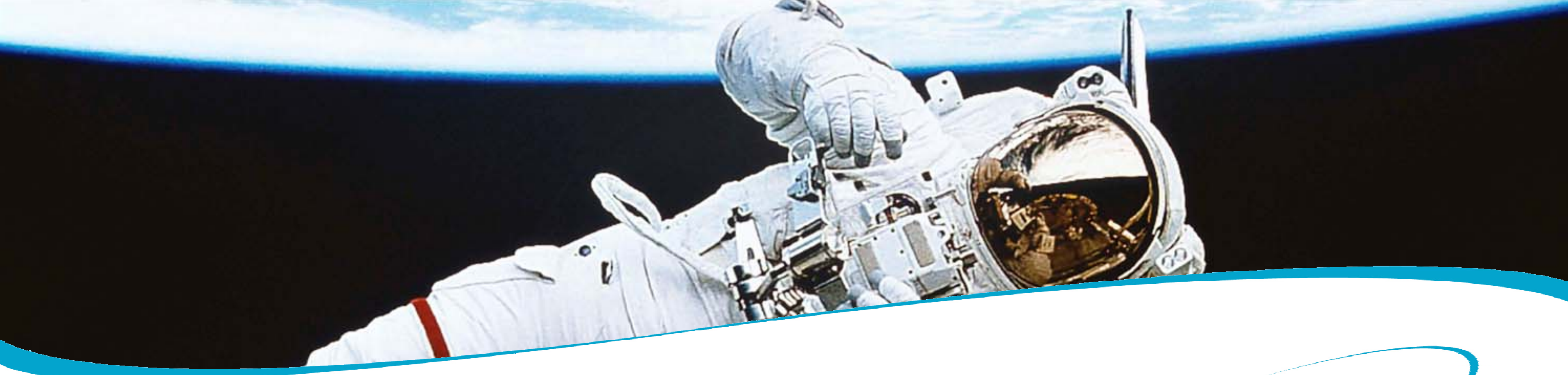

RHA Industry policy

3rd RADECS Thematic Workshop – SET – January 29th 2009 – PSI – Villigen

Michel Mélotte – Ronan Marec

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Ref : RHA Industry policy.

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Plan

- History
- Lesson learnt
- TAS SET methodology
- Implementation - Applicability
- Advantages - Disadvantages
- Conclusions

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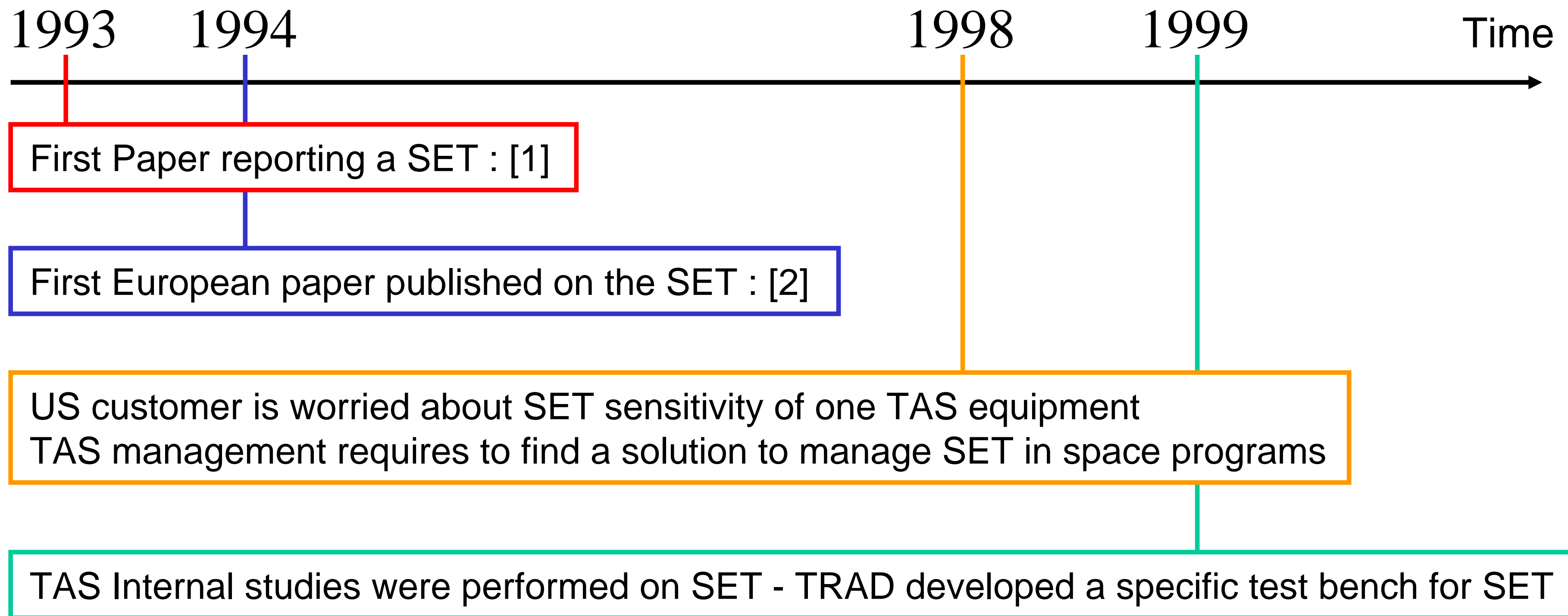
SET History



[1] – R. Koga, S.D. Pinkerton and al. , "Observation of Single Event Upsets in Analog microcircuits," IEEE Transactions on Volume 40, Issue 6, Dec. 1993 Page(s):1838 - 1844

[2] – R. Ecoffet, S. Duzellier, P. Tastet, C. Aicardi, and M. Labrunee, "Observation of heavy ion induced transients in linear circuits," IEEE Radiation Effects Data Workshop, 1994, pp. 72–77

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SET History

2000 2001 2002 Time

TAS present 2 papers on SET at NSREC in 2000
ESA presented a paper on SET characterisation of ICs for ESA's satellites
SET are application dependent – TRAD improve is test bench

A lot of papers were published on SET : Pease, Poivey, Stenberg….
It seems necessary to perform heavy ion test on each application : Unacceptable
TAS analysis show the large impact on program of late "critical SET"
TAS develop a methodology to anticipate SET effects during design phase
The TAS methodology, using worst-case shapes, is presented at RADECS 2001

For the first time, in flight SET is reported by ESA: [3]
TAS « SAV » reports some in anomalies due to SET since several years
TAS implement his SET RHA. All the new designs are SET tolerant.

[3] – R. H. Sorensen and al. ,
"Observation and Analysis of Single Event Effects On-Board the SOHO Satellite"

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SET History – The End

And now in 2009 . . .

As result, no in-flight anomaly were reported due to SET
since this policy is applied!

Thanks' to design engineers!

By using the worst-case shapes,
they can analyse the SET tolerance
of their concepts earlier in the design flow

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TAS publications on SET

1 – « Application-Oriented Radiation Evaluation of Commercial Linear Integrated Circuits » Marec R, Chatry C., Adell P., Barillot C. , Mion O., Ecoffet R., presented at NSREC in 2000

2 – « Analysis of single-event transients in analog circuits » Adell, P.; Schrimpf, R.D.; Barnaby, H.J.; Marec, R.; Chatry, C.; Calvel, P.; Barillot, C.; Mion, O.; Nuclear Science, IEEE Transactions on Volume 47, Issue 6, Part 3, Dec. 2000 Page(s):2616 - 2623

3 – « Towards a single event transient hardness assurance methodology » Marec, R.; Chatry, C.; Adell, P.; Mion, O.; Barillot, C.; Calvel, P.; Cresciucci, L.; Radiation and Its Effects on Components and Systems, 2001. 6th European Conference on 10-14 Sept. 2001 Page(s):343 – 350

4 – « Single Event Transient Propagation Through Digital Optocouplers » Adell, P.C.; Mion, O.; Schrimpf, R.D.; Chatry, C.; Calvel, P.; Melotte, M.R.; Nuclear Science, IEEE Transactions on Volume 52, Issue 4, Aug. 2005 Page(s):1136 – 1139

5 – « Single Event-Induced Instability in Linear Voltage Regulators Adell, P. C.; Witulski, A. F.; Schrimpf, R. D.; Marec, R.; Pouget, V.; Calvel, P.; Bezerra, F. »; Nuclear Science, IEEE Transactions on Volume 53, Issue 6, Part 1, Dec. 2006 Page(s):3506 - 3511

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Important Lessons Learnt

Based on our experience . . .

The only way to predict the SET rate is :

- To perform heavy ion tests in real application conditions (with all conditions)
- To consider only events with critical impacts at system level

The best way to conduct a test campaign is :

- To store all SET events
- To analyse it carefully, with an ad hoc software

The best way to mitigate the SET is :

- To give the responsibility of the SET RHA to the design engineer
  - He/she is the right person to manage the corrective actions
- To anticipate, at the beginning of the program, the SET analysis

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SET RHA - Policy – Do not forget !

To answer to this chalenge, TAS has developed his RHA SET policy

The goal of RHA SET policy is to provide
good practices, guide lines, instructions, recommendations

The goal is, notably, to reach an outstanding level of competitivness

Based on our expertise, the good practices, guide lines, instructions, recommendations must be construct with an adequat level of risks

- Too risky, it is not good, but too much margin, it is even worst !

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SET RHA Methodology

SET methodology is published

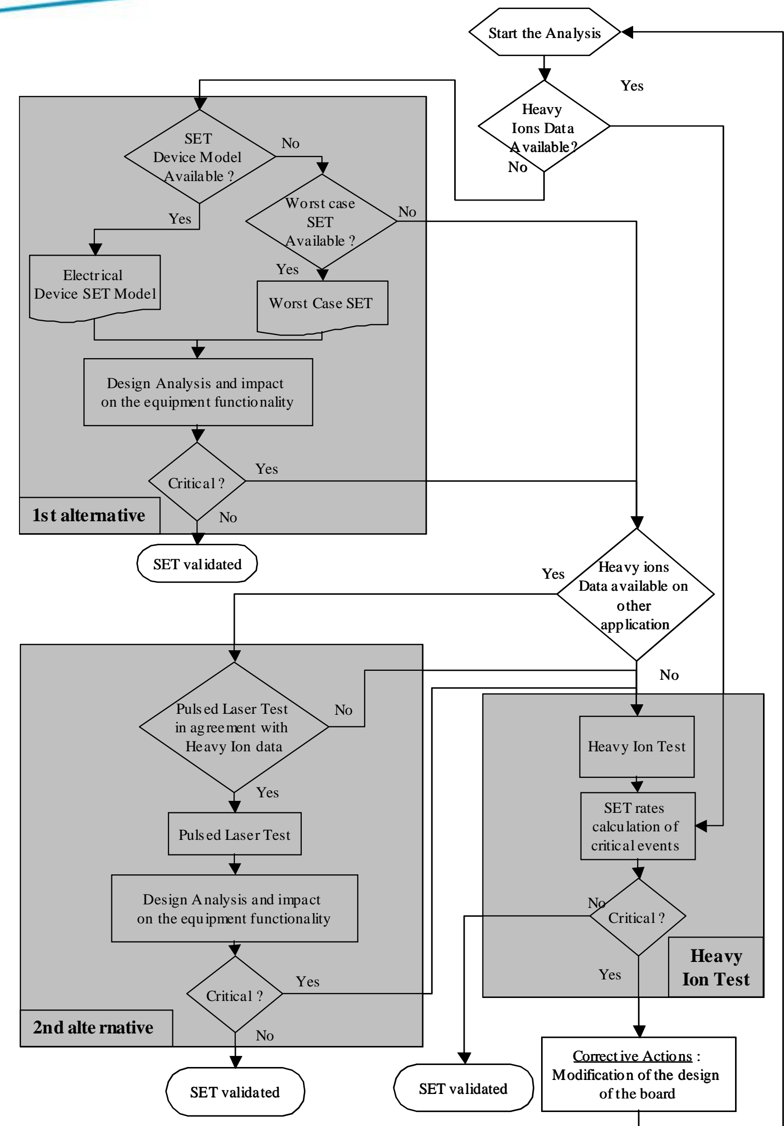
« Towards a single event transient hardness assurance methodology »

Marec, R.; Chatry, C.; Adell, P.; Mion, O.; Barillot, C.; Calvel, P.; Cresciucci, L.;

Radiation and Its Effects on Components and Systems, 2001. 6th European Conference on 10-14 Sept. 2001 Page(s):343 – 350 »

It is based on three steps

- Assessment, via worst case pulse shape, of the design criticality
- Heavy ions on real application test
- Pulsed laser test



Ref : RHA Industry policy.

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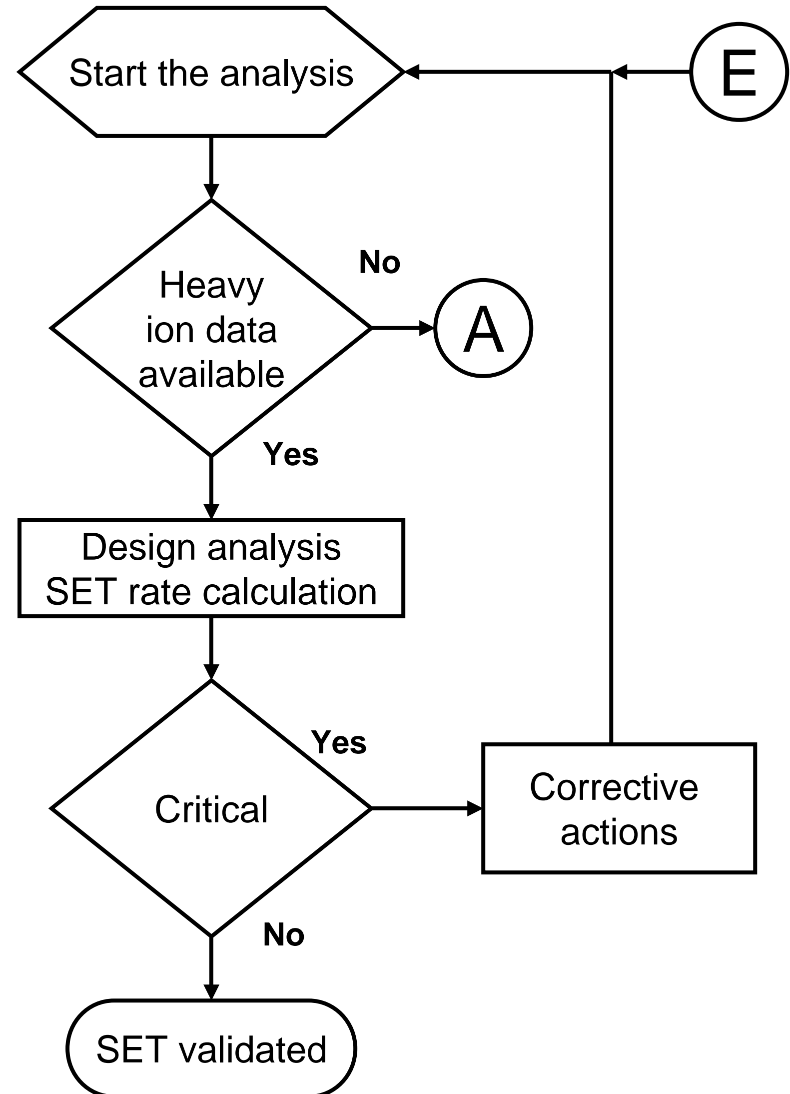
SET RHA Methodology - Description

At the beginning . . .

- Identify all linear integrated circuits in the application
- One analysis for :
    - Each part
    - Each bias conditions
- Calculate the SET rate
- Analyse the critical aspects



Corrective actions

- Take an other circuit type
- Change architecture - redundancy
- More filtering
- Negotiate the specification

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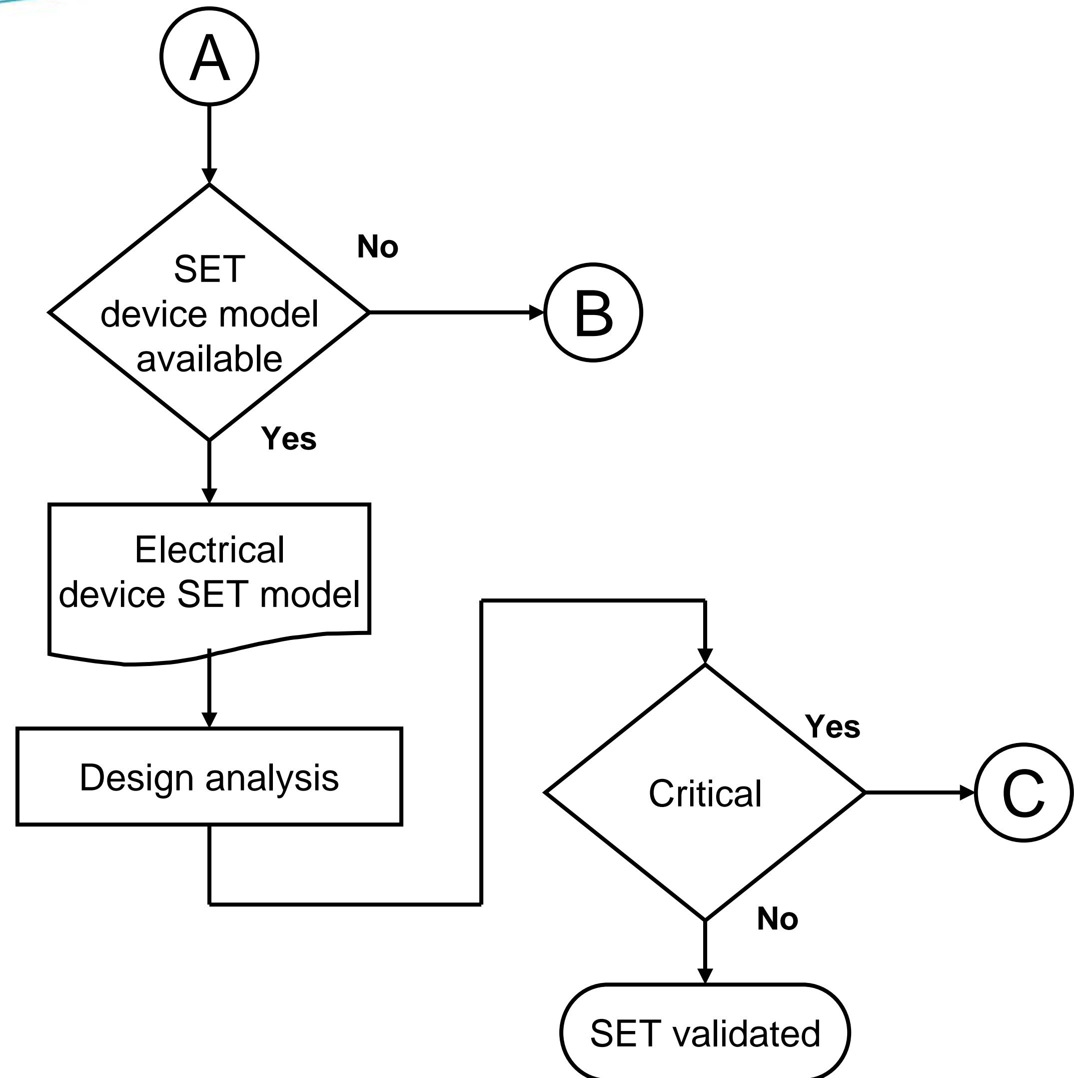
SET RHA Methodology - Description

Alternative . . .

- Use of SPICE model
- Impose the availability of an accurate SPICE model of the device
- Gives good results [4]
- Analysis of the impact in comparison with spec.
- Analyse the critical aspects



[3] – **P. Adell and al. , IEEE TNS 2000 "Analysis of Single Event Transients in Analogue Circuits"**

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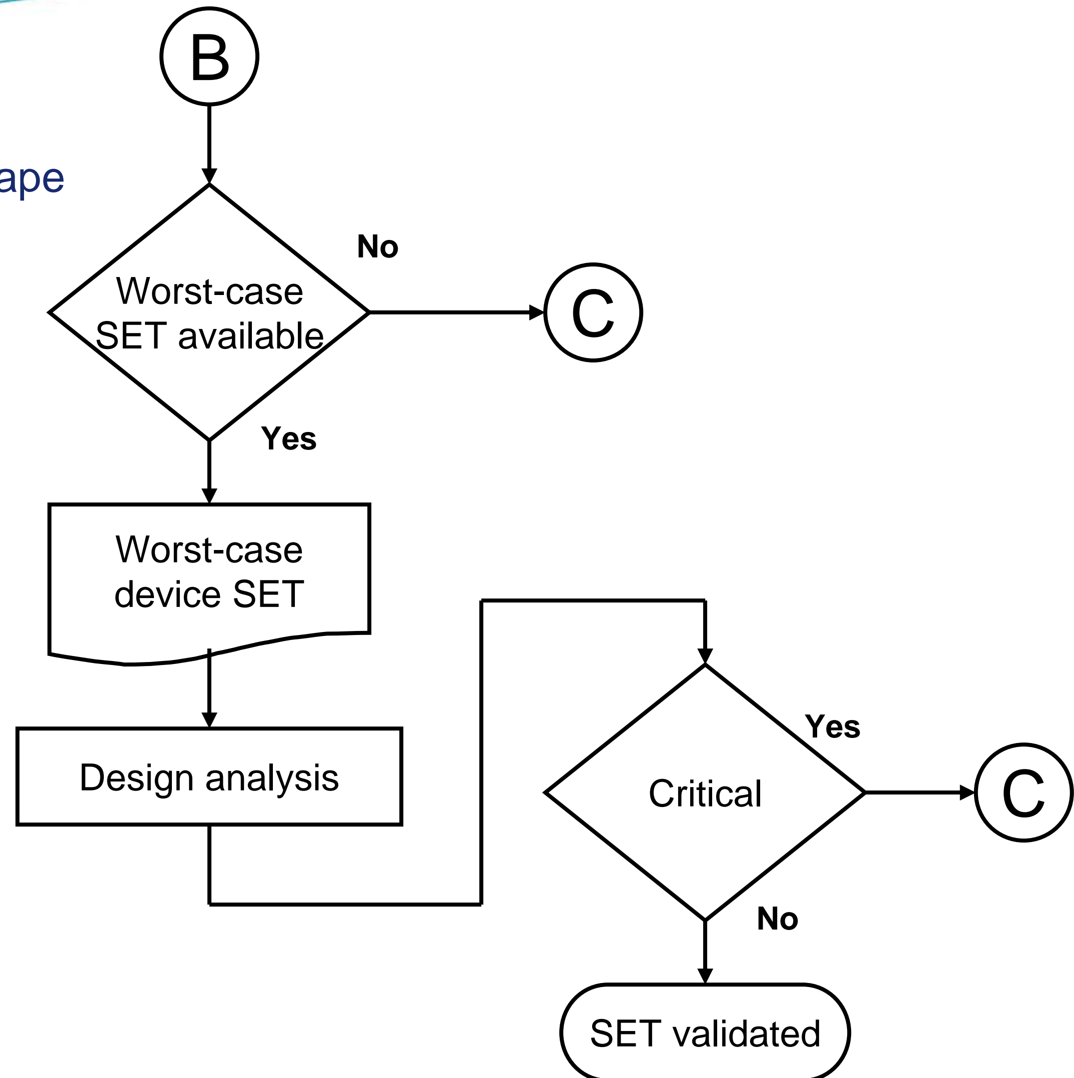
SET RHA Methodology - Description

Alternative . . .

- Use of worst-case pulse shape
- Analysis perform
  via circuit simulation
  by injection of the pulse
  at the output of the devise
- Analysis of the impact
  in comparison with spec.
- Analyse the critical aspects



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SET RHA Methodology - Description

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Worst Case pulse Shape :

- how it look like in Thales Alenia Space document . . .

8.5 SINGLE EVENT TRANSIENT EFFECTS ANALYSIS

RAD-21	The subcontractor is required to perform a SET effects analysis in order to demonstrate to determine the effects of SET on equipment performance.

It is required to determine the following effects on performance :

OP-amps	$\Delta V_{max} = +/- V_{cc}$ & $\Delta t_{max} = 15\,\mu s$
Comparators	$\Delta V_{max} = +/- V_{cc}$ & $\Delta t_{max} = 10\,\mu s$
Voltage Regul.	$\Delta V_{max} = +/- Vcc$ & $\Delta t_{max} = 10\,\mu s$
Voltage Ref.	$\Delta V_{max} = +/- V_{cc}$ & $\Delta t_{max} = 10\,\mu s$
PWMs	Double Pulses, two missing pulses, multiple missing pulses in a row, device shut off. Assess impact in specific application.

For those applications, demonstrate that a SET will not produce an out of specification.

Of course, this table is living . . .

- New type of devices must be extensively tested !

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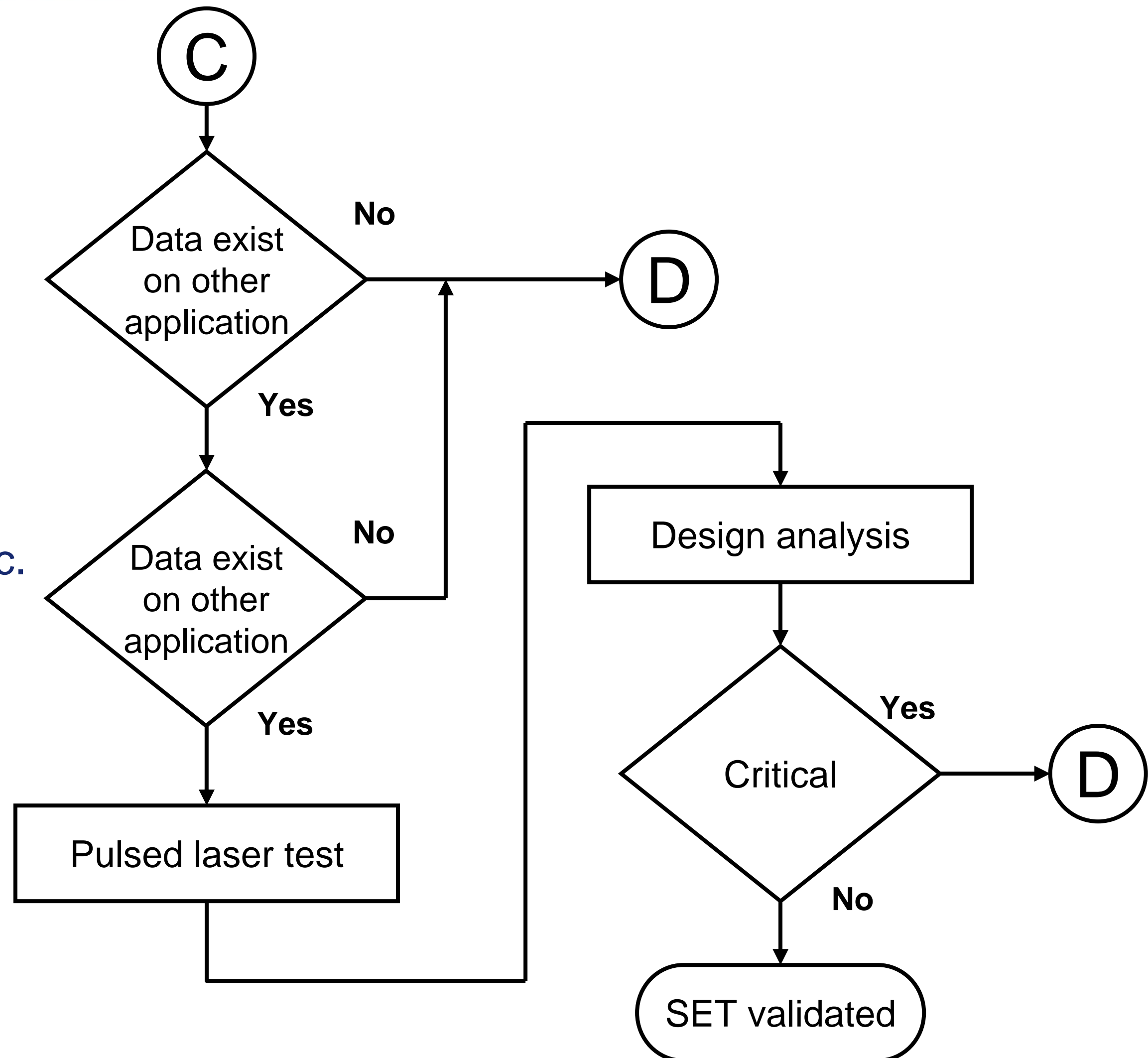
SET RHA Methodology - Description

Alternative . . .

- Use of data on other application
- Use pulsed laser to extrapolate
- Analysis of the impact in comparison with spec.
- Analyse the critical aspects



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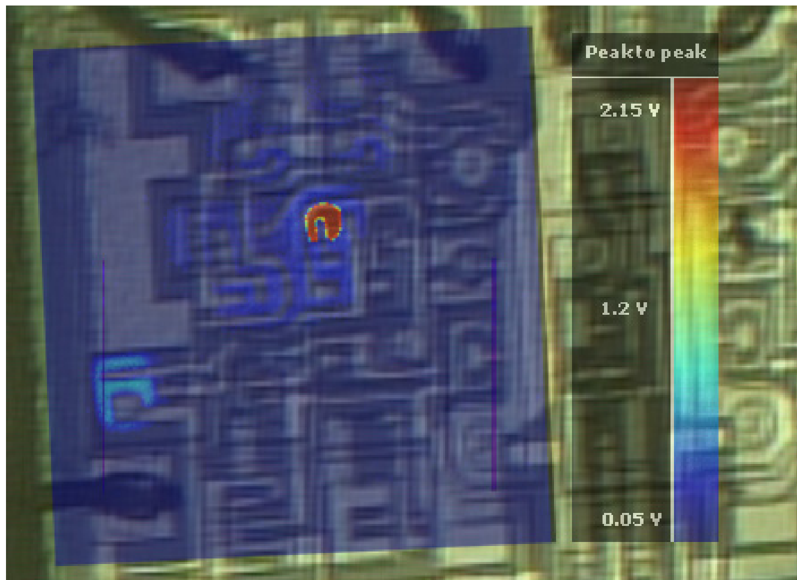
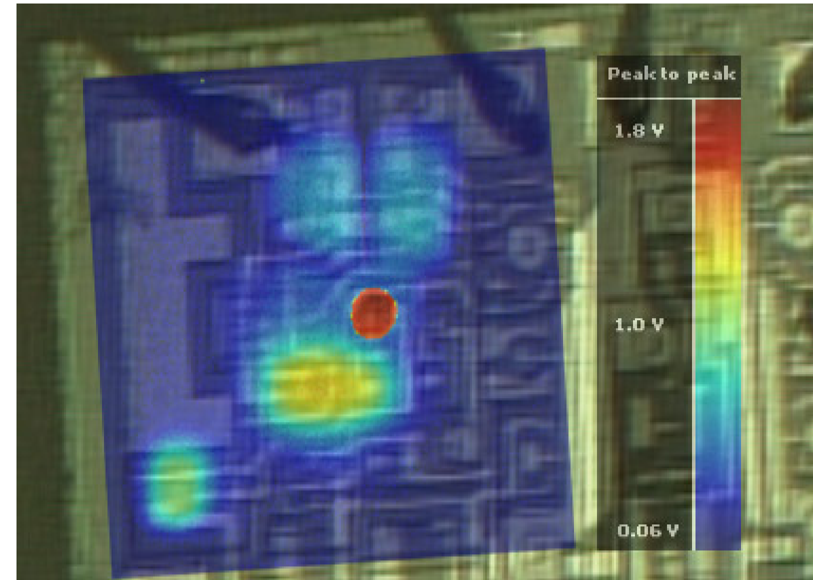
Pulsed Test Laser : Procedure

- Based on know heavy ion data, search the low thresholds for the laser parameters (energy and objective focus) to observe the same events





- Irradiate, with the laser set with the same parameters, the new application
- Record the events

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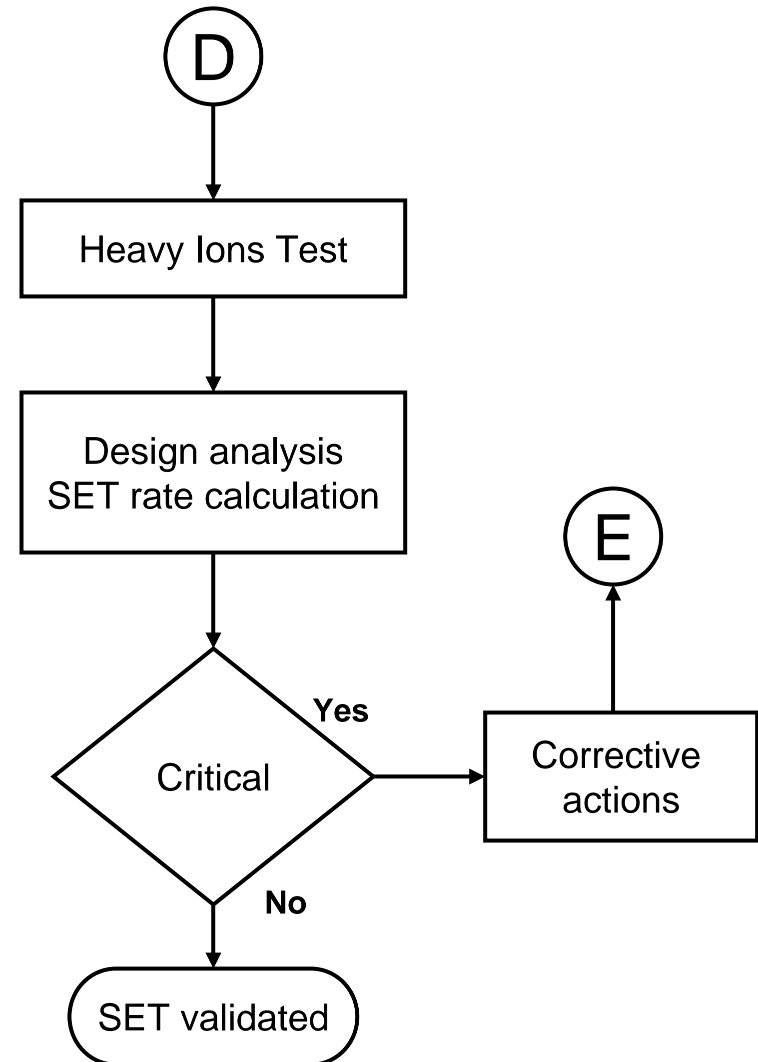
SET RHA Methodology

And at last : Heavy Ions Test

- Record the shape of all events
- Determine the application fear event
- Determine the cross-section vs LET for the fear event
- Calculate the SET rate
- Analyse the critical aspects



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Implementation - Applicability

A practical demonstration . . . Via electrical simulations

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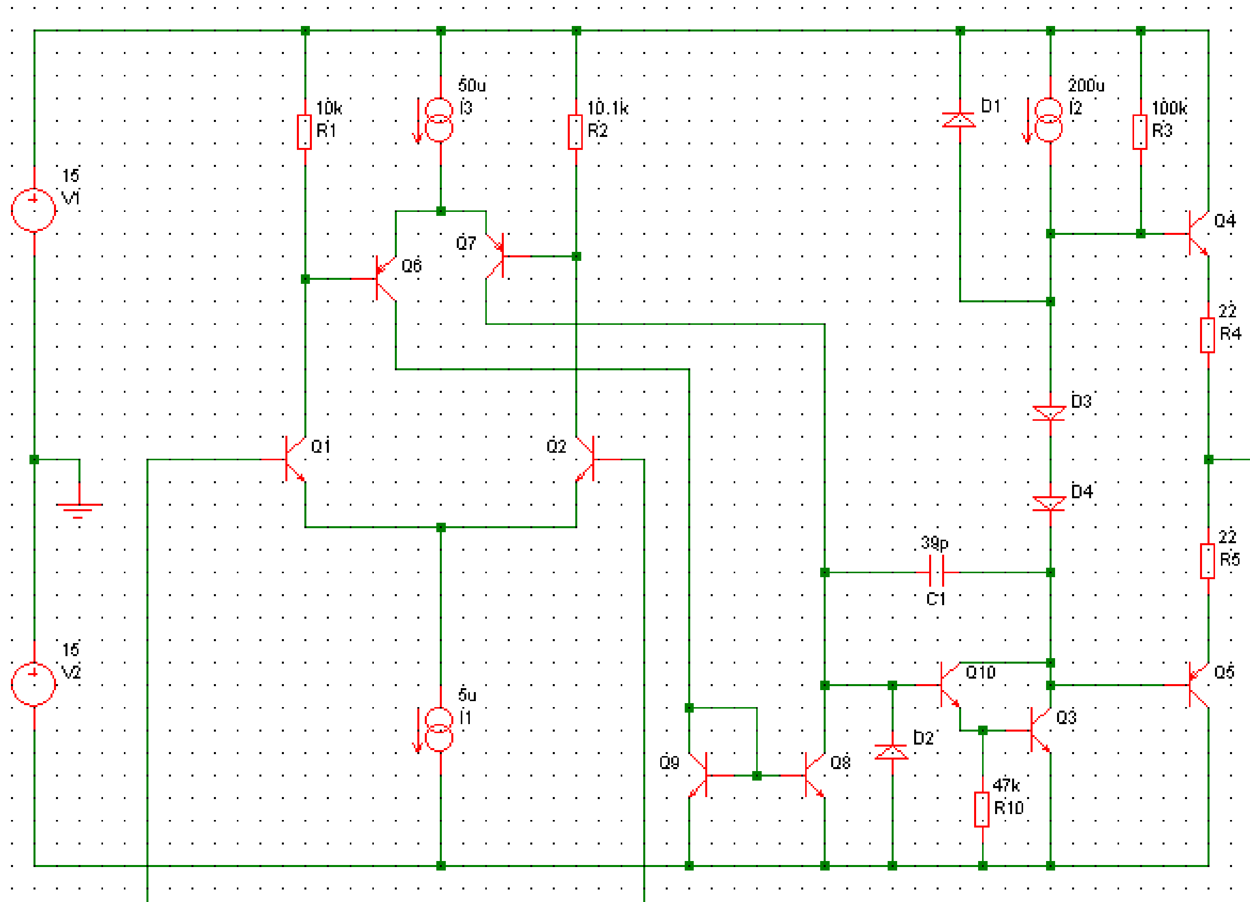
Implementation - Applicability

Take a simplified schematic of an op-amp



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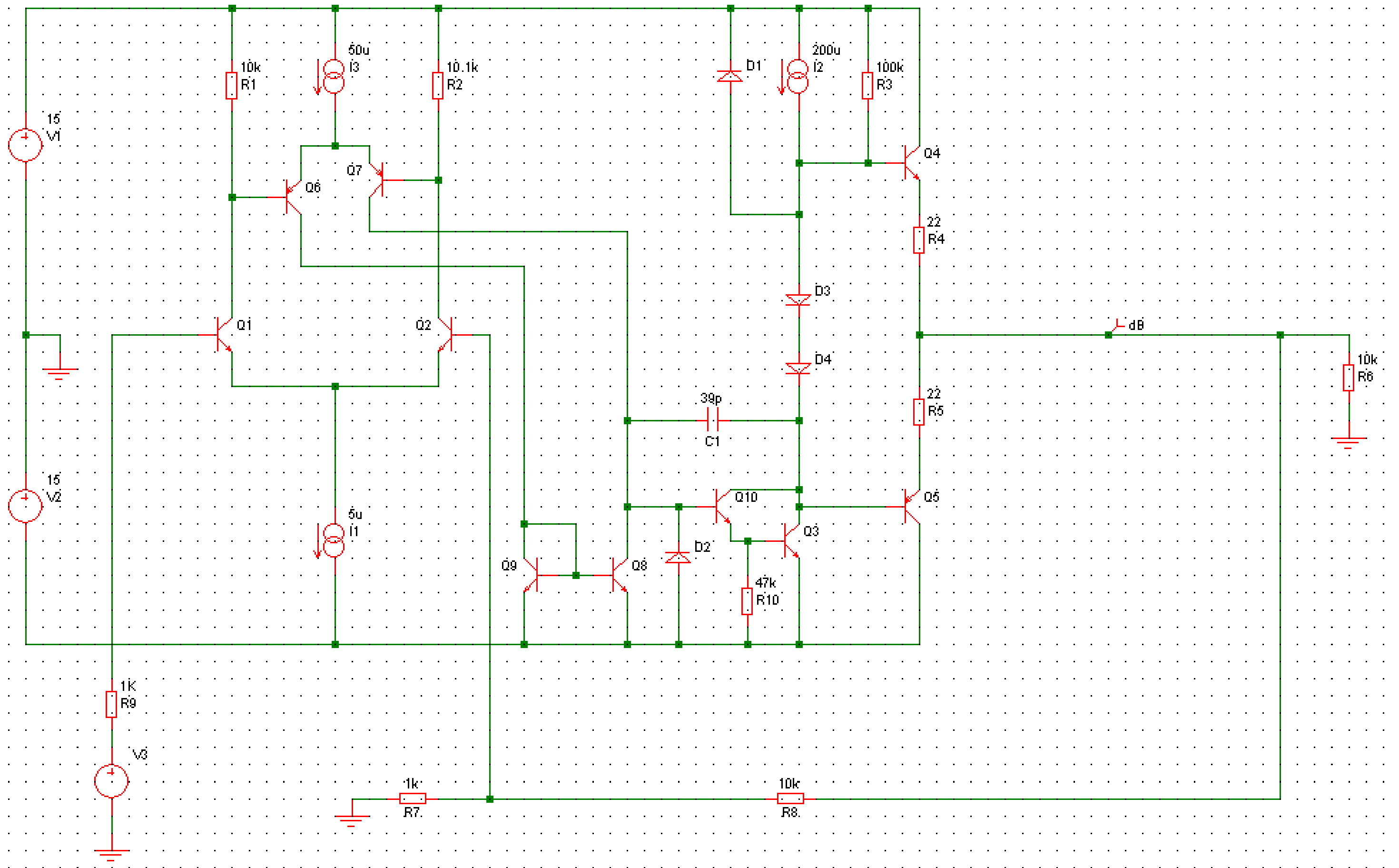
Implementation - Applicability

Use as a standard amplifier



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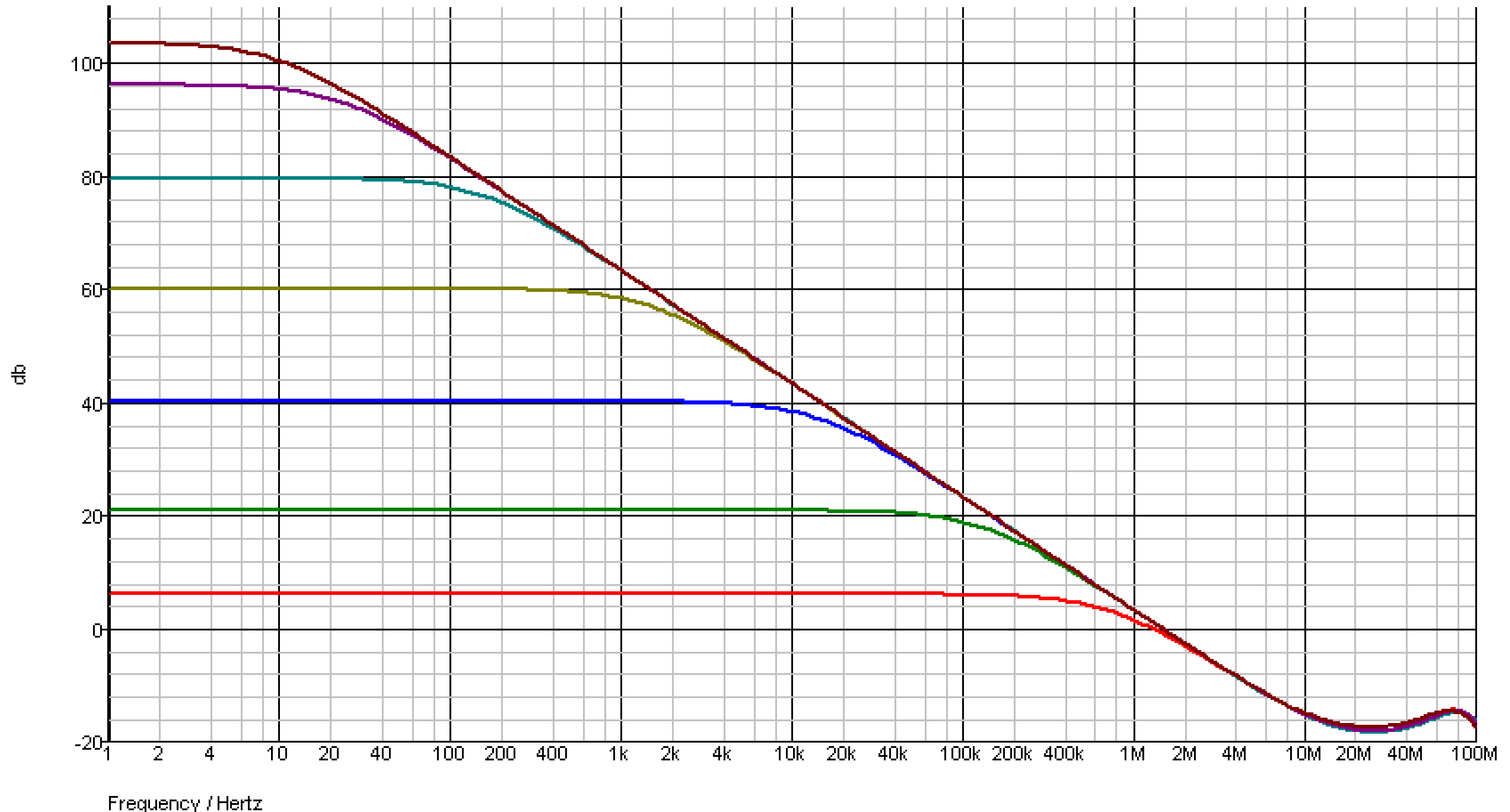
Implementation - Applicability

Characteristics BW product: 1.5 MHz – OL Gain: 104 dB – Main pole: 10 Hz



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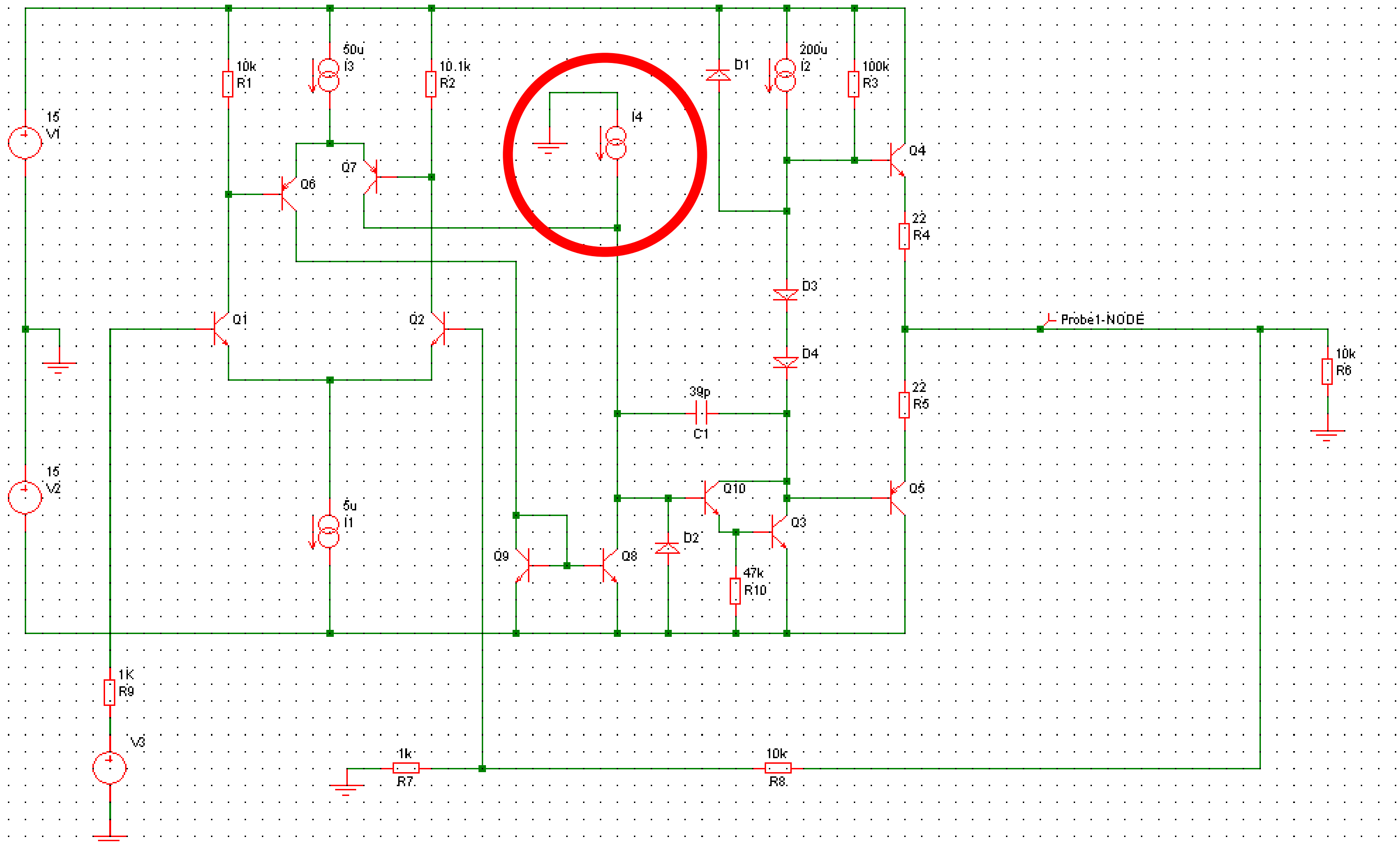
Then, if we inject 15 pC . . .



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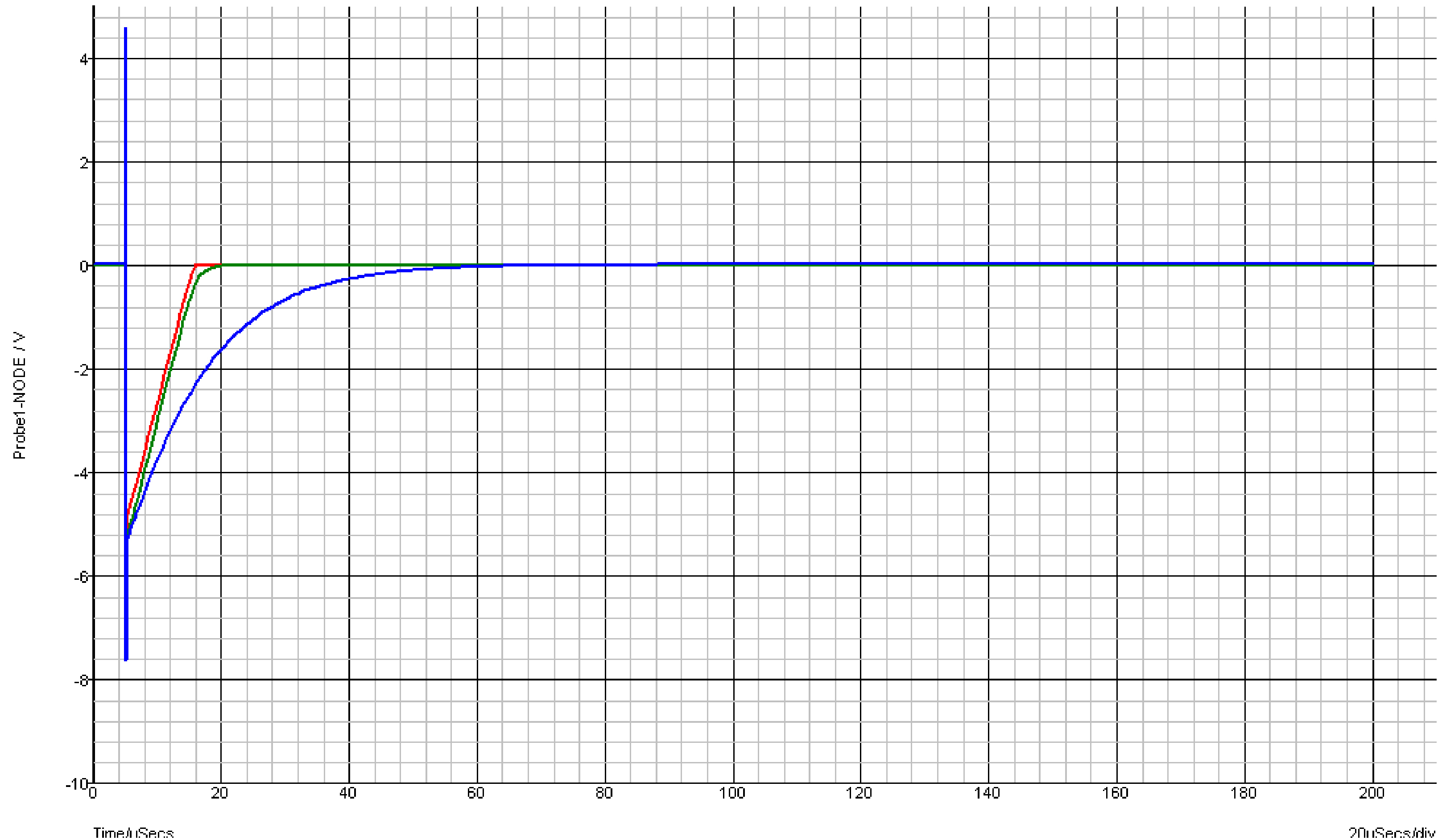
Implementation - Applicability

We found this result . . .



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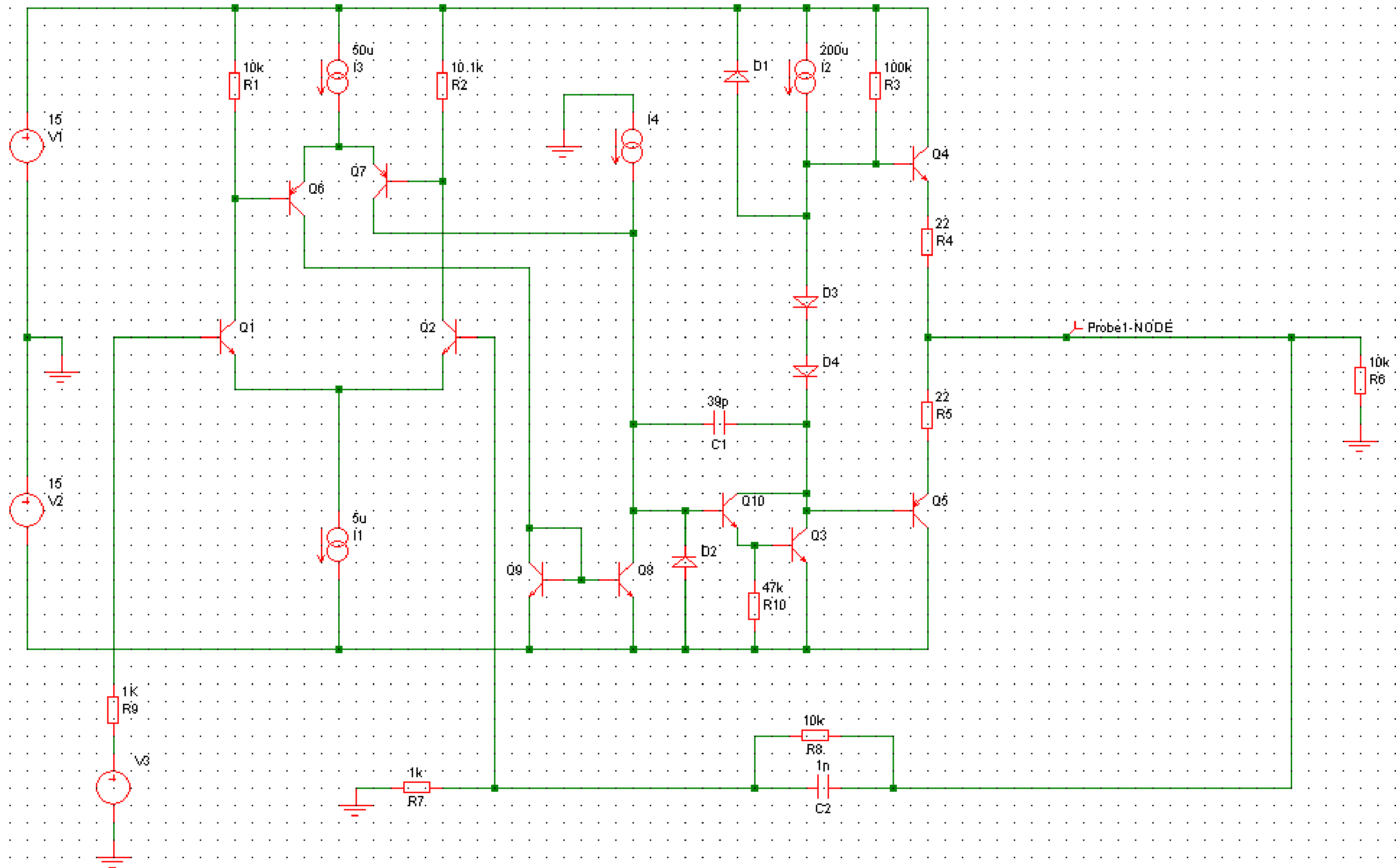
Implementation - Applicability

And if we ad a zero in the feedback network . . .



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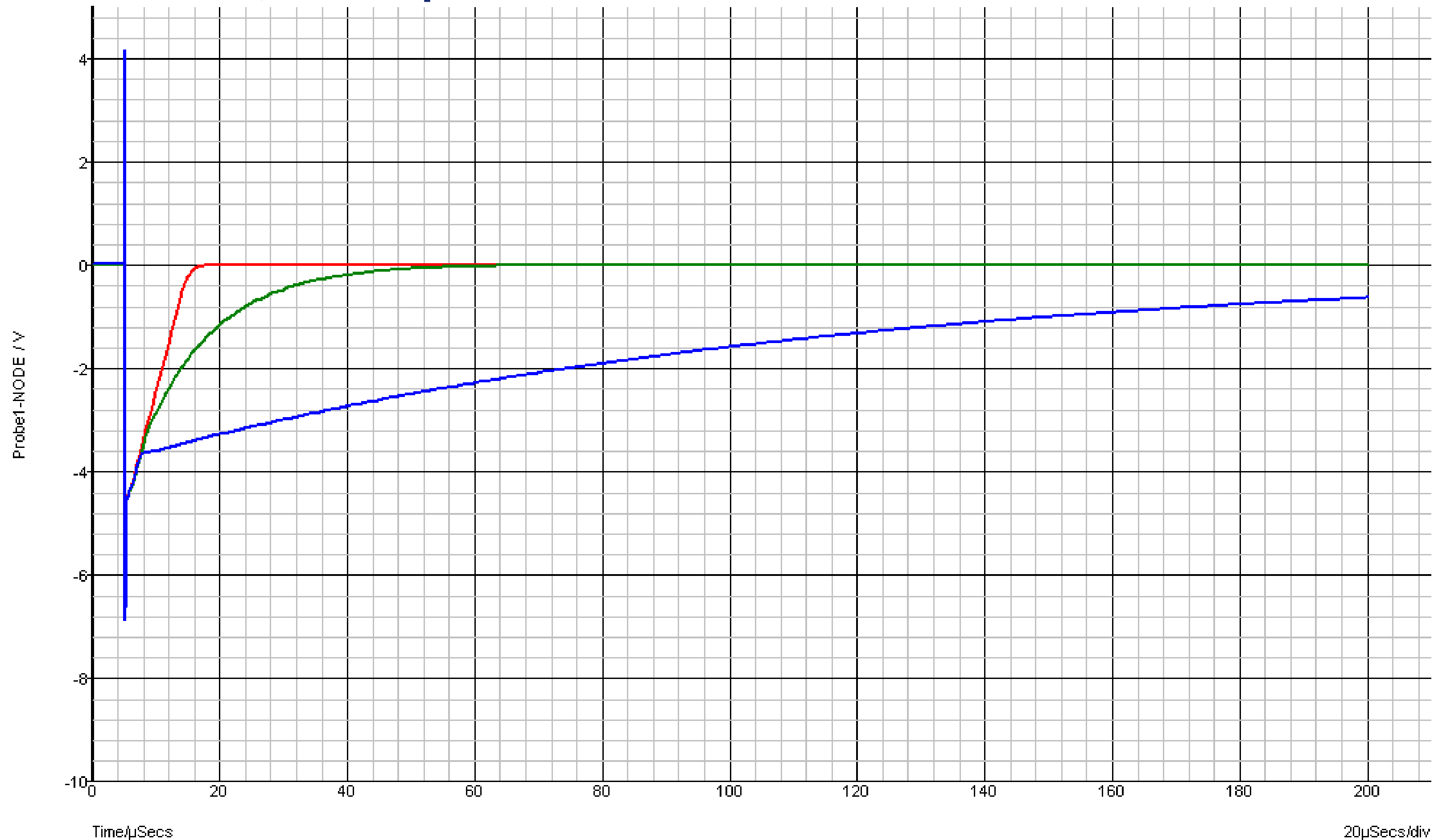
Implementation - Applicability

In this case, the response is slower . . .



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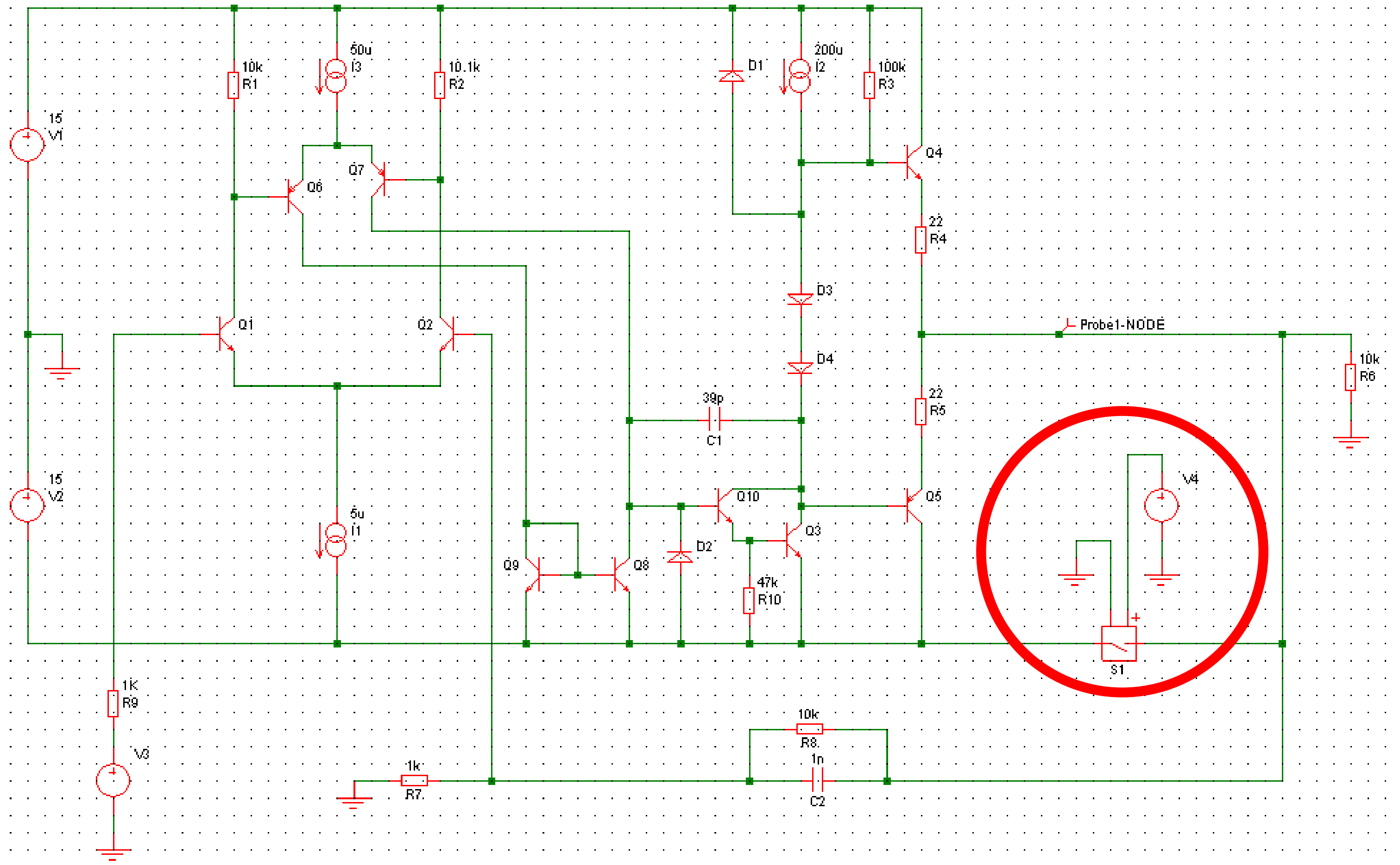
Implementation - Applicability

And if we try with the worst-case pulse . . .



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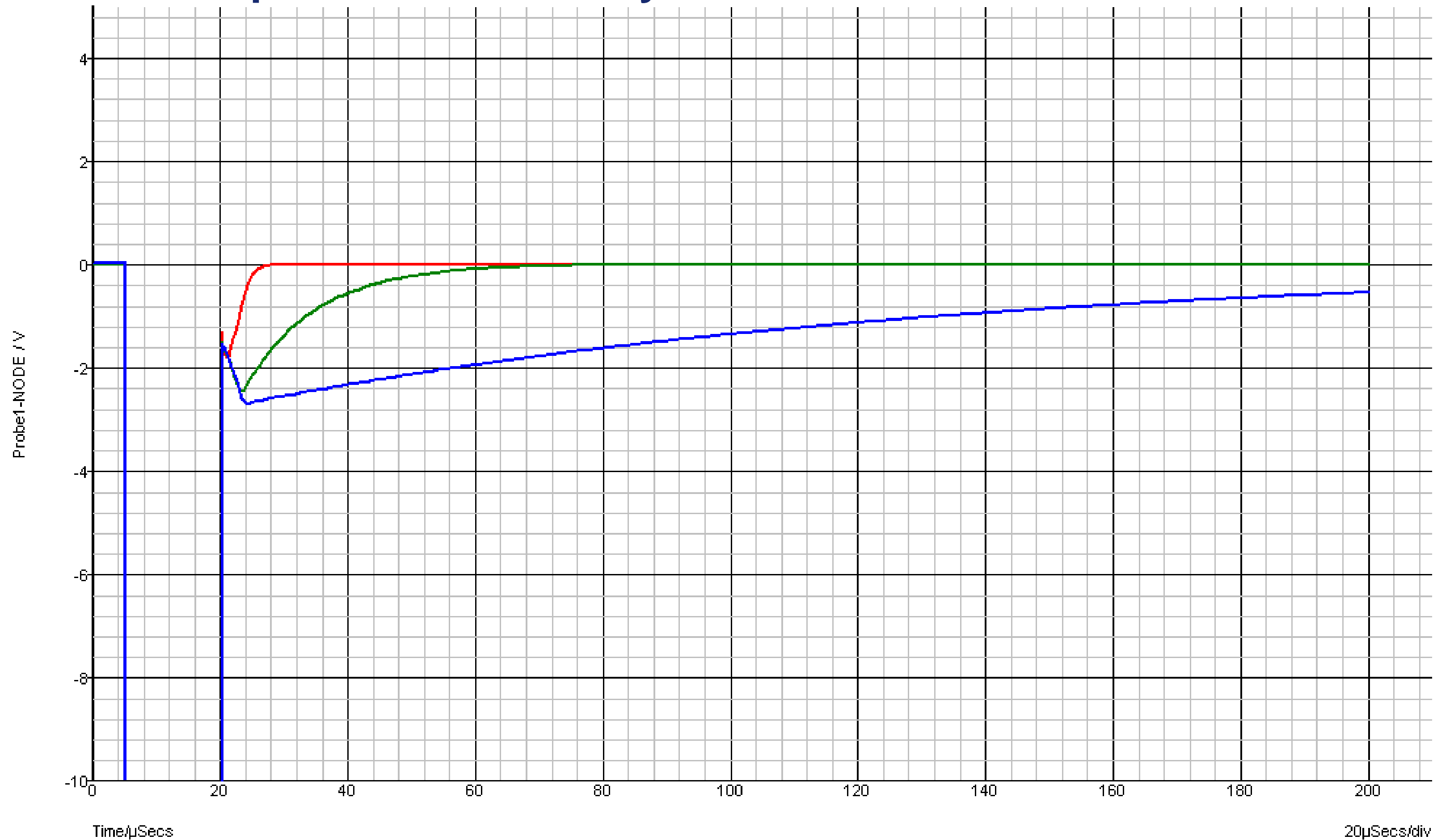
Implementation - Applicability

. . . The response time is nearly the same !



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Advantages - Disadvantages

Advantages - This methodology . . .

- . . . can be applied at the first step of the design flow
- . . . allow substantial saving of SET testing (cost – planning)
- . . . give a sense of responsibility to the electrical designer in SET RHA
- . . . reduce (cancel) the risk of in-flight anomaly

Disadvantages - This methodology . . .

- . . . need to manage the table of worst-case pulses
- . . . need to train the electrical designer to apply it

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Conclusions

The THALES ALENIA SPACE policy for Single Event Transient has been presented . . .

The objective is :

- To analyse the impact of SET in the early stage of the design flow
- To reduce at minimum the number of heavy ions tests
- To improve competitiveness and planning
- To involve the design engineer in SET RHA
- And finally, to cancel the risk of in-flight anomaly

Thank you for your attention . . .

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