Characterization of Single-Event Transients in the LM119 Voltage Comparator

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• DTRA RHM

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Outline

• Introduction
• Comparison of Pulsed-Laser Data, Modeling and Heavy-Ion Data
  – Dependence on Differential Input Voltage
  – Negative vs Positive differential voltages
• Conclusions
SETs in Linear Circuits

• SETs are momentary disturbances in the output voltage following an ion strike to a sensitive node in a circuit.

• SETs have been observed in
  – Voltage comparators (LM111, LM119, LM139)
  – Operational amplifiers (LM124)
  – Hybrids such as DC to DC Converters (2812)
SETs in Linear Circuits

- Depend on Operating Conditions:
  - Power supply
  - Output load
  - Input voltages

- SET Characteristics:
  - Amplitude
  - Width
  - Threshold

\[ \begin{align*}
V_{\text{in}(+)} & \quad \text{LM119} \\
V_{\text{in}(-)} & \quad V_{\text{dd}} \\
& \quad V_{\text{ss}} \\
\end{align*} \]
LM119 Heavy Ion Data

- Testing under limited set of conditions - results may not be applicable to another application

\[ V_{dd}=+15V, \ V_{ss}=-15V \]

Koga et al. 1997
Characterization Approach

To minimize costs of characterizing SET sensitivity of linear circuits, use a canonical set of data:

- heavy-ion tests (Cross-section vs LET and transients waveforms)
- modeling (device and circuit simulator programs)
- ion microprobe (focused beam on known locations)
- pulsed laser (focused beam of light)
LM119 Circuit Diagram

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LM119 Photomicrograph

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SET Sensitive Region for Q6

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SET Sensitive Region for Q10

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Pulsed-Laser Induced Transients

Amplitude (V)

Time (s)

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Pulsed-Laser Induced Transients
Comparison of Transistor Sensitivity to SEE from Pulsed Laser Light and Modeling

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# Pulsed Laser Results

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Heavy Ion Results

LM119

Cross Section (cm²)

LET (MeV.cm²/mg)

Vdd=5V
Vss=-5V
R=1.7 K

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Pulsed Laser Results

Differential Input Voltage (V) vs. SET Amplitude (V)

- Circuit Simulation
- Pulsed Laser Data with Small Qdep
- Pulsed Laser Data with Large Qdep
Pulsed Laser Results

![Graph showing the relationship between SET Amplitude (V) and Differential Input Voltage (V).]
Heavy Ion Results

LET (MeV.cm²/mg)

Cross-Section (cm²)

Vdd = 5V, $V = 4.5V$

Vdd = 5V, $V = 0.12V$

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Heavy Ion Results

LM119

Cross Section (cm$^2$)

LET (MeV.cm$^2$/mg)

Vdd=5V
Vss=-5V
R=1.7 K?

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Conclusions

- There is a wide parameter space for SETs in linear circuits.
- Avoid heavy-ion testing for each condition by doing modeling.
- SPICE modeling requires a significant effort particularly if transistor parameters are not known.
- SET data from a pulsed laser can be used to validate SPICE models in a feedback mode.
- Ion microprobe is a valuable aid because of limitations of laser, i.e. metal coverage and penetration depth of the light.
- Pulsed laser can be used to check unique conditions rapidly.