

A Rad-hard FPGA Tile SAND2018-0703C

for Embedded & Platform FPGA Applications

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Outline

- FPGA design options
- FPGA Tile
 - Overview
 - Design flow
 - Performance
 - Array configurations
- Embedded FPGA example
- Platform FPGA example
- Conclusion

Rad-Hard FPGA Design Options

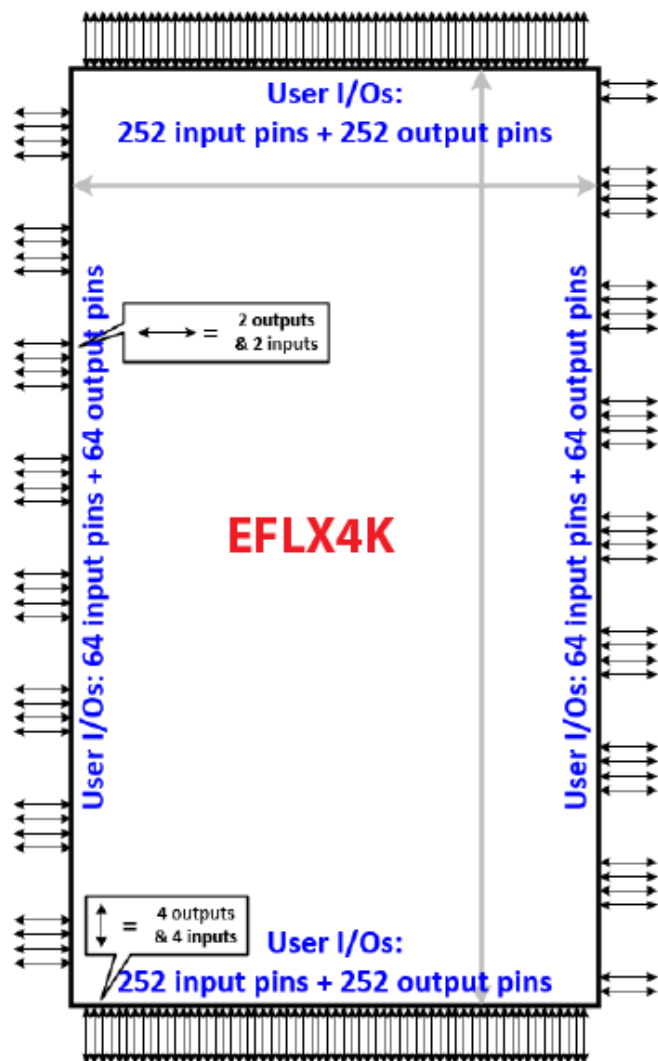
- Design constraints
 - Need to obtain FPGA hardware architecture and software tool flow from commercial industry (versus developing in house)
 - Needs to be cost-effective to implement in a 180-nm rad-hard process
 - 7 metal layer limit (including power, ground, flip-chip pads, etc.)
 - If possible, reuse existing rad-hard cell layouts

- Option #1: Port platform FPGA device into rad-hard process
 - ✓ Compatible with commercial devices and software
 - ❑ No ability to customize FPGA resources, configuration protocols, etc.
 - ❑ Business model does not match need (focus on selling devices vs selling IP)
 - ❑ Difficult to reuse existing rad-hard cell layouts

- Option #2: Port embedded FPGA tile into rad-hard process
 - ✓ Compatible with commercial software
 - ✓ Ability to customize FPGA resources, configuration protocols, etc.
 - ✓ Business model matches need (focus on selling IP vs selling devices)
 - ✓ Able to reuse existing rad-hard cell layouts

Licensing embedded FPGA offers the most flexibility

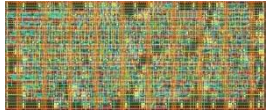
Rad-hard FPGA Tile



- Licensed commercial EFLX[®]4K embedded FPGA (eFPGA) logic core from Flex Logix Technologies, Inc.
 - EFLX4K proven in multiple commercial nodes
 - Layout was ported to Sandia's 180-nm strategically radiation hardened process
- Key features of the rad-hard FPGA tile
 - 1.8V operation
 - 6 metal layers
 - SRAM-based, reconfigurable fabric
 - 2520 Look-up Tables (LUTs)
 - 6-input or dual 5-input logic functions
 - Roughly equivalent to 4K 4-input LUTs
 - 6304 user registers
 - 20-Kbits distributed memory
 - 1264 user I/O ports
 - Tile is array-able to build larger blocks

Based on a modern, commercial eFPGA design

Rad-hard FPGA Tile Design



*Sandia 180nm rad-hard
cell layouts*

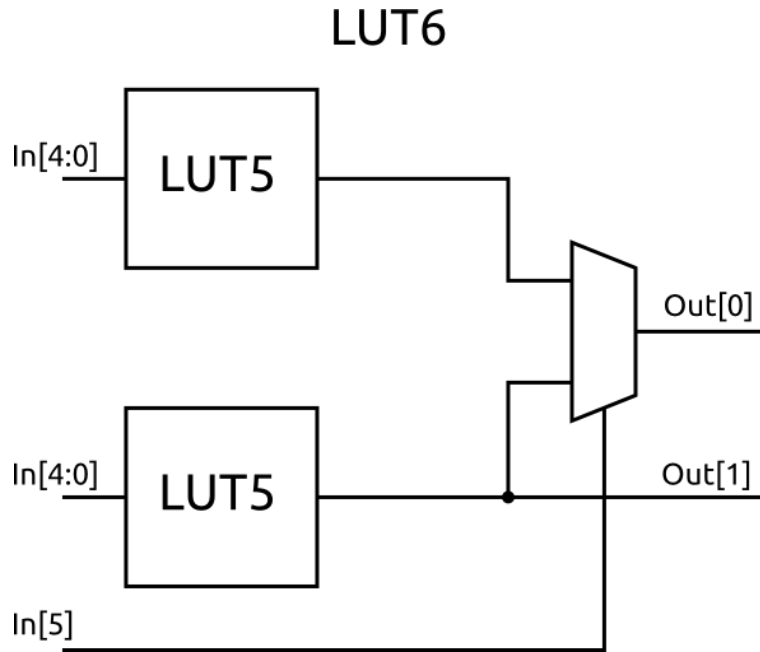


*Rad-hard EFLX-4K
eFPGA macro layout*

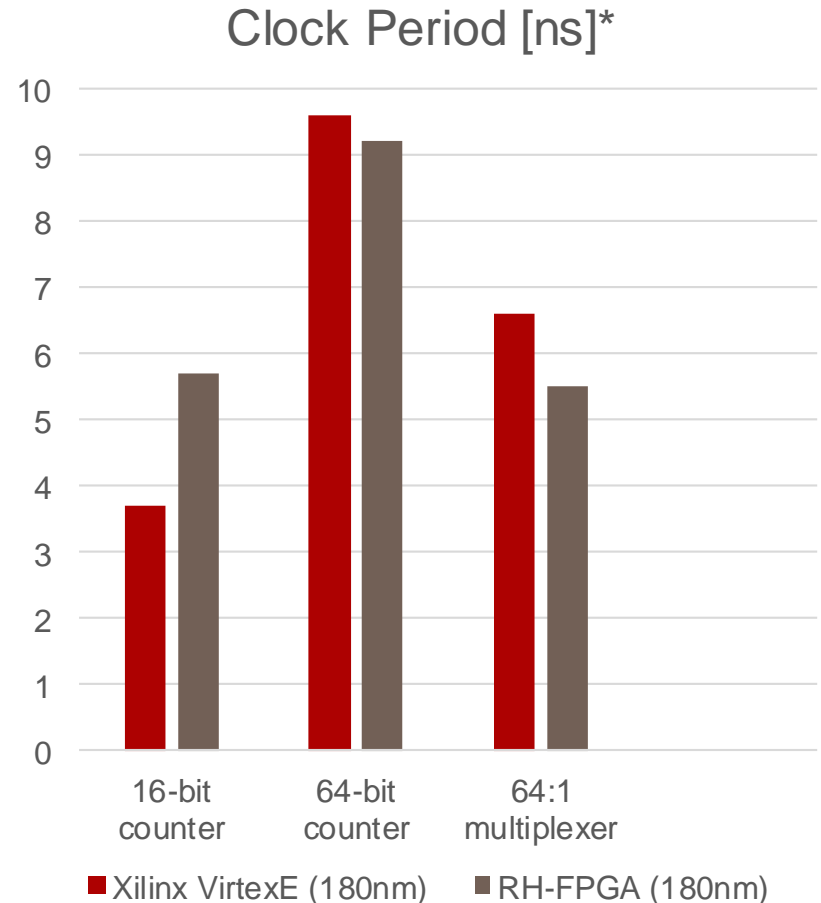
- Sandia's rad-hard logic and rad-hard memory cells were the starting point for the rad-hard FPGA tile design
 - Used to generate EFLX[®]4K macro layout
- All FPGA circuit elements were hardened against radiation effects
 - User registers, user memory, configuration bits, logic, etc.
 - Hardened by process and by cell design
- Rad-hard implementation is transparent to the FPGA user
 - No scrubbing
 - No Triple-Modular-Redundancy
 - No Error-Detection-And-Correction

Reuse of existing RH-cells reduces qualification risks

Rad-hard FPGA Tile Performance

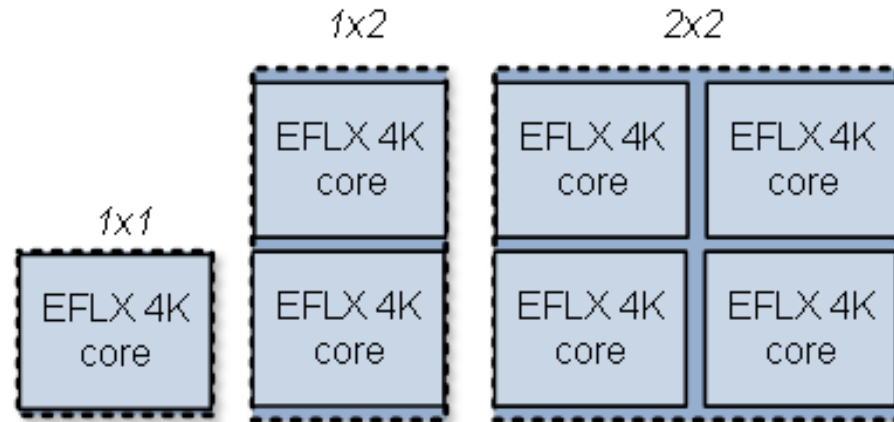


Rad-hard LUT can realize 6-input logic function or dual 5-input logic function



Logic delays are similar to commercial 180-nm FPGAs

Rad-hard FPGA Tile Arrays

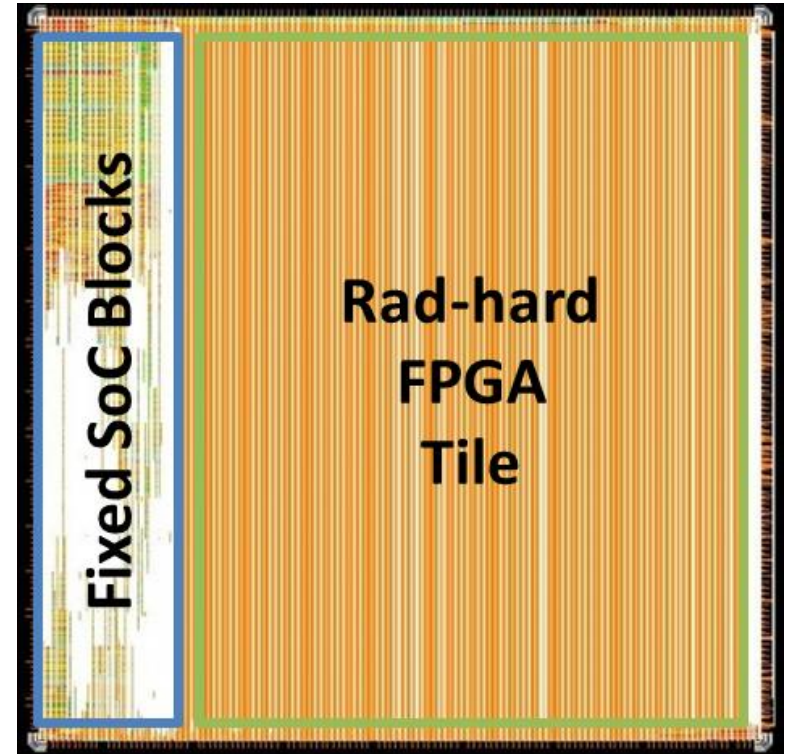
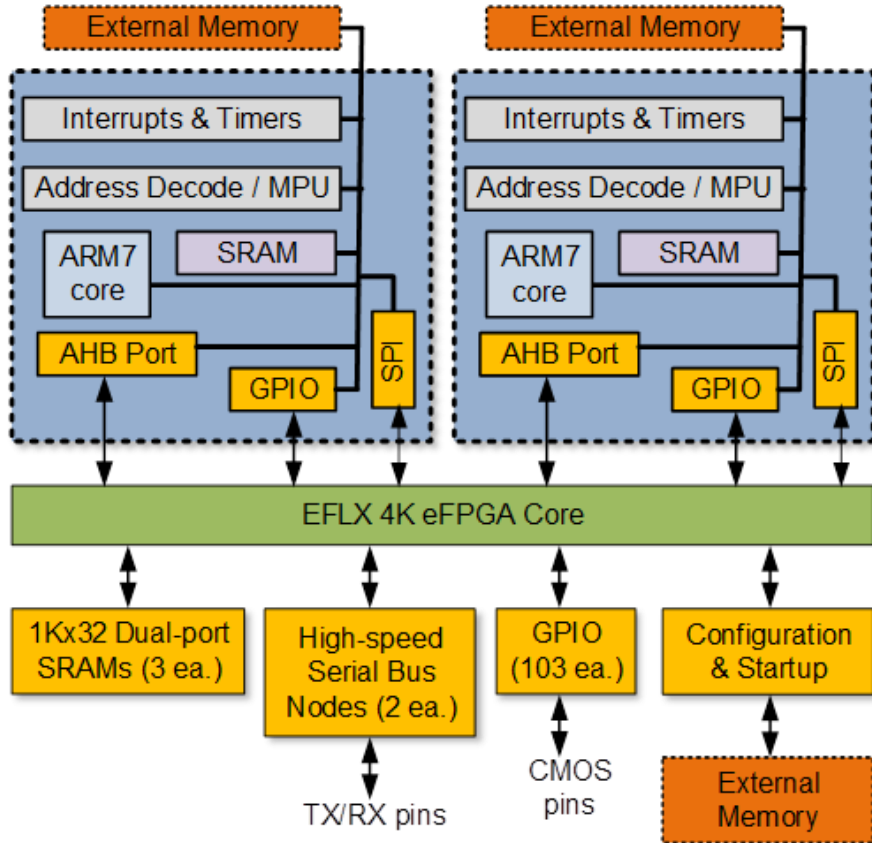


	1x1 Array	1x2 Array	2x2 Array
LUTs	2520	5040	10080
Registers	6304	11600	22688
Distributed SRAM	20Kb	40Kb	80Kb
User I/O ports	1264	1520	2528

FPGA tile is array-able to create larger FPGA macros

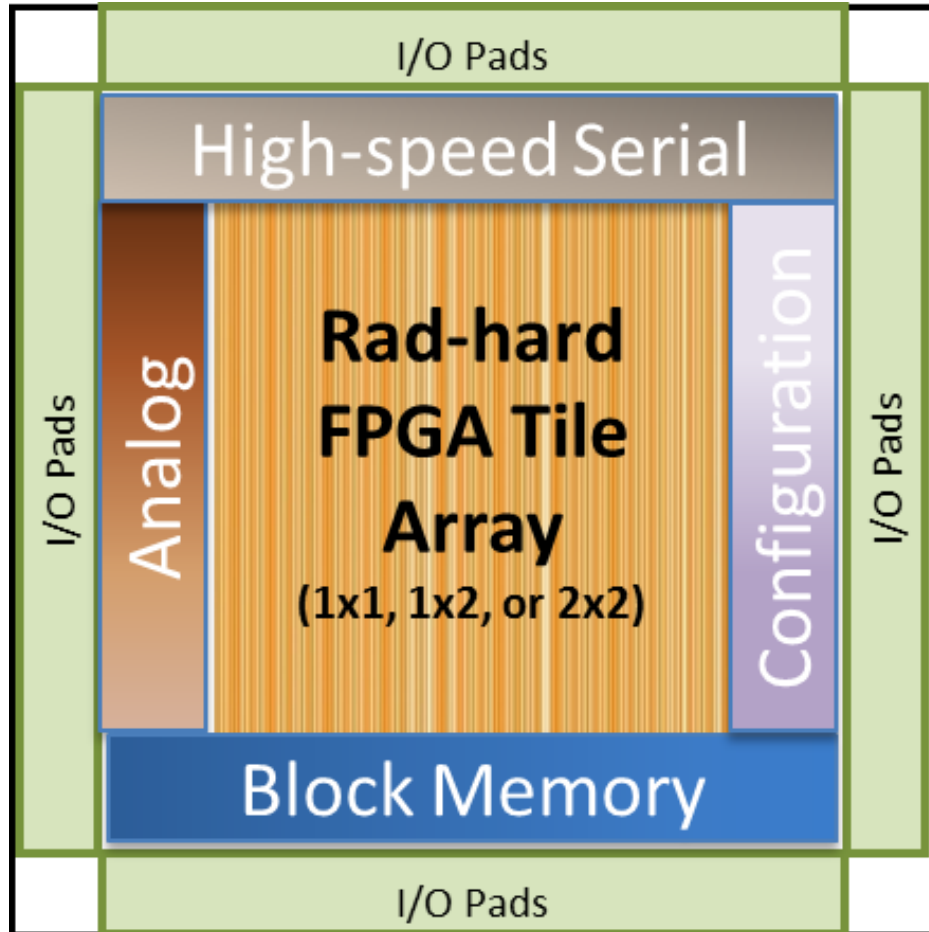
Application #1: Embedded FPGA

Use rad-hard FPGA tile as an “embedded FPGA” inside of a System-on-Chip



Enables reconfigurable System-on-Chips

Application #2: Platform FPGA



- Build your own custom rad-hard FPGA platform
 1. Select desired rad-hard FPGA array size
 2. Instantiate desired block memory, configuration protocol logic (SPI, JTAG, AXI, etc.), analog blocks, I/O pads, etc.
 3. Run through standard ASIC design flow
 - Synthesis
 - Auto-place-and-route
 - Timing closure
 - Tapeout

Enables application-specific FPGAs

Conclusion

- Sandia has licensed the EFLX[®]4K eFPGA tile from Flex Logix Technologies for use in its 180-nm rad-hard process node
- This rad-hard FPGA tile can significantly improve the re-configurability of System-on-Chip devices, and increase their reuse potential in multiple application areas
- This rad-hard FPGA tile also enables the creation of application-specific FPGA devices, which can be highly customized for a given set of applications

Questions?