Comparison of Single Event Transients Induced in an Operational Amplifier (LM124) by Pulsed Laser Light and a Broad Beam of Heavy Ions

LM124
Single Event Transients in LM124

Voltage Follower

Non-Inverting G =11

10K

100K

Presented by S. Buchner at RADECS03 in Noordwijk Holland September 16 2003
New Approach to SET Testing of Linear Devices

• It is expensive and time-consuming to do SET testing for every configuration of:
  – supply voltage,
  – input voltage,
  – gain
  – output loading

• Approach – Use a combination of pulsed laser and modeling to reduce (not replace) the amount of accelerator testing.
Previous Work

• Previous work showed excellent comparisons between ion and pulsed laser-light induced SETs. The results were incomplete because:
  – Ions had low LETs and small ranges, so not all transistors were SET sensitive,
  – metal coverage may have obscured some SET sensitive regions,
  – Laser light had a small penetration depth.
Photomicrograph of LM124

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Comparison of Transients: Pulsed Laser Light and Low LET Heavy Ions

Inverting Configuration:

\[ V_{dd} = \pm 6 \text{ V} \]
\[ V_{in} = 60 \text{ mV} \]
Comparison of Transients: Pulsed Laser Light and High LET Heavy Ions

Voltage follower:
$V_{dd} = +/-15$ V
$V_{in} = 5$ V
Pulsed Laser Data: Q20

![Graphs showing relationship between SET Amplitude and Pulse Width, as well as Output Signal over Time.](image-url)
Pulsed Laser Data: Q20

![Graph showing SET Amplitude vs. Pulse Width and Output Signal vs. Time](image.png)
**Pulsed Laser Data: Q20**

![Graph showing the relationship between SET Amplitude (V) and Pulse Width (µs).](image1)

![Graph showing the relationship between Output Signal (V) and Time (µs).](image2)
Pulsed Laser Data: Q20

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Pulsed Laser Data: Q20

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Pulsed Laser Data: Q20
Pulsed Laser Data: Q20

![Graph of Pulsed Laser Data: Q20](image)

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Pulsed Laser Data: Q20

![Graph showing SET Amplitude and Output Signal vs Pulse Width and Time.]

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Pulsed Laser Data: Q20

[Graph showing the relationship between SET Amplitude, Pulse Width, and Output Signal over time]
Pulsed Laser Data: Q20

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Pulsed Laser Data: Q20

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Pulsed Laser Data: R1

![Graph of SET Amplitude vs. Pulse Width]

- Set Amplitude, V
- Pulse Width, µs

![Graph of Output Signal vs. Time]

- Output Signal, V
- Time, µs

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Pulsed Laser Data: R1

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Pulsed Laser Data: R1

![Graph showing SET Amplitude vs. Pulse Width and Output Signal vs. Time](image-url)
Pulsed Laser Data: Q19

![Graph showing SET Amplitude vs. Pulse Width](image1)

- SET Amplitude, V
- Pulse Width, µs

![Graph showing Output Signal vs. Time](image2)

- Output Signal, V
- Time, µs
Pulsed Laser Data: Q16

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Pulsed Laser Data: All Nodes

![Graph showing SET Pulse Amplitude versus SET Pulse Width](image)

- SET Pulse Amplitude, V
- SET Pulse Width, $\mu$s

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Comparison of Pulsed Laser and Ion Data

• Laser data obtained by focusing light on a transistor and varying deposited energy.

• Ion data obtained by keeping deposited energy constant and vary location.
Low LET Ions and Laser Data

Voltage Follower
$V_{in} = 5.0$ Volts

Active Components:
R1 & Q20 (near C1)
- Laser Data
- Heavy Ion Data

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Moderate LET Ions and Laser

Voltage Follower
$V_{in} = 5.0$ Volts

Active Components:
- R1 & Q20 (all regions)
- Q4, Q5, Q6 & Q9

- Laser Data
- Heavy Ion Data

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High LET Ions and Laser Data
High LET Ions and Laser Data

Non-Inverting Gain = 11
$V_{in} = 0.5$ Volts

Active Components:
- R1 & All Transistors
- Laser Data
- Heavy Ion Data

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Configuration Comparison

- Voltage Follower, $V_{in} = 5$ Volts
- Non-Inverting Gain = 11 Volts, $V_{in} = 0.5$ Volts
High LET Ions 5V and 10V Inputs
Voltage Follower

Voltage Follower
$V_{\text{in}} = 5.0$ Volts

Active Components:
- R1 & All Transistors
- Laser Data
- Heavy Ion Data

Voltage Follower
$V_{\text{in}} = 10.0$ Volts

Active Components:
- R1 & All Transistors
- Laser Data
- Heavy Ion Data

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Phase Space of Concern

Concern if:

- $|V| > 10\,\text{V}$,
- $\Delta t > 20\,\mu\text{s}$

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Summary and Conclusions

• Laser light produces same SETs as high LET ions.
• The good agreement between laser and heavy ion SET shapes suggests that the laser measurements are not limited by the short penetration depth of light or metal coverage.
• Plots of V vs Δt are powerful way of visualizing SETs
• The pulsed laser is a powerful tool for understanding SETs in bipolar linear devices and for helping in reducing the amount of heavy-ion testing by bounding the problem.