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### Summary of Proton Test on the Actel RH1020 at

#### Indiana University

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Revision A.

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#### Test Facility

The Actel RH1020 was tested at the Indiana University Cyclotron Facility (IUCF). The proton energy was 193 MeV and the flux was set at approximately  $1 \times 10^9$  p/cm<sup>2</sup>/sec. The total fluence for each device was  $1.6 \times 10^{12}$  p/cm<sup>2</sup> corresponding to a total dose of 100 kRads (Si); 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 CQFP84 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. Since the devices are quite hard to total dose effects, the test equipment was run in an SEU time-tagging mode to aid in the detection and instrumentation of clock upsets. The test pattern used, TMRA1BRB, contains 136 flip-flops with 102 in a TMR configuration and 34 in a shift register. The Act 1 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 "pre-production" lot and a production lot. In this case, the difference between the devices were an improved clock buffer for 'clock upset' (production lot) and the thickness of the antifuses, with the production devices having a 90Å thick antifuse and the pre-production devices having a 96Å thick antifuse.

#### Test Results

The table included below summarizes the device, bias conditions, and irradiation.

Five devices were irradiated with a 5V bias and three with a 4.5 bias with a total of 3 upsets for all of the runs. The cross-sections can be estimated as  $1.8 \times 10^{-15}$  cm<sup>2</sup>/flip-flop at V<sub>CC</sub> = 5V and  $1.5 \times 10^{-15}$  cm<sup>2</sup>/flip-flop at V<sub>CC</sub> = 4.5VDC. Obviously, with the small error counts, the statistics are poor, and it would be expected that the device would have a larger cross-section at the lower bias level.

There was no evidence of any clock upset in either the pre-production devices or the hardened production lot.

The device's total dose performance was excellent, with changes of currents not exceeding more than a few hundred microamps. This also shows, as expected, no antifuse damage. Previous testing has shown that at LET = 37 MeV-cm<sup>2</sup>/mg, a bias of 6.1 volts was necessary to rupture a production device (two samples tested). Note also that these devices had already been previously irradiated during heavy ion tests.

S/N	Lot	Bias (Volts)	Total Dose kRads (Si)	Upsets	Fluence (p/cm <sup>2</sup> )
RH3	Production	5.0	100	0	$1.6 \times 10^{12}$
RH4	Production	5.0	100	0	$1.6 \times 10^{12}$
RH6	Production	5.0	100	2	$1.6 \times 10^{12}$
RH1095	Pre-Production	4.5	100	0	$1.6 \times 10^{12}$
RH1098	Pre-Production	4.5	100	1	$1.6 \times 10^{12}$
RH1099	Pre-Production	5.0	100	0	$1.6 \times 10^{12}$
RH1101	Pre-Production	5.0	100	0	$1.6 \times 10^{12}$
RH3769	Pre-Production	4.5	100	0	$1.6 \times 10^{12}$