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Summary of Proton Test on the Actel

RT54SX16 Prototype at Indiana University

June, 1998

Prepared by: R. Katz, NASA/GSFC

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Test Facility

The Actel RT54SX16 prototype FPGA was tested at the Indiana University Cyclotron Facility (IUCF). The proton energy was 193 MeV and the flux was set at approximately 1 x 10^9 p/cm^2/sec. The total fluence for each device was determined by the total dose response of the device and it's affect on the current draw; details for each device including bias are given in the chart below. The device was irradiated normal to the beam.

Device Under Test

The devices were in a PQFP208 package and were active during irradiation. Upsets and currents were monitored in real-time with the device being clocked at 1 MHz. The stimulation pattern was a 500 kHz square wave. The test pattern used contains 400 flip-flops. The RT54SX16 architecture only has hard-wired flip-flops with the available software; there are no I/O module flip-flops.

Sample devices were taken from a prototype lot, and $I_{DDSTDBY}$ currents were normal, just a few hundred microamps. The "p-fuse" was programmed on these devices and the TCK pin (an input to the IEEE 1149.1 JTAG TAP controller) was not active for runs with S/N MKJ1 and MKJ2; it was active at 6 kHz for MKJ3. The date code was 9733 with the chip also marked as PO6GNC WFR #7,8.

Test Results

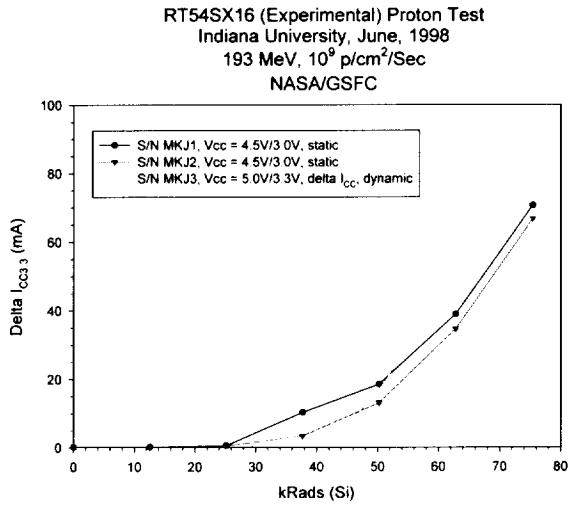
The following table summarizes the device, bias conditions, and irradiations.

S/N	Lot	TCK	Bias (Volts)	Total Dose kRads (Si)	Upsets	Fluence (p/cm^2)
MKJ1	Prototype D/C 9733	Off	4.5/3.0	75.4	2	1.2 x 10^{12}
MKJ2	Prototype D/C 9733	Off	4.5/3.0	75.4	4	1.2 x 10^{12}
MKJ3	Prototype D/C 9733	6 kHz	5.0/3.3	103.1	2	1.6 x 10^{12}

Three devices were irradiated, two with worst-case biases of 4.5V and 3.0V and the other with a nominal biases of 5.0V and 3.3V. An estimate of the cross-sections can be computed as 6.3 x 10^{-15} cm^2/flip-flop at the worst-case voltage and as 3.1 x 10^{-15} cm^2/flip-flop at nominal supply voltages. Obviously, with the low error counts, more devices would be needed to get an accurate cross-section.

There was no clock upset detected in any of the devices and no upsets were detected in the JTAG TAP controller.

The device's total dose performance was good, falling into the rad-tolerant range. The curves for S/N MKJ1 and S/N MKJ2 are made by plotting static currents at the end of each proton run, with the symbols representing each step. The curve for S/N MKJ3 is the delta current recorded during the run. The dose rate was high at about 250 kRads (Si) / hour. Only moderate (< 1.5 mA) changes in the 5V bias currents were observed for S/N MKJ1 and S/N MKJ2. For S/N MKJ3, which had the higher total dose, the 5V bias current increased to 1.1 mA after 67 kRads (Si) and to 8.1 mA after 103 kRads (Si). Note that further experiments on this part type has shown lot splits with > 100 kRads (Si) total dose capability.



Summary of Proton Test on the Chip Express

QYH530 at Indiana University

June, 1998

Prepared by: R. Katz, NASA/GSFC

Date: June 17, 1998

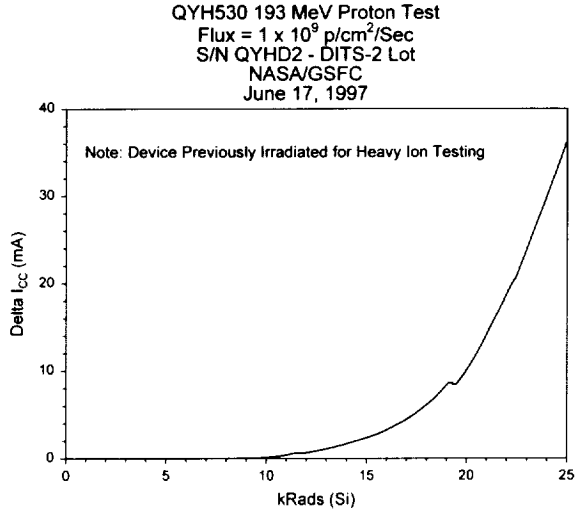
Test Facility

The Chip Express QYH530 was tested at the Indiana University Cyclotron Facility (IUCF). The proton energy was 193 MeV and the flux was set at approximately 1 x 10^9 p/cm^2/sec. The total fluence for each device was determined by the total dose response of the device and it's affect on the current draw; details for each device including bias are given in the tables below. The device was irradiated normal to the beam.

Device Under Test

The devices were in a PGA180 package and were active during irradiation. Upsets and currents were monitored in real-time with the device being clocked at 1 MHz. The stimulation pattern was a 500 kHz square wave. The test pattern used contains 1200 flip-flops. The QYH500 architecture only has routed flip-flops; there are no hard-wired or I/O module flip-flops.

Sample devices were taken from two lots, a "DITS-2" flight lot and a production lot used for shielding experiments; no radiation shields were used on any of the devices in this test. All devices were processed with Chip Express' One-Mask technology with no laser programmed devices tested during these runs. These devices had already been subjected to heavy ion tests at Brookhaven National Laboratory.



Test Results

The following table summarizes the device, bias conditions, and irradiations.

S/N	Lot	Bias (Volts)	Total Dose kRads (Si)	Upsets	Fluence (p/cm_2)
QYHD1	DITS-2	4.5	18.9	0	0.3×10^{12}
QYHD2	DITS-2	3.3	25.1	0	0.4×10^{12}
QYHD3	DITS-2	3.3	25.1	0	0.4×10^{12}
QYH55	LOT OF 70	3.3	25.1	0	0.4×10^{12}
QYH56	LOT OF 70	3.3	25.1	0	0.4×10^{12}

Five devices were irradiated, one with a 4.5V bias and four with a 3.3 bias with no upsets for all of the runs. An estimate of an upper bound for the cross-sections can be computed, assuming a single upset, as 0.5×10^{-15} cm^2/flip-flop. There was no clock upset detected in any of the devices.

The device's total dose performance was good, even though the devices had been previously irradiated. Nevertheless, the following table and figure shows radiation-tolerant performance. The dose rate was high at 216 kRads (Si) / hour.

Table 1. Static current after each run in mA.

Note: Devices previously irradiated with heavy ions.

	6.3 kRads (Si)	12.6 kRads (Si)	18.8 kRads (Si)	25.1 kRads (Si)
QYHD1	0	1.7	31.6	
QYHD2	0	0.6	8.5	35.9
QYHD3	0	0.0	7.3	32.9
QYH55	0	0.2	5.1	25.5
QYH56	0	0.0	3.3	23.3