Total Dose and Single Event Effects in Commercial PWM's and Gate Drivers

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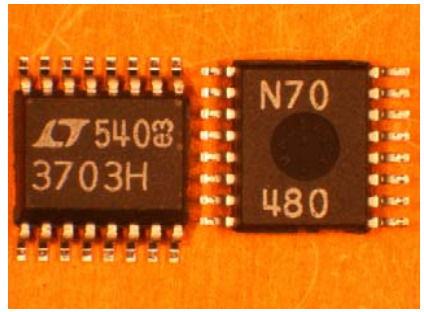
Proposed Study

- TID & SEE Tests of 3 PWM's and 3 Gate Drivers
  - TID; 5 biased & 2 unbiased samples tested
  - SEE; 2 samples tested
  - One device removed from original list
    - LTC3418 /Linear Technology
      - Monolithic synchronous step-down DC/DC converter
      - 38-lead plastic QFN
    - Difficult to maintain proper function after removing plastic
    - TID failure after ~20 krad

Test Samples PWMs

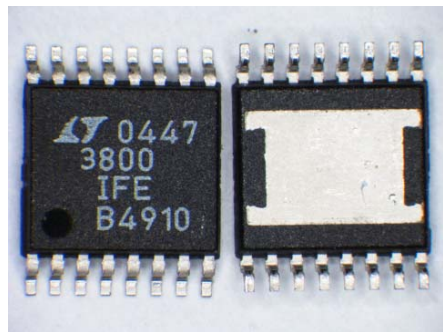
- **2 Pulse Width Modulators**



16-lead thermally enhanced TSSOP

— LTC3703, Linear Technology, BiCMOS

  - switching regulator capable of driving multiple MOSFETS for high current application, soft-start function controlled with 100pF



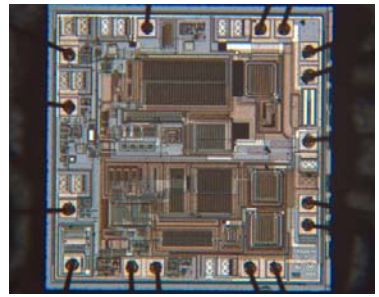
16-lead thermally enhanced TSSOP

— LT3800, Linear Technology, Bipolar

  - fixed frequency high-voltage synchronous current mode step-down switching regulator, soft-start disabled during irradiation

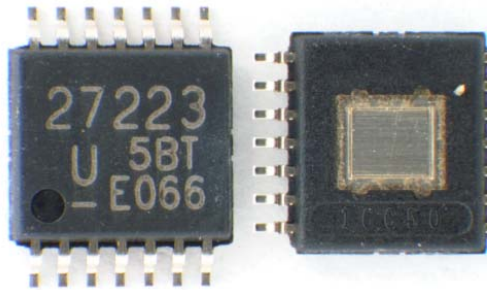
3 Gate Drivers

14-lead SOIC (D-package)

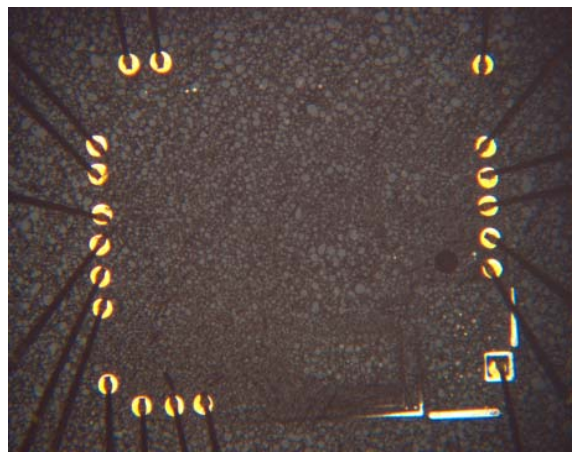


- TPS2834 Texas Instruments, BiCMOS synchronous buck driver

HTSSOP-14



- UCC27223, Texas Instrument, Bipolar high-speed synchronous buck driver with enable function,
  - difficult to prepare for SEE



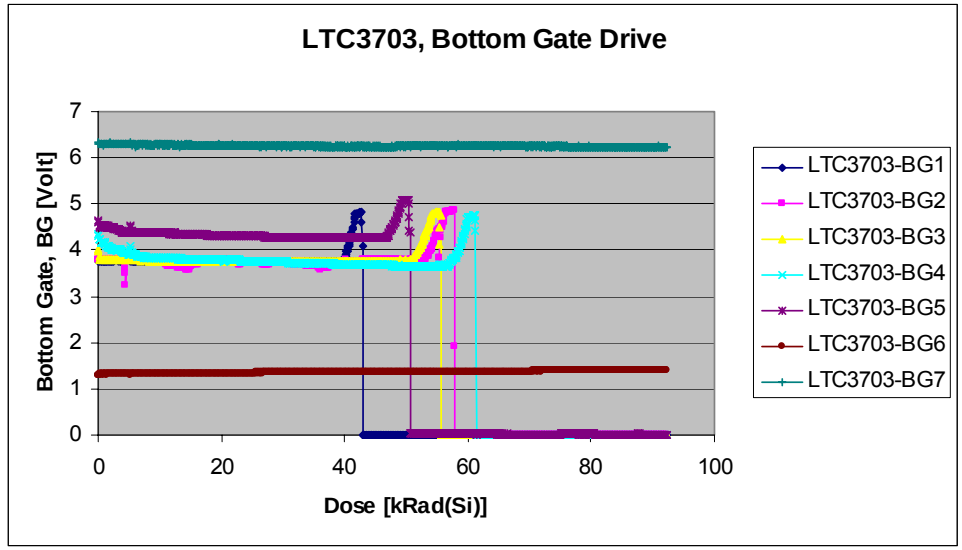
- UCC27423, Texas Instrument, Bipolar dual high-speed synchronous buck driver with enable function.
  - difficult to prepare for SEE

TID Test Results PWMs

➢ **LTC3707 BiCMOS**

Biased; failed ~ 40-60 krad(Si), no recovery during high temperature anneal

Unbiased: no degradation to 80 krad(Si)

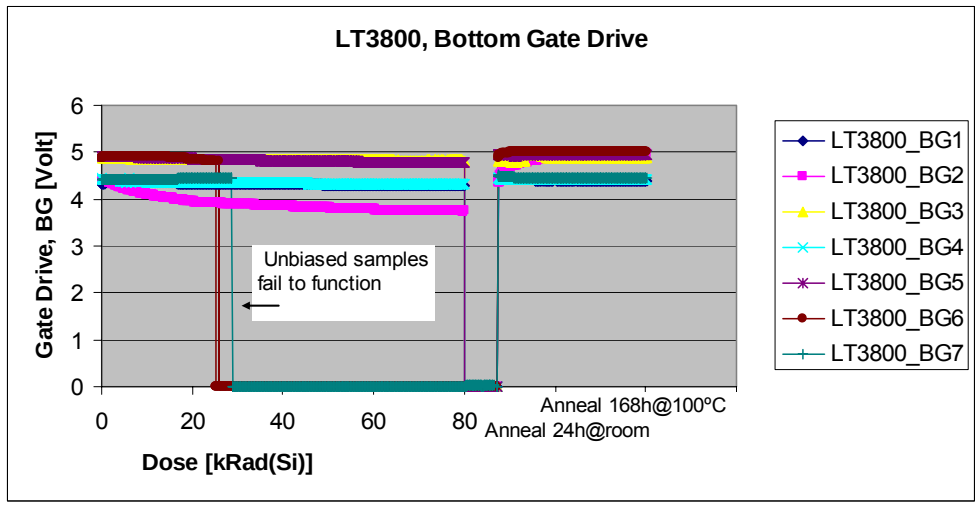


•LT3800 Bipolar

Biased; worked up to 80 krad(Si), fail to start after power-off at end of irradiation

Unbiased; fail to function ~ 25 krad(Si)

Biased & Unbiased samples recovered during high temperature annealing.



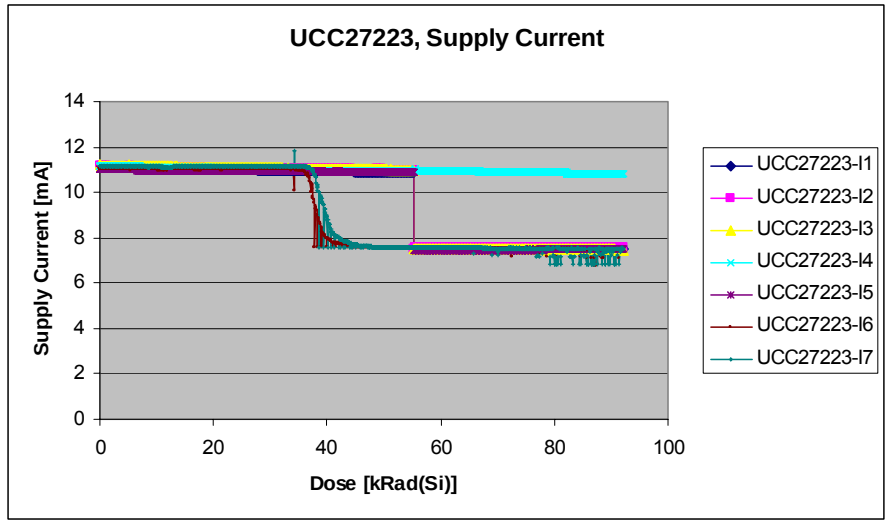
TID Results Gate Drivers

• UCC27223 BiCMOS

Biased; functioning up to 55 krad,
after planned power break,
4 of the 5 samples failed to work.

Unbiased; failed before 40 krad

No samples recovered in high temperature anneal

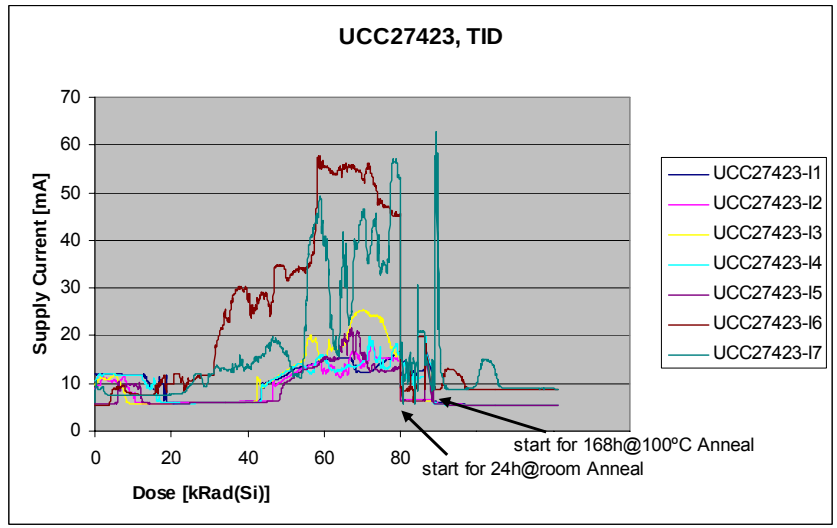


•UCC27423 BiCMOS
(same functions as UCC27223, fewer control possibilities)

Biased; current increase, no failure up to 80 krad

Unbiased; current increase, failure ~75 krad

All samples functioned after anneal



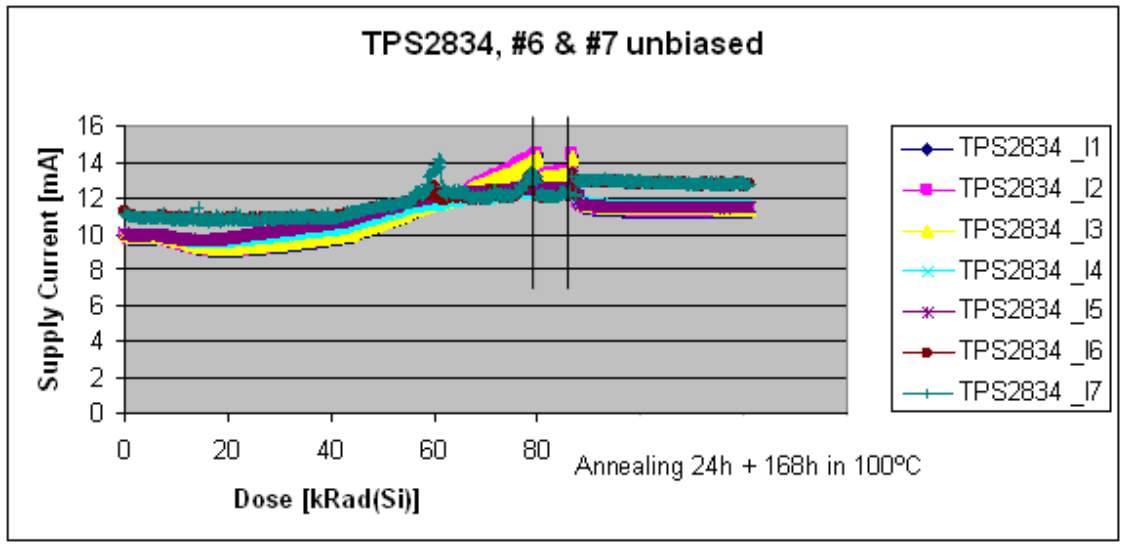
TID Results Gate Drivers

- TPS2834 BiCMOS

Biased; current increase, functioning up to 80 krad

Unbiased; current increase, functioning up to 80 krad

Current recover after high temp anneal



SEE Test Results - Gate Driver

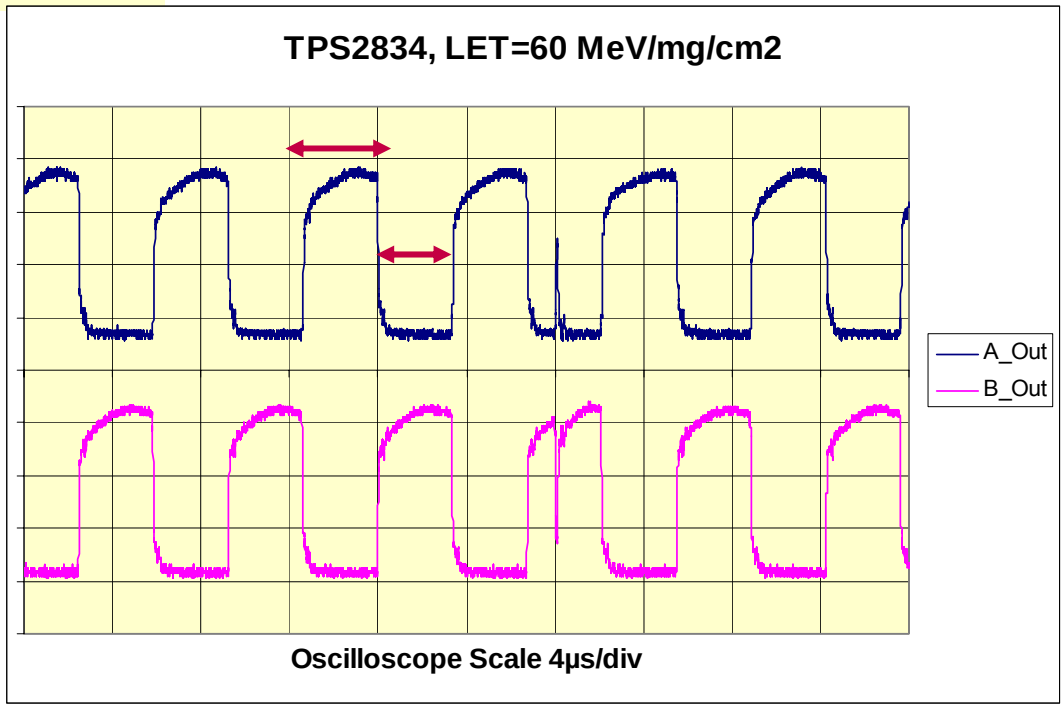
➢ TPS2834

No LU (LET=80 MeV/mg/cm2)

Only very short glitches observed up to LET=80 MeV/mg/cm2

Two outputs; A_out and B_out
Trigger requirements on both
- Too-long ON time
-Too-long OFF time
- Period 6,5µs

Only narrow glitches were detected for TPS2834



SEE Test Results –Gate Driver

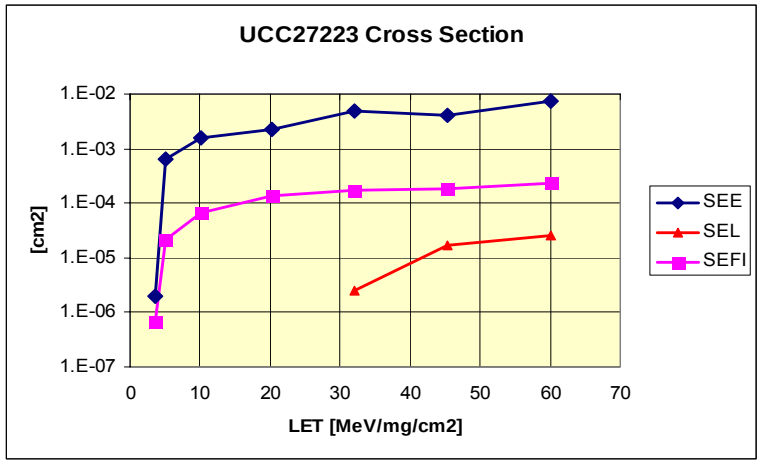
➢ UCC27223

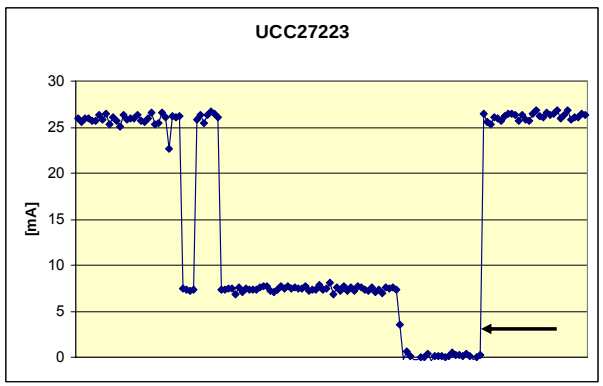
LU observed at LET=32 MeV/mg/cm2

SEFI first detected at LET=3,6 MeV/mg/cm2

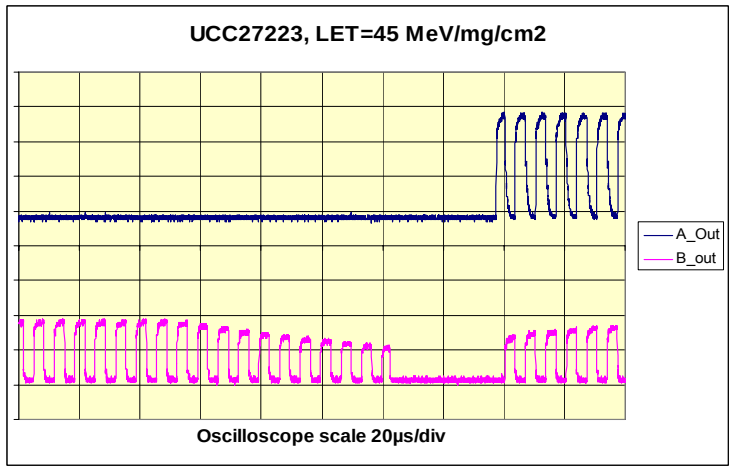
Very SET sensitive with long periods of lost pulses

No “too-long” pulses detected





Current jumps caused by irradiation. The arrow indicates where a reset has been performed by switching off - on the pulse generator to the input



Oscilloscope picture of output A and B showing worse case errors observed during irradiation with Kr-ions tilted at 45° (Let=45.4 MeV/mg/cm2).

SEE Test Results PWM's

- **UCC27423**

No LU observed at LET=80 MeV/mg/cm2

No SET observed at LET=80 MeV/mg/cm2

?

(The devices were really Working)

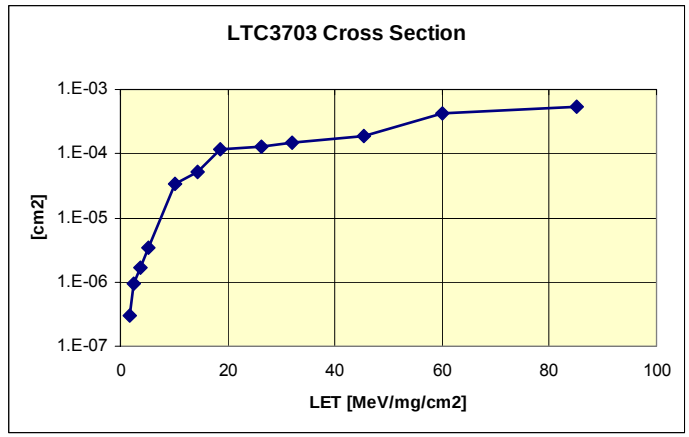
SEE Test Results - PWM

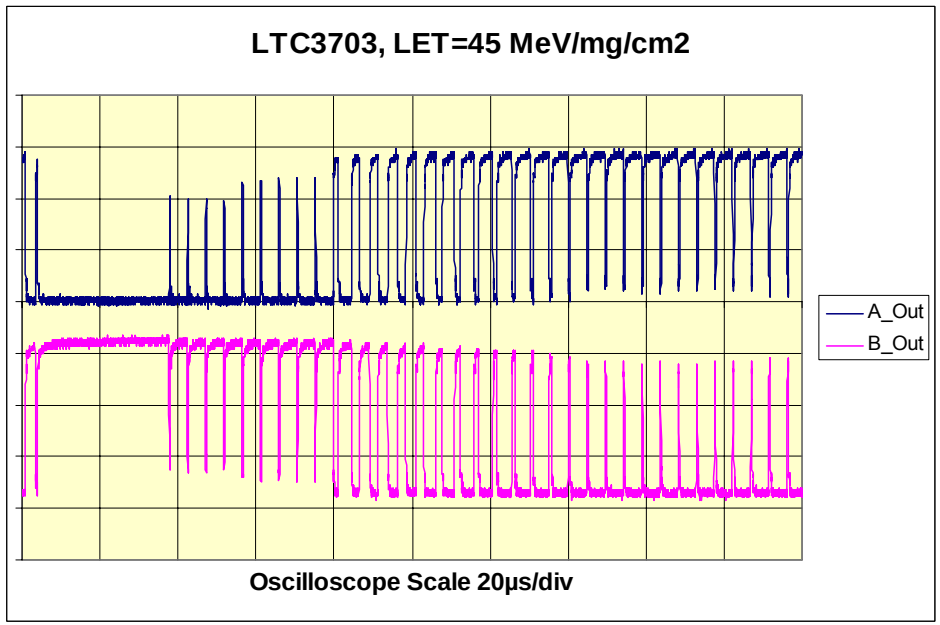
➢ LTC3707

No LU (LET=80 MeV/mg/cm2)

Very SET sensitive with long periods of lost pulses

No “too-long” pulses detected





Typical oscilloscope picture,
data at 82Kr tilted at 45°, similar behaviour observed for 40 Ar (LET=10 MeV/mg/cm2).

The period time for the PWM was 4.6 µs.
oscilloscope triggered on A Out OFF-time criteria too long

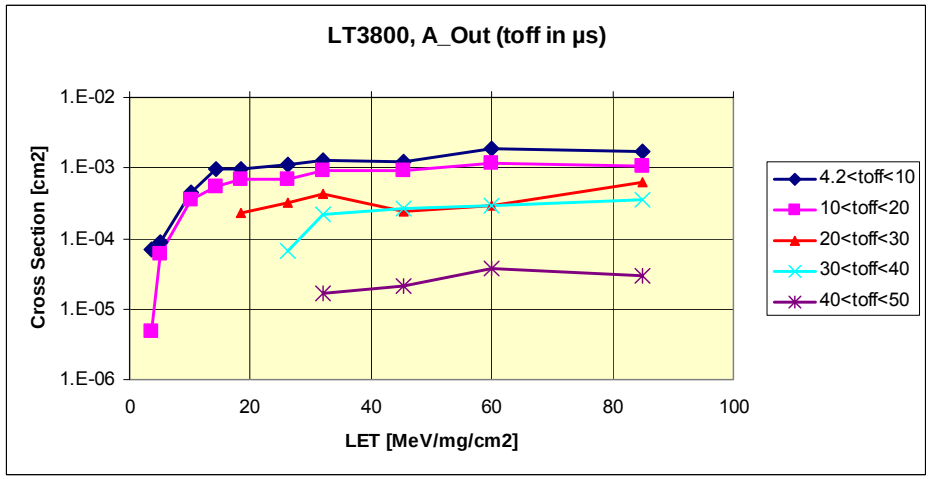
SEE Test Results - PWM

➢ LT3800

No LU (LET=80 MeV/mg/cm2)

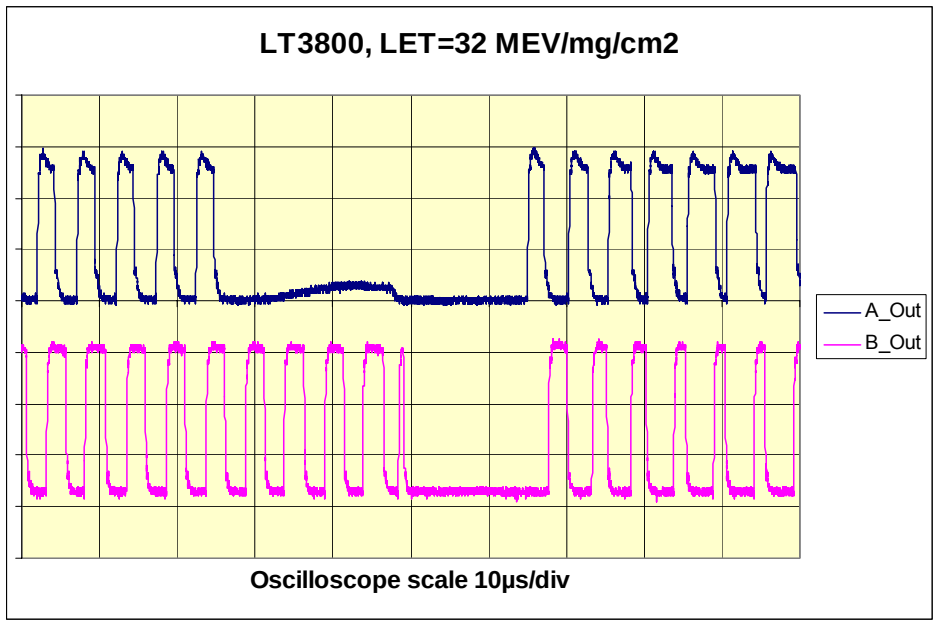
Very SET sensitive with long periods of lost pulses

No “too-long” pulses detected



Typical oscilloscope picture for OFF time too long on output A and B at the same time. Oscilloscope triggered on A Out

The period time for the PWM was 4.8 µs.



Conclusion

- PWM's
  - TID Acceptable for short missions/ low irradiation requirements,
  - SEE Not Acceptable
- Gate Drivers
  - TID reasonable results
  - SEE 2 types showed no/small glitches,
  - 2 "similar" Gate Drivers indicated remarkably different results

Thank You