Goddard Space Flight Center

GSFC NASA ADVISORY

1. Advisory Number	2. Subject
NA-GSFC-2004-08	Testing of Actel SX-A and RTSX-S Programming Algorithms.

3. Manufacturer	4. Manufacturer CAGE Code	5. Federal Stock Code
Actel Corporation 2061 Stierlin Court Mountain View, CA 94043-4655	0J4Z0	N/A

6. Part/Material/Process Number	7. Lot Date Code/Batch Code/Serial Number	8. Controlling Spec/Document Number
RT54SX32S; RT54SX72S; A54SX32A; A54SX72A	All from MEC production lots	Various

9. References
NA-GSFC-2004-06 Actel RTSX-S and SX-A Programmed Antifuses; More references on pages 3 and 4.

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11. Problem Description and Details: *(Continued on pages 2, 3, and 4)*

NA-GSFC-2004-06 covered the eleven confirmed programmed antifuse failures in the SX-A and RTSX-S series Actel FPGAs, built in the 0.25 µm MEC/Tonami process and were either programmed with hardware that subsequently failed calibration, or operated in an out-of-specification or unknown electrical environment. No programmed antifuse failures have been reported with 0.22 µm SX-A or eX series devices.

Actel Corporation has developed and completed qualification of a new programming algorithm for the SX-A and RTSX-S devices built in the 0.25 µm MEC/Tonami process, which has been released in May, 2004. Their internal testing has, to date, produced no detected failures in over 800 devices. It is noted that devices programmed with the old programming algorithm and subjected to the same electrical environment, failed at a rate of approximately 2.5%. The new programming algorithm has been released in the updated software revision starting with 4.44.0 (Windows) and 3.81 (DOS).

An "Industry Tiger Team," led by The Aerospace Corporation, will evaluate RTSX-S series devices programmed with the old algorithm. This approach is dictated by Aerospace Corporation management and is based on certain programs' desire to rationalize using existing hardware "as is."

In light of the above, the NASA Office of Logic Design (OLD) will evaluate RTSX-S series devices programmed with Actel's new algorithm. This independent NASA activity is endorsed and sponsored by the NASA Engineering and Safety Center (NESC).

12. Actions Recommended:

1) Actel has released and recommends use of a new programming algorithm for the SX-A and RTSX-S devices built in the 0.25 micron MEC/Tonami process. Users must note that the qualification program was conducted at high temperatures only and that comprehensive temperature data is not yet available. NASA will produce a comprehensive data set, including both cold (-55 degrees C.) and hot (+125 degrees C.) temperatures, under the sponsorship of the NASA Engineering and Safety Center (NESC). Test devices will consist of 300 RTSX-S 0.25 µm MEC devices and 300 RTSX-SU 0.25 µm UMC devices. For further information, contact Rich Katz or your resident FPGA expert.

2) Users retain the option of using the old programming algorithm by not upgrading their software and must note that there are a significant number of programmed antifuse failures that are under investigation (Reference: NASA Advisory NA-GSFC-2004-06).

3) All relevant personnel must also review NA-GSFC-2004-06, and the documents referenced, to ensure that all specifications, manufacturer's guidance, and good engineering practices are **always** followed and conservative design practices employed.

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16. Released by: ***(Signature)***
Original signed by
GSFC NASA Advisory Coordinator

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Performance Comparison of Old vs. New Programming Algorithms, A54SX72A-PQ208 (Actel internal testing results)

A comparative evaluation of old and new algorithms has been made by subjecting devices to a "dirty burn-in" test. A dirty burn-in environment is defined as a set of operating conditions in violation of the manufacturer's specification. Specifically, these conditions are as follows:

- Approximately 20 I/O's toggled simultaneously with an undershoot of -1.1V (absolute maximum specification of -0.5V).
- Maximum Recommended Operating Conditions
  - Temperature of 125 °C
  - V_{CCA} of 2.75V
  - V_{CCI} of 5.25V
- Test vehicle is the A54SX72A-PQ208, built in the 0.25 µm MEC/Tonami process.

The results with old programming algorithm are as follows:

- 16 out of 623 devices failed during the first 168 hours of test. All failures isolated to single programmed antifuse failures.
- 225 devices continued on to complete a total of 500 hours of test with no additional failures detected.

The results for the new programming algorithm are as follows, at the time of this writing. Note that the tests are cumulative, with 705 devices total in test, with different batches started at different times.

- 5 different production shippable A54SX72A wafer lots were used, with a minimum of 100 parts per lot.
- 705 devices completed 500 hours of test.
- 605 devices completed 1,000 hours of test.
- No failures have been detected.

Testing of RTSX-S Series Devices Programmed with the New Algorithm (Actel internal testing results)

RT54SX32S

- Approximately 20 I/O's toggled simultaneously with an undershoot of approximately -2.0V (absolute maximum specification of -0.5V).
- Maximum Recommended Operating Conditions
- Temperature of 125 °C
- V_{CCA} of 2.75V
- V_{CCI} of 5.5V
- The test vehicle is the RT54SX32S-CQ208 built in the 0.25 µm MEC/Tonami process.
- 0 failures were detected out of 100 devices at 1,000 hours

RT54SX72S

- Approximately 20 I/O's toggled simultaneously with an undershoot of approximately -2.0V (absolute maximum specification of -0.5V).
- Temperature = 150 °C (125 °C is the maximum recommended operating condition)
- V_{CCI} = 5.5V (Maximum recommended operating condition)
- V_{CCA} = 2.75V (Maximum recommended operating condition)
- 0 failures were detected out of 102 devices at 184 hours.

NASA Independent Test and Evaluation

An "Industry Tiger Team," led by The Aerospace Corporation, will evaluate RTSX-S series devices programmed with the old algorithm. This approach is dictated by Aerospace Corporation management and based on certain programs' desire to rationalize using existing hardware "as is." In light of this, the NASA Office of Logic Design will evaluate RTSX-S series devices programmed with Actel's new algorithm. This independent NASA activity is endorsed and sponsored by the NASA Engineering and Safety Center. Three hundred RT54SX32S-CQ208 (0.25 µm MEC) devices will be tested, all configured with the new programming algorithm. Aerospace Corporation-led testing will comprise 1,150 devices of the same type, all configured with the old programming algorithm. NASA OLD will also test 300 RT54SX32SU-CQ208 (0.25 µm UMC) components. Both NASA OLD and Aerospace Corporation test environments will be harsher than Actel's "dirty burn-in" test conditions, with electrical stress applied via simultaneous switching outputs, simultaneous switching undershoot, and excessive V_{CCA} noise, at increasingly severe levels. Additionally, the NASA OLD test will include both hot and cold temperature stresses.

Heavy ion SEE testing will be conducted.

Programming Algorithms: Outlook

The new programming algorithm has passed internal qualification at Actel and is utilized in the updated software revision, which is now released and recommended for use by Actel. Users retain the option of using the old algorithm by not updating their software.

Programming algorithm testing is an ongoing activity at a number of organizations. Presently available data indicates a significant improvement in robustness of programmed antifuses has been achieved by utilizing the new algorithm. An examination of antifuse stress levels, as tabulated in the Appendix, suggests that the RTSX-S series devices programmed with the new algorithm will also exhibit increased robustness -- consistent with preliminary RT54SX32S and RT54SX72S testing -- where no failures have been detected to date.

It is recommended that users continue to follow test developments closely, in particular the independent NESC-sponsored evaluation of the new programming algorithm.

Software Version Information

The new programming algorithm for SX-A and RTSX-S series FPGAs, built in the 0.25 µm MEC/Tonami process, is incorporated in software versions starting with 4.44.0 (Windows) and 3.81 (DOS).

Appendix: Antifuse Stress

One measure of antifuse stress, for this class of device, is the ratio of the peak operating current through the antifuse to the programming current through the antifuse. Since absolute values are the manufacturer's proprietary information, the chart below contains normalized values. It is seen that the highest stress device is the A54SX72A and the lowest stress device is the RT54SX72S. In general, the RTSX-S series devices, which incorporate series resistors at the output of each R-Cell and C-Cell, have lower stress levels than their commercial/military SX-A counterparts. This data is for devices built in the 0.25 µm MEC/Tonami process.

Table 1
Normalized $I_{OPERATING}/I_{PROGRAMMING}$
0.25 µm MEC/Tonami process

	'32	**'72**
SX-A	0.94	1.00
SX-S	0.82	0.79

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