

Rad-hard Standard Cell Library

Enabling 'Space-Grade' electronics and ultra-low error-rate level-5 autonomous vehicles



Single Event Effects (SEEs), including Single Event Transient (SET) and Single Event Upset (SEU), cause soft errors to electronics systems. For space/satellite and level-5 autonomous vehicles, SEEs need to be addressed to achieve ultra-low error rate (and/or error-free) and ultra-high reliability.

ZES's Rad-hard Standard Cell Library provides a unique set of combinational logic and sequential logic that feature **ultra-low error rate**, yet with **very-low Power, Area and Delay**.

ZES's Rad-Hard Standard Cell Library

- Four pending patents
- 47 Rad-Hard combinational cells @ 65nm CMOS
- 11 Rad-Hard sequential cells @ 65nm CMOS
- Full characterized files for digital design methodology: .lib, .db, .lef, .spec, .v
- SET-free up to LET = 10 MeV.cm²/mg
- Standalone flip-flop with SEU error rate @ GEO 4.6×10^{-10} error/bit/day
- Redundancy flip-flop with SEU error rate @ GEO 1.0×10^{-13} error/bit/day
- Latchup-free up to LET = 50 MeV.cm²/mg
- Total-Ionizing-Dose-free up to 100 Krad(Si)

22nm FD-SOI will be available soon

❑ **Advantage (Power x Delay x Area x Error-Rate) over state-of-the-art: ~3.3x**

Table I: Comparison

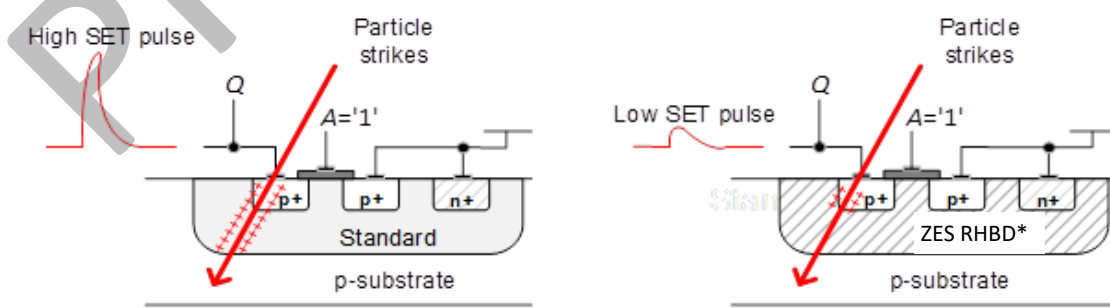
D Flip-Flop	Power (P), μW/100MHz	Delay (D), ps	Area (A), μm ²	Error-Rate, 10 ⁻¹⁰	Normalized PxDxA	Normalized PxDxAxE
RH Trans. Gate	12.9 (2.58x)	83 (0.66x)	45.6 (1.92x)	4.6 (1.00x)	3.27x	3.27x
RH DICE version 1 *#	6.6 (1.32x)	249 (1.99x)	30.1 (1.26x)	4.7 (1.02x)	3.31x	3.38x
RH DICE version 2 *#	6.6 (1.32x)	193 (1.54x)	37.4 (1.57x)	4.7 (1.02x)	3.19x	3.26x
ZES Design	5.0 (1.00x)	125 (1.00x)	23.8 (1.00x)	4.6 (1.00x)	1.00x	1.00x

* The metal 2/3 layers are required, otherwise the area cost will increase.

The critical-node pairs in DICE are not floor-planned apart (hence compromising the DICE hardness), otherwise the area cost will increase.

(LETh) Linear Energy Transfer Threshold, simulated using Silvaco Smartspice tool

Error/bit/day simulated using CRÈME 96 tool (GEO orbit @ solar quiet, Shielding 100mils Aluminium, ions up to element=92)



Standard Method (high error-rate)

ZES Method (low error-rate)

* With layout, novel transistor configuration and sizing (patent-pending)