

- **RTAX4000S Qualification Summary**
 - **Introduction**
 - **Qualification Vehicles**
 - ◆ **RTAX4000S-CG1272 Master design**
 - ▶ *Qualification Burn-In (QBI) block*
 - ▶ *Enhanced Antifuse Qualification (EAQ) block*
 - ▶ *High single S-Antifuse & High single B-Antifuse (HSB) block*
 - **Qualification Experiments**
 - ◆ **HTOL**
 - ◆ **LTOL**
 - ◆ **Thermal Runaway Characterization**
 - ◆ **Generic BI Qualification**
 - ▶ *RTAX4000S Generic BI Features & Implementation*
 - ▶ *Generic BI Experiments*
 - **Class V Qualification Status**

- **RTAX4000S is Actel's most recent and largest antifuse FPGA**
 - **Wafers fabricated on 0.15 μ m process at United Microelectronics Corp (UMC), Taiwan**
 - **4 million user gates**
 - **System Solution - 30 times the size of an RTSX32SU**
- **First Antifuse FPGA that offers up to 4 Million system gates with enhanced features:**
 - **Embedded RAM blocks**
 - **Extensive I/O standard support**
 - **Hardened charge pump, clock trees, Power On Reset circuit**
 - **TMR Flip Flops**

	RTAX4000S
Equiv. System Gates	4,000,000
ASIC Equivalent Gates	500,000
Dedicated Registers	20,160
Max Registers	42,840
I/O Registers	2,520
Total Modules	60,480
RAM Blocks	120
Total RAM Bits	540K
Max User I/Os	840
Packages	352-CQFP 1272-CCGA/LGA

- **RTAX4000S-CG1272 was used for the qualification**
 - **Utilizing the largest package to ensure maximum number of I/O's were exercised**
- **Master design specially generated for the RTAX4000S**
 - **Design includes all types of reliability test designs used for RTAX-S**
 - ◆ **QBI: Maximizes resource utilization**
 - ◆ **EAQ: Uses highly perceptive and stressful designs for antifuse evaluation**
 - ◆ **HSB: Maximizes the utilization of single S-Antifuse and single B-Antifuse**
 - ◆ **TID, SEE blocks are also added in the Master design**
- **Design Utilization**

Info		Utilization								
		Pins	Clocks			Logic Cells		Summary		
Device	Package	I/O	RCLK	HCLK	RAM/FIFO	Carry Chain	R-Cell	C-Cell	seq + combo	Total Modules
RTAX4000S	CG1272	840	4	4	120	387	20,155	40,298	99.96%	60,453

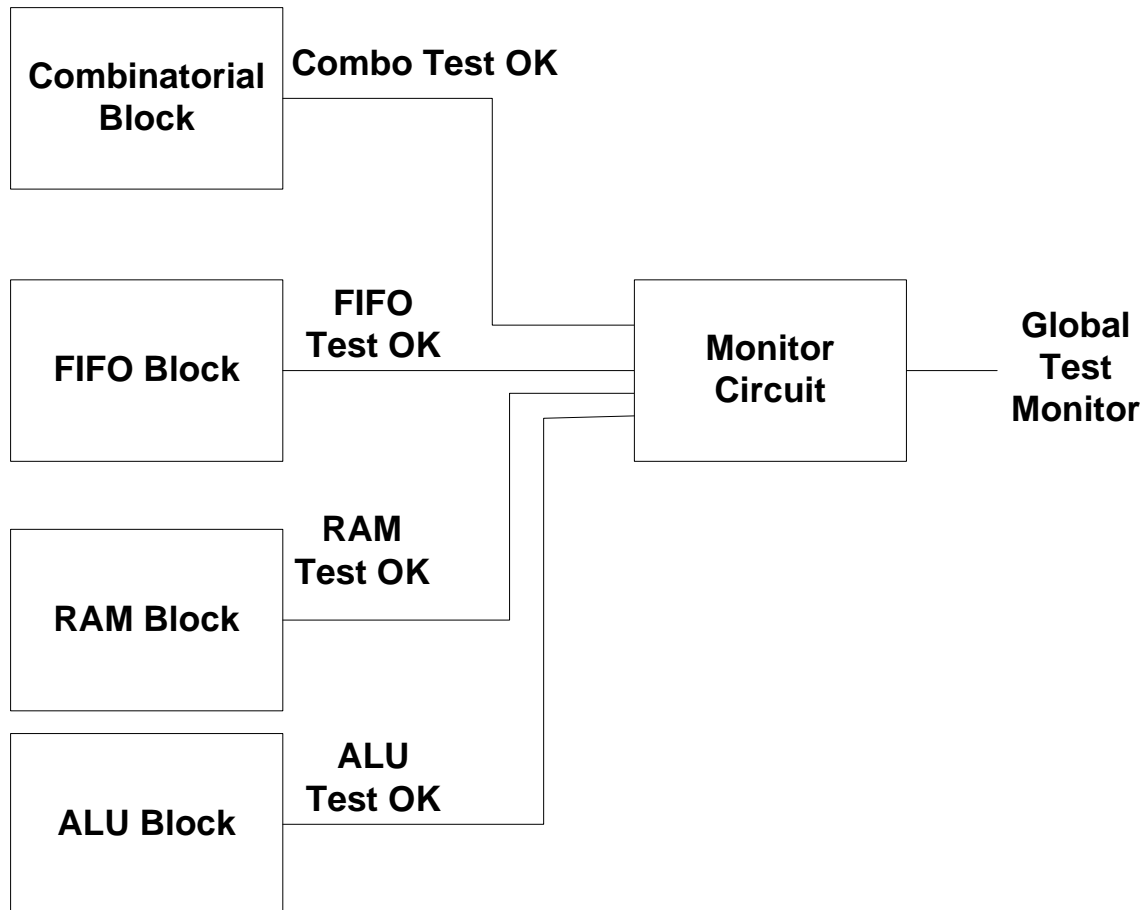
- **Different I/O standards are utilized in the design**
 - ◆ **Single ended, differential, and voltage referenced I/O's are configured**

■ Design Overview

- **QBI (Qualification Burn In) design**
- **Goal of this design:**
 - ◆ **Maximum utilization of logic cells**
 - ◆ **Test all IO standards**
 - ◆ **Testing of all macros offered (like Carry chain, buffys etc)**
 - ◆ **Test RAM feature**
- **QBI block also used as Quality Control Monitor (QCMON) design in smaller devices**

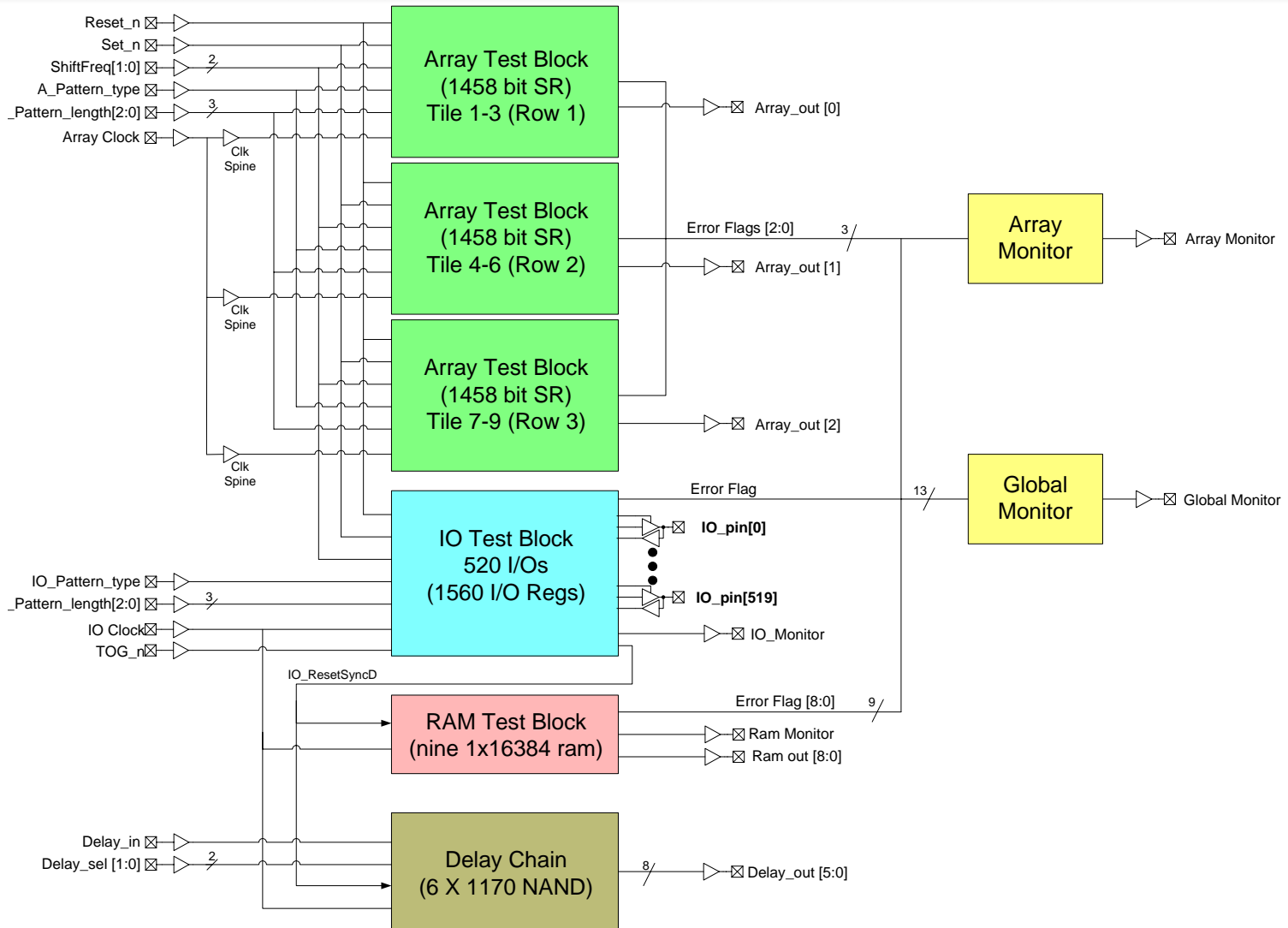
QBI DESIGN FEATURES

- Top level design includes different blocks to ensure testing of all device features with maximum utilization

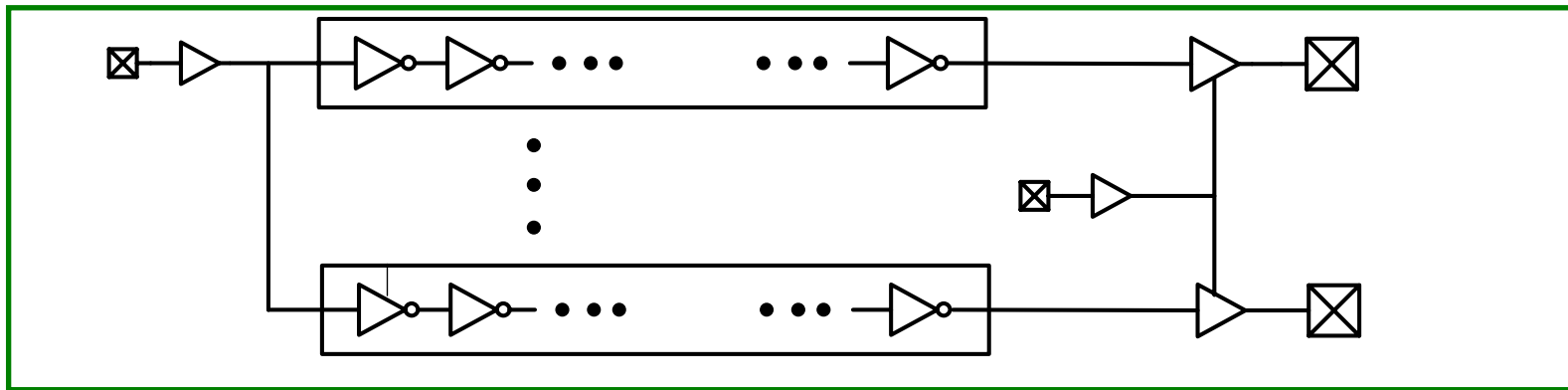


- Goal of Enhanced Antifuse Qualification (EAQ) design
 - Design used for study of antifuse reliability experiment
 - Design fully utilized smaller devices
 - ◆ RTAX2000S, RTAX1000S, RTAX250S
 - Design has high perceptibility of delay measurement deltas
 - ◆ Multiple delay lines of combinatorial modules
 - ◆ I/O test block
 - ◆ RAM test blocks

Top level diagram (EAQ Block)



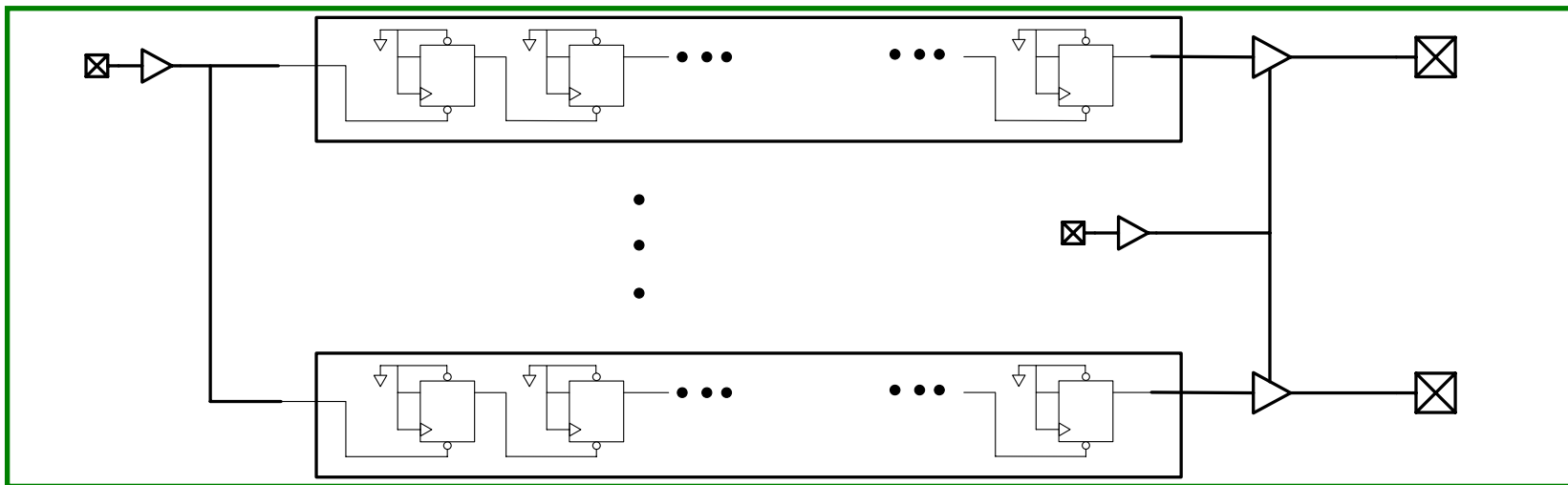
- Goal of High Single-S and Single-B antifuse design
 - Increase the utilization of Single-S and Single-B antifuse
 - Short delay lines of combinatorial and sequential logic
 - Multiple delay lines per device compared against each other at every burn-in pull point
 - ◆ Combinatorial delay lines shown below



Combinatorial delay lines

■ Sequential delay lines

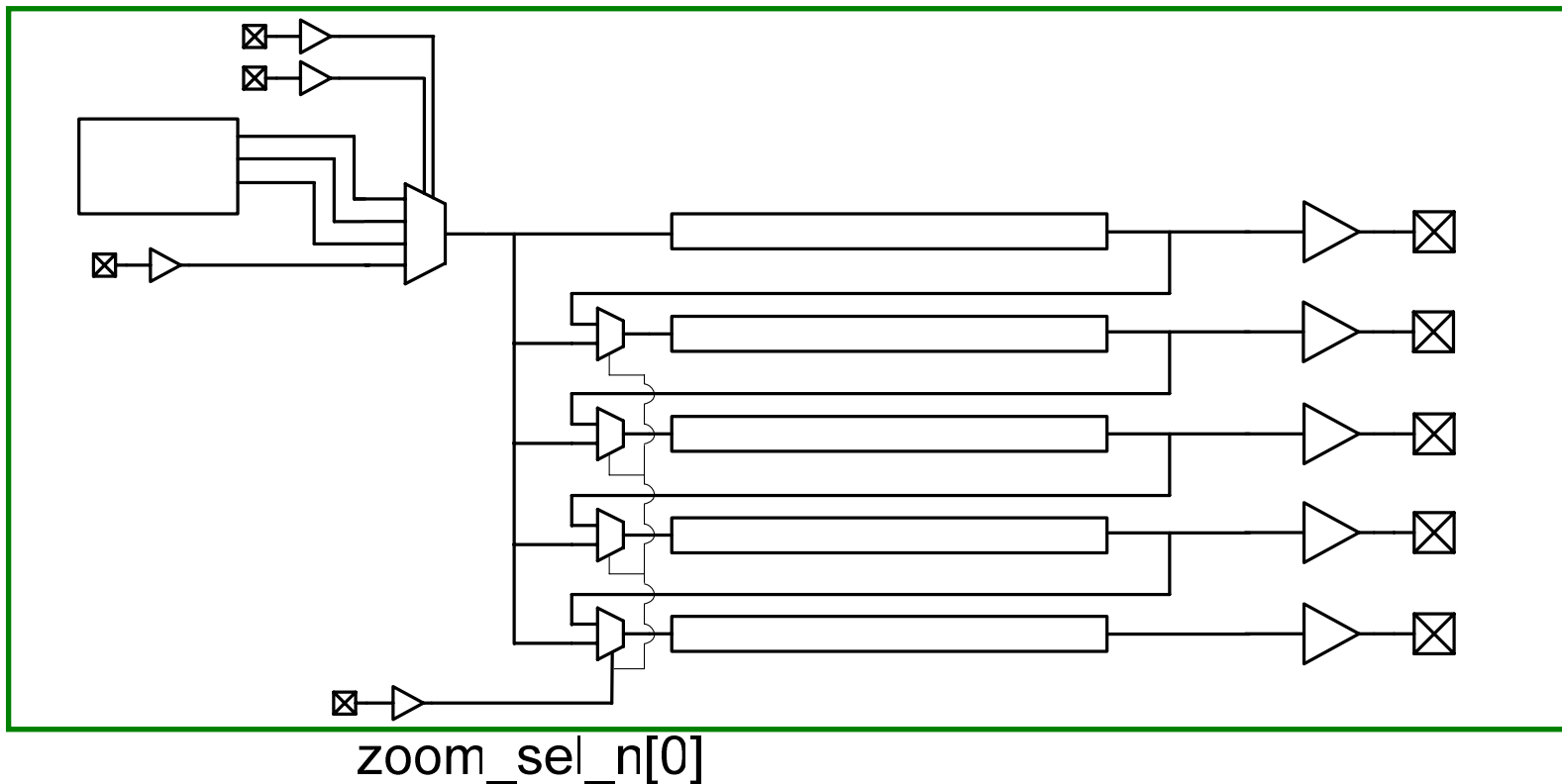
- **Both sequential and combinatorial delay lines exercised during burn-in with the same 2 MHz clock frequency**



Sequential delay lines

SEU Combinatorial Delay Block

- SEU delay lines have longer delays compared to EAQ and HSB delay lines
 - The delay line could be exercised through an input pin or a clock divider block
 - Each delay line can be cascaded to make up one long delay line



Master Design - Antifuse Utilization

Antifuse Type	Number of Antifuses	Description
F	69,251	Between module output segment & short vertical segment
H	21,370	Antifuse between two horizontal tracks
I	127,644	Between short horizontal segments & module input segment
S	42,710	Semi-direct antifuse
V	10,179	Antifuse between two vertical tracks
X	72,244	Antifuse Between short horizontal & vertical segments
K	14,379	Between routed clock horizontal segments & module input segment
CSR	10,144	Antifuse for I/O configuration options
SSR1	8	Silicon Signature antifuse in silicon signature words
LDH	600	Horizontal inter-tile antifuse
LDV	2,925	Vertical inter-tile antifuse
B	4,160	Between local segment (DB inverter output) & input segment
LL	10,219	Between RX/TX input/output module segment & long horizontal/vertical segment
Total Antifuses	1,265,487	

- Qualification was done with MIL-PRF-38535, Class EV Level Compliance
 - **Master Design used to program qualification life test devices**
 - ◆ Tri-temp (-55°C, 125°C, 25°C) functional testing performed
 - ◆ Qualification devices processed through class EV assembly and screening before programming
 - **Group C test**
 - ◆ (High Temp Operating Life) HTOL stress at 125°C for 1,000 hours
 - ◆ 77 RTAX4000S-CG1272 devices were programmed for this test
 - ◆ Burn-In performed at maximum supply conditions of $V_{CCA}=1.6V$ & $V_{CCI}=3.6V$
 - **Group A, B, D, ESD, Latch-Up, IO Capacitance were also performed**
 - **Characterization completed with 2 lots of RTAX4000S**
 - ◆ Characterization report available with the qualification report

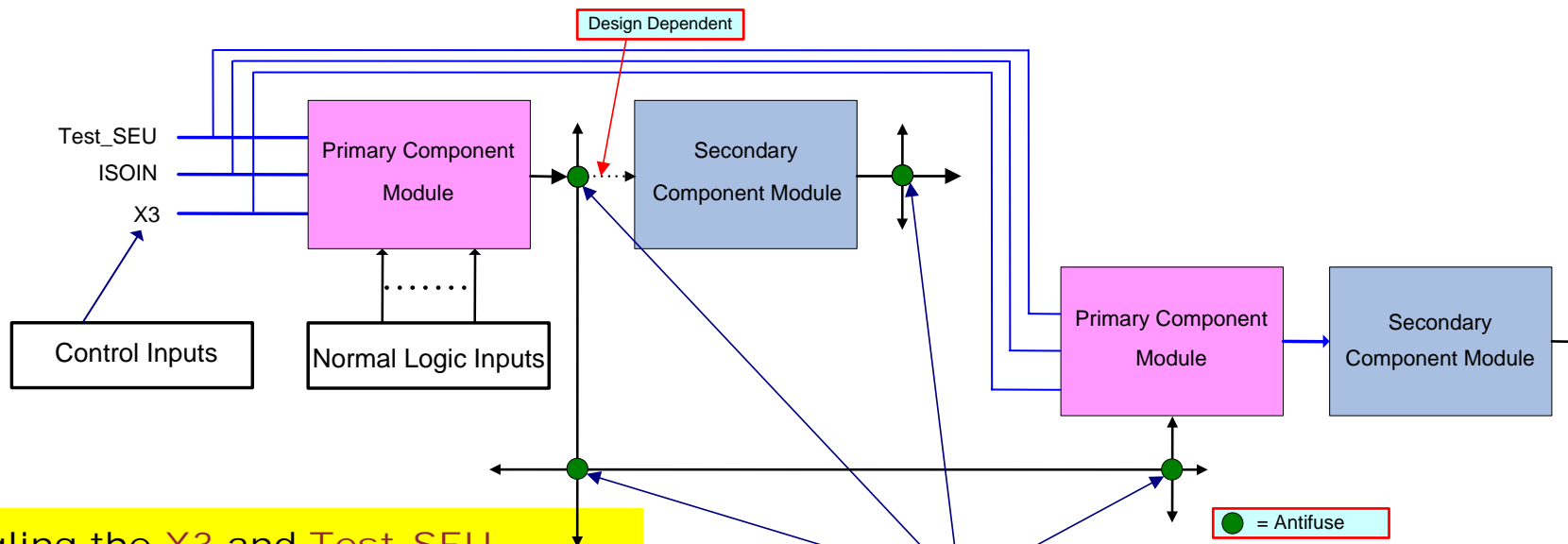
- **Qualification Experiments Cont'd**
 - **LTOL (Low Temp Operating Life) test**
 - ◆ 24 RTAX4000S devices were stressed for 1,000 hours of LTOL at -55°C
 - **Class B qualification of the RTAX4000S completed at the end of 2007**
 - **Thermal runaway characterization completed**
 - ◆ Thermal runaway characterization was completed up to junction temperature of 150C
 - ◆ No thermal runaway issues were found
- **Class V Qualification**
 - **The 1,000 hours HTOL extended to 6000 hours to qualify the RTAX-S family as class EV device**
 - ◆ Qualification devices completed 5000 hours HTOL with NO silicon failures
 - ◆ Class V qualification to be completed with the 6000hrs HTOL on schedule for Nov 2008
 - **Qualification devices have been processed through class EV flow**
 - ◆ Class EV screening performed starting from assembly through blank device screening
 - **Same “Master” design will be used for production Enhanced Lot Acceptance (ELA) test**

■ Generic Burn-in Features

- Actel customers will never need to generate specific test patterns for their programmed RTAX4000S design, saving both time and costs.
- ASIC burn-in test vectors often achieve less than 70% AC toggle coverage of the design whereas an Actel Generic Burn-in provides complete network exercise.
- Specific Burn-in boards are not required to accommodate custom user designs.
- RTAX4000S Programmed parts with multiple designs can be burned-in simultaneously using “Actel Generic Burn-In” boards.
- The generic burn-in test is implemented using existing global test circuit commands
- Simplified schematic of the combinatorial module test shown on next slide

Simplified Signal Path Schematic

■ Schematic of the combinatorial module path



By toggling the **X3** and **Test_SEU** control inputs of each "Primary Component" module, the outputs of the secondary modules will toggle. As a result, the network routing driven by that module will be exercised.

All antifuses associated with the normal user circuit path will be exercised.

Generic Burn-in Verification and Qualification

- Verification of the Generic Burn-in concept was performed with software simulation and burn-in system
 - Bench level testing using dedicated Silicon Explorer probe pin outputs as well as TDO outputs verified cell toggling on all the available device features
 - Logging of pre and post burn-in data required
- Generic Burn-in qualification was completed with 1000 hours HTOL
 - Pre and post Burn-in data is logged and compared at each pull-point
 - 24 RTAX4000S-CG1272 devices were used for the qualification
 - ◆ All devices passed successfully and no delay or faults were observed
 - ◆ These are the same devices which were used for the LTOL qualification

- Actel has successfully completed the Mil-Std 883B qualification of the RTAX4000S
 - **Reliability experiments with HTOL and LTOL were completed with NO silicon failures**
- Generic burn-in feature verification and qualification was completed
- Class V qualification of the RTAX4000S will be completed with 6000 hour HTOL
 - **5000 hours already completed with no silicon failures and 6000 hours HTOL will be completed by November 2008**
 - **All qualification devices were processed through Class V process flow**
 - **This will establish Class V level compliance for RTAX-S products**