Radiation Pre-Evaluation of FPGA

ESA Contract 11407/NL/MV/CCN-3, COO-1

ESA_QCA991102T_C , Influence of TID Test Condition on Actel A1425A
ESA_QCA9911TS_C , Radiation Evaluation of Actel 54SX16 and A14100A
ESA_QCA991101T_C , TID and LU Tests of A1020B

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Saab Ericsson Space

Radiation Pre-Evaluation of FPGA
ESTEC / QCA Final Presentation Day 2000-01-26

Work Performed Under This Contract

- **Design and Manufacturing of Test and Control Boards , 40 MHz**
- **Evaluation of Dynamic Test Conditions Using A1425A as Test Vehicle**
- **Radiation Evaluation of Actel 54SX16 and A14100A**

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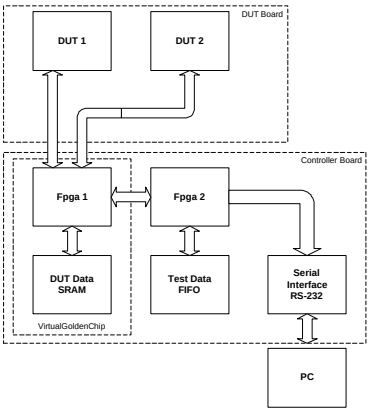
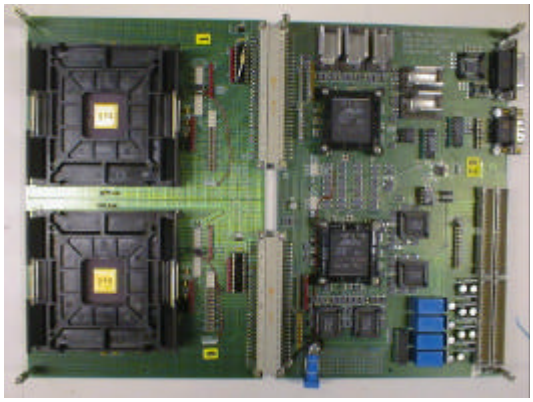
Test Board

Controller board testing one DUT at a time

using a "virtual golden chip" test method





Radiation Response vs Test Conditions
Actel A1425A

Is It Relevant to Perform Steady State TID Tests on Parts Operating in Dynamic Modes ?

Actel A1425A Test Vehicle

"Static Mode"- **Samples biased, unclocked**

"50% Dynamic" - **Samples biased, toggled unclocked/ clocked for 64 clock pulses at 20 MHz**

"100% Dynamic" - **Samples biased, clocked at 20 MHz 100% of the time**

Radiation Response vs Test Conditions
Actel A1425A

Test Methods

- **4 Samples for each mode irradiated to 30 krad**
- **In-Situ Standby Current and Function Measurements**
- **Pre- and Post Irradiation Parameter Measurements**

1) "Static Mode"
2) "50% Dynamic"
3) "100% Dynamic"

- **DUT in static mode for 1 minute, measurement of standby current**
- **DUT Off 10 sec**
- **DUT On, function test at 20 MHz**
- **DUT irradiated for 30 minutes**

TEST PARAMETER	TEST CONDITIONS
Icc	Vcc = 5,0 V
Functionality	f_{CLK} =20 MHz
Input current low , I_{il}	Vin = 0,3 V,
Input current high , I_{ih}	Vin = 5,0 V,
Voltage output low , V_{ol} (CMOS)	Vcc = 5,0 V, Output current = 6.0 mA
Voltage output high , V_{oh} (CMOS)	Vcc = 5,0 V, Output current = -6.0 mA
Timing = delay of signal between two I/O pins	Vcc = 5,0 V, Threshold = 1,5 V

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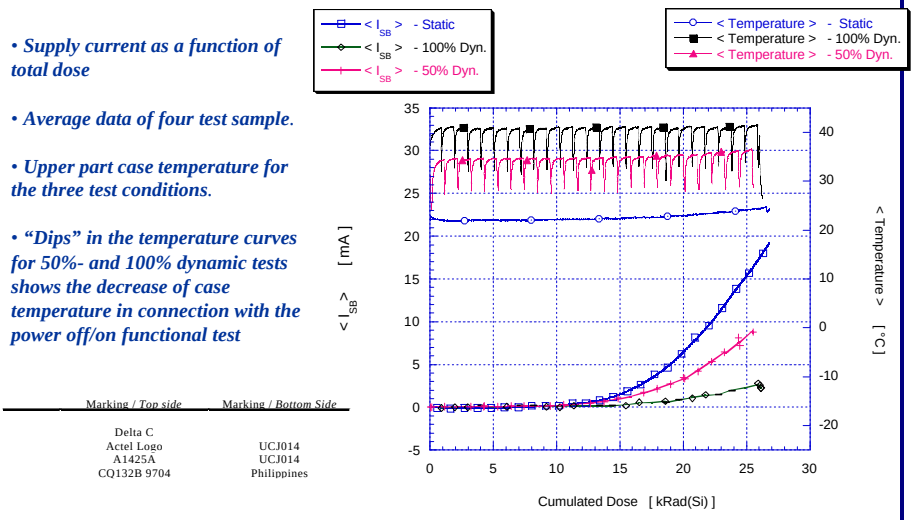
ESTEC / QCA Final Presentation Day 2000-01-26

Radiation Response vs Test Conditions
Actel A1425A

- ***Supply current as a function of total dose***
- ***Average data of four test sample.***
- ***Upper part case temperature for the three test conditions.***
- ***"Dips" in the temperature curves for 50%- and 100% dynamic tests shows the decrease of case temperature in connection with the power off/on functional test***

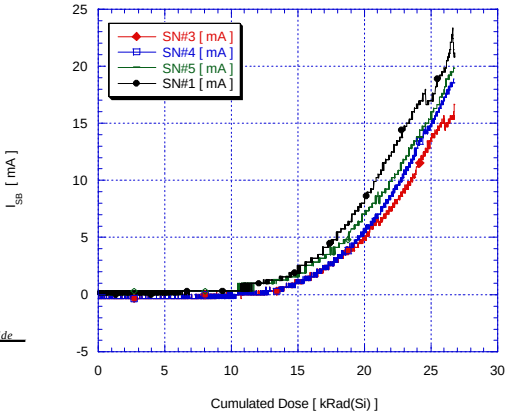


Marking / *Top side*	Marking / *Bottom Side*
Delta C Actel Logo A1425A CQ132B 9704	UCJ014 UCJ014 Philippines

Radiation Response vs Test Conditions
Actel A1425A

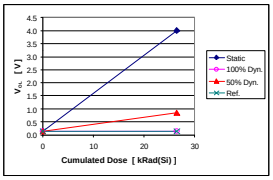
- ***Supply current as a function of total dose for the static conditions.***
- ***Spread representative for all test conditions***

Marking / *Top side*	Marking / *Bottom Side*
Delta C Actel Logo A1425A CQ132B 9704	UCJ014 UCJ014 Philippines

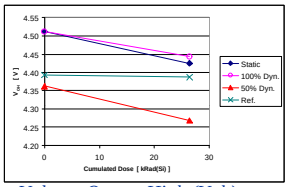


Radiation Response vs Test Conditions
Actel A1425A, Parameters

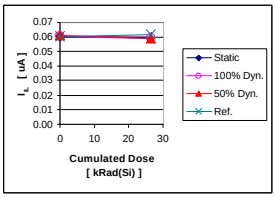
Pre- and Post Electrical Measurements
Average values over 4 samples



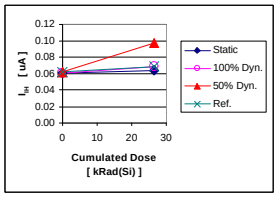
Voltage Output Low (Vol)



Voltage Output High (Voh)



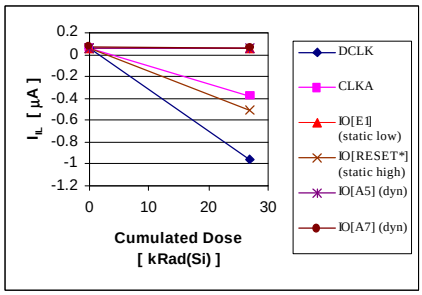
Input Current Low (Iil)



Input Current High (Iih)

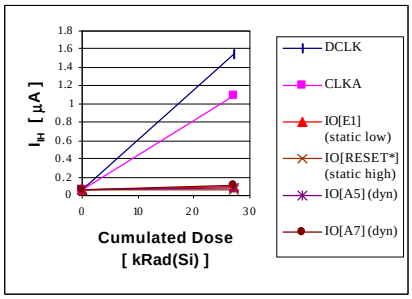
Radiation Response vs Test Conditions
Actel A1425A, Parameters

Pre- and Post Electrical Measurements



Input Current Low (Iil)

50% Dynamic test,
6 different I/O's



Input Current High (Iih)

50% Dynamic test,
6 different I/O's

Summary of A1425A TID Tests

Conclusion from the A1425A TID tests

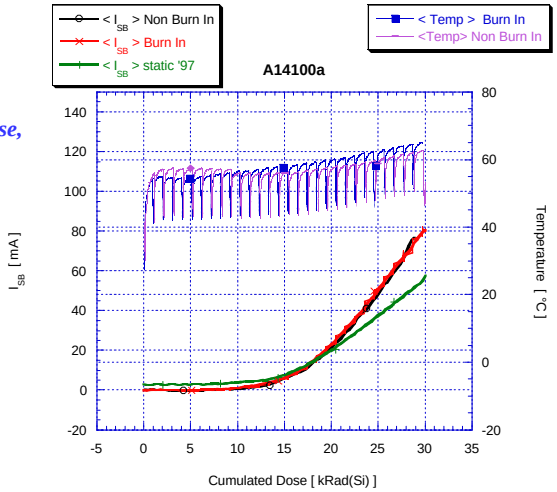
- Onset of increase in Standby Current about the same for Static and 50% Dynamic Tests, a little higher for 100% Dynamic

- 100% (and 50%) Dynamic Tests Result In Higher TID Tolerance, within spec at 30 krad(Si

TID tests of Actel A14100A
50% Dynamic mode

A14100A TID Tests

- *Standby Current vs Cumulated Dose, average of 4 samples for burn-in / non burn-in*
- *20 MHz, 50% Dynamic mode + earlier results from static test*
- *Right scale, Case Temperature, power Off/On every krad(Si)*



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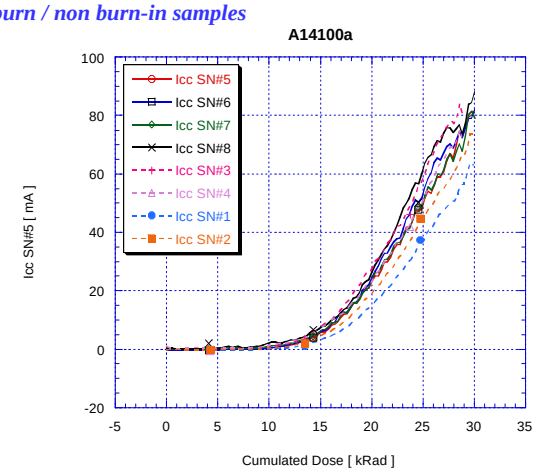
TID tests of Actel A14100A
50% Dynamic mode

A14100A TID Tests

- *Standby Current vs Cumulated Dose burn / non burn-in samples*
- *20 MHz, 50% Dynamic mode*
- *Burn-in samples full drawn lines*
- *Non burn-in samples dashed lines*
- *Right scale, Case Temperature, Power Off/On every krad(Si)*

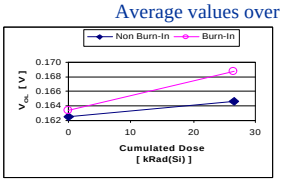


TID tests of Actel A14100A
50% Dynamic mode

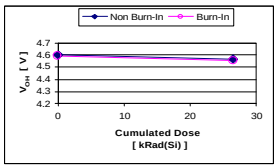
Pre- and Post Electrical Measurements

Average values over 4 samples for burn-in / non burn-in

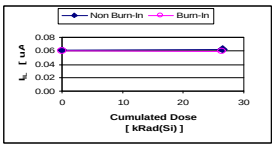
Output Voltage Low (Vol)



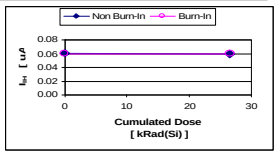
Output Voltage High (Voh)



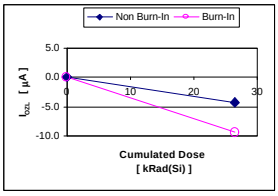
Input Current Low (Iil)



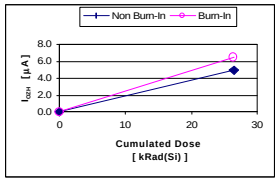
Input Current High (Iih)



Output Tristate Current Low (Iozl)



Output Tristate Current High (Iozh)



Summary of A14100A TID Tests

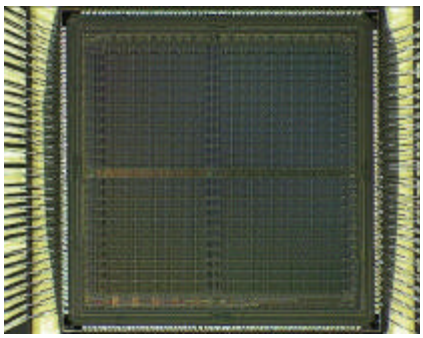
Conclusion from the A14100A TID tests

- The Standby Current is the most sensitive parameter
- Onset of increase in Standby Current about the same for Static and 50% Dynamic Tests
- Spread in current values with cumulated dose seems to be less for samples subjected to Burn-in, however, the shift in parameter values seem to be larger for samples subjected to Burn-in

RT54SX16

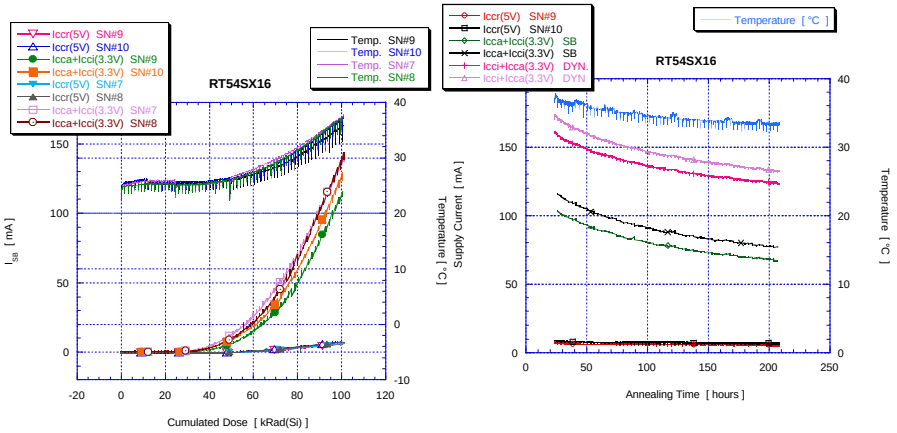
- RT - 0.6µ technology manufactured at Matsushita (MEC)
- 16 - 16000 Gates, metal-to-metal
- Logical modules 1452,
  - R-cells 528
  - C-cells 924, (c-cells only have not been tested)
  - User I/O's 177
- JTAG - not tested
- Up to 160 MHz on-chip performance
- Package 256 CQFP

Chip size 77 x 77 mm



TID tests of Actel RT54SX16
50% Dynamic mode, 20 MHz

- ***Standby Current vs Cumulated Dose of 4 samples,*** ***Room temperature anneal***
- ***Right scale, case temperature***



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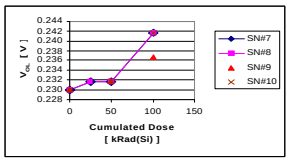
ESTEC / QCA Final Presentation Day 2000-01-26

TID tests of Actel RT54SX16
50% Dynamic mode, 20 MHz

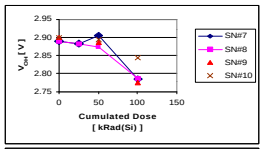
Pre- and Post Electrical Measurements

Average values over 4 samples

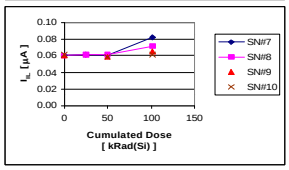
Output Voltage Low (Vol)



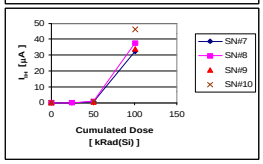
Output Voltage High (Voh)



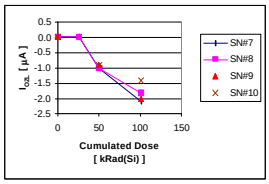
Input Current Low (Iil)



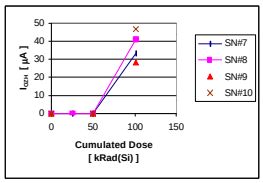
Input Current High (Iih)



Output Tristate Current Low (Iozl)



Output Tristate Current High (Iozh)



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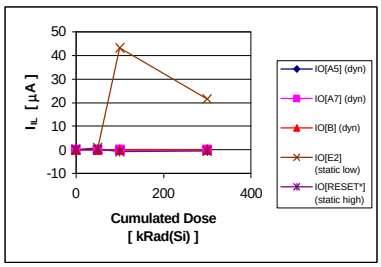
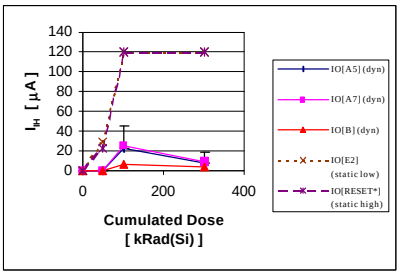
TID tests of Actel RT54SX16
50% Dynamic mode, 20 MHz

Pre- and Post Electrical Measurements



Input Current Low (Iil)

50% Dynamic test,
5 different I/O's



Input Current High (Iih)

50% Dynamic test,
5 different I/O's
Room Temp Anneal included

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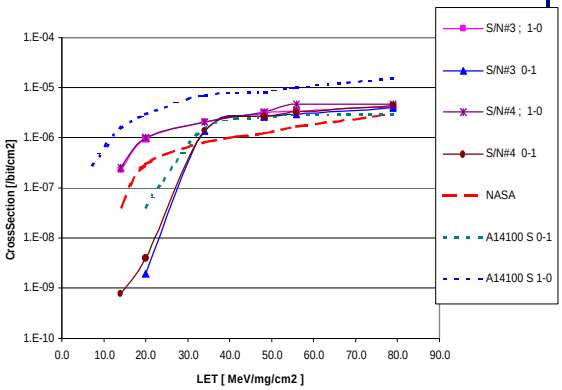
SEU tests of Actel RT54SX16
Heavy Ions

RT54SX16 SEU Tests

- *Ne, Ar, Kr, Xe- ions, 0 and 45 deg*
- *0-1 less sensitive then 1-0*
- *Results similar to A14100A*



Summary of RT54SX16 Tests

Conclusion From the RT54SX16 Tests

- A device type with a TID tolerance of about 50 Krad(Si)
- Functioning at 100 krad(Si) with high leakage current, one week biased room temperature anneal decrease the leakage current with a factor of two
- About the same Heavy Ion response as earlier Actel FPGA, which means that majority voting may be necessary for critical functions