areas were not light sensitive

RH1013 was not light sensitive at all

?

Only visible difference is the bonding of one pin


RH1014 (NO light)


RH1014 (Little Ambient Light)

Conclusion

- Summary (for beginners)
  - Plan for 2 trips (particularly for complex devices)
  - Application Like Test boards an advantage
  - Verify Unforeseen Data at Different Flux
  - Data diverging from standard "dull" SET behaviour - Ask for more money to perform further analysis

Thank You