Radiation-Tolerant FPGAs
Space Solutions
Taking Designs From Earth to Outer Space

Microchip’s high-reliability, low-power spaceflight FPGAs are your best design choice for low Earth orbit, deep space or anything in between. With a history of providing the most reliable, robust, low-power Flash- and antifuse-based FPGAs in the industry, we offer the best combination of features, performance and radiation tolerance.

In addition to FPGAs, we provide radiation-hardened and radiation-tolerant solutions ranging from diodes, transistors and power converters to ASICs, RF components, oscillators and timing products, to mixed-signal integrated circuits, custom semiconductor packaging and integrated power distribution systems.

Feature Overview

<table>
<thead>
<tr>
<th>Radiation-Tolerant FPGAs</th>
<th>Now delivering high-speed signal processing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Microsemi’s flight heritage</td>
</tr>
</tbody>
</table>

RTG4

- QML Class V-qualified RT FPGA
- Developed for high-speed signal processing
- Radiation hardened by design
- Immune to radiation configuration upsets

RTAX-S/SL

- Industry-standard QML Class V-qualified RT FPGA
- High performance and low power consumption
- Unprecedented 33 M+ device hours of reliability data from flight and commercially-equivalent units

RTAX-DSP

- High-speed arithmetic functions for spaceflight applications
- Embedded hardwired radiation-tolerant multipliers
- QML Class V qualified

RT ProASIC3

- Very low power consumption spaceflight FPGA
- Reprogrammability without radiation-induced configuration upsets
- Single-chip form factor

RTSX-SU

- High-reliability, radiation-tolerant, antifuse-based FPGAs
- Flight heritage established on many programs

FPGA Packages

- Package dimensions

Design Environment for Microsemi System Critical Devices

- Libero® Integrated Design Environment (IDE) tools and editions

Designing with RTG4

- Development kit and design software

Intellectual Property Cores for System Critical FPGAs

- MIL-STD-1553B IP cores
- Digital signal processing IP cores

Prototyping Flows

- Prototyping options for RT FPGA families

Package Prototyping Solutions

- Adapter sockets

Daisy-Chained Packages

- Facilitating PCB assembly validation and package qualification

Device Programming

- Silicon Sculptor 3, FlashPro4, and FlashPro5 device programmers

For the latest device information and valid operating codes, see [www.microsemi.com/products/fpga-soc/rad-tolerant-fpgas](http://www.microsemi.com/products/fpga-soc/rad-tolerant-fpgas) and the appropriate product datasheets.
Now Delivering High-Speed Signal Processing

Microchip's FPGAs facilitate the design of high-speed communications payloads, high-resolution sensors and instruments, and flight-critical systems that enable tomorrow's space missions. Only we can meet the power, size, cost and reliability targets that reduce time-to-launch and minimize cost and schedule risks.

Flight Heritage

**RTSX-SU**
- Flight heritage since 2005
- EAR-controlled
- QML class Q qualified

**RTAX**
- Flight heritage since 2007
- On-board SRAM and DSP Mathblocks
- EAR-controlled
- QML class V qualified

**RT ProASIC3**
- Flight heritage since 2013
- First Flash-based RT FPGA in space
- EAR-controlled
- QML class Q qualified

For more information, see [www.microsemi.com/products/fpga-soc/rad-tolerant-fpgas](http://www.microsemi.com/products/fpga-soc/rad-tolerant-fpgas)
Remote Sensing Payload Example

Microchip FPGAs have achieved flight heritage on many programs in command and control applications that require limited amounts of logic and modest performance levels. RTG4™ has much greater logic density and much higher performance, which give a >20x improvement in signal processing throughput. Now, designers of high-speed datapaths in space payloads can use RTG4 to take advantage of the flexibility and ease-of-use of programmable logic. This is particularly important for remote sensing instruments, which must perform rapidly increasing amounts of on-board processing, as sensor resolution is increasing faster than downlink bandwidth.

RTGX-SU, RTAX and RT ProASIC3 FPGAs are used for command, control and interfacing applications, where limited logic and performance is needed. RTG4 can be deployed where maximum data throughput is needed, such as in signal processing and compression.

RTG4 Radiation Effects

RTG4 FPGAs are manufactured on a low-power 65 nm process with substantial reliability heritage. RTG4 FPGAs are qualified to QML Class V per MIL-PRF-38535.

RTG4 FPGAs are immune to radiation (SEU)-induced changes in configuration due to the robustness of the Flash cells used to connect and configure logic resources and routing tracks. No background scrubbing or reconfiguration of the FPGA is needed to mitigate changes in configuration due to radiation effects. Data errors due to radiation are mitigated by hardwired SEU resistant flip-flops in the logic cells and mathblocks. Single Error Correct Double Error Detect (SECDED) protection is optional for the embedded SRAM (LSRAM and uSRAM) and the DDR memory controllers. This means that if a one-bit error is detected, it will be corrected. Errors of more than one bit are detected but not corrected. SECDED error signals are brought to the FPGA fabric to allow the user to monitor the status of these protected internal memories.

- Immune to single event latch-up
- Immune to configuration upsets
- Total ionizing dose to >100 Krad (Si)
- Single event upsets <1 x 10¹¹ errors/bit-day (GEO solar min)
Radiation-Tolerant FPGAs

High-Speed RT FPGAs for Signal-Processing Applications

RTG4 FPGAs integrate Microchip’s fourth-generation Flash-based FPGA fabric high-performance serialization/deserialization (SERDES) transceivers on a single chip while maintaining resistance to radiation-induced configuration upsets in the harshest radiation environments, such as space flight (LEO, MEO, GEO, HEO and deep space), high-altitude aviation, medical electronics, and nuclear power plant control.

RTG4 Product Family

<table>
<thead>
<tr>
<th>Features</th>
<th>RTG4150</th>
<th>RTG4150</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packages</td>
<td>CCGA/CLGA 1657</td>
<td>CQ352</td>
</tr>
<tr>
<td>Logic/DSP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum logic elements (LUT4 + TMR flip-flop)</td>
<td>151, 824</td>
<td>151, 824</td>
</tr>
<tr>
<td>Mathblocks (18-bit x 18-bit)</td>
<td>462</td>
<td>462</td>
</tr>
<tr>
<td>Radiation-tolerant PLLs</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Memory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSRAM 24.5 kbit blocks (with ECC)</td>
<td>209</td>
<td>209</td>
</tr>
<tr>
<td>uSRAM 1.5 kbit blocks (with ECC)</td>
<td>210</td>
<td>210</td>
</tr>
<tr>
<td>Total SRAM Mbits</td>
<td>5.2</td>
<td>5.2</td>
</tr>
<tr>
<td>uPROM Kbits</td>
<td>374</td>
<td>374</td>
</tr>
<tr>
<td>High-Speed Interface</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SERDES lanes (3.125 Gbps)</td>
<td>24</td>
<td>4</td>
</tr>
<tr>
<td>PCIe endpoints</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>DDR2/3 SDRAM controllers (with ECC)</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>SpaceWire clock and data recovery circuits</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>User I/Os</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSIO (3.3V)</td>
<td>240</td>
<td>166</td>
</tr>
<tr>
<td>MSIOD (2.5V)</td>
<td>300</td>
<td>0</td>
</tr>
<tr>
<td>DDRIO (2.5V)</td>
<td>180</td>
<td>0</td>
</tr>
<tr>
<td>User I/O (excluding SERDES)</td>
<td>720</td>
<td>166</td>
</tr>
</tbody>
</table>

For more information, see www.microsemi.com/products/fpga-soc/radtolerant-fpgas/rtg4
Logic Module
Dedicated STMR flip-flop with asynchronous self correction
• With enable, global asynchronous set/reset and local synchronous set/reset
• Fast carry chain to complement Mathblock performance
• 300 MHz for 32-bit functions (no SET filter)
• 250 MHz for 32-bit function (SET filter deployed)
• Industry standard LUT4 for efficient synthesis
• LUT4 and flip-flop in same module can be used independently
• Hierarchical routing architecture enables >95% module utilization

Mathblock
18 × 18 multiplier with advanced accumulate
• High performance for signal processing throughput
• 300 MHz without SET mitigation
• 250 MHz with SET mitigation
• New 3-input adder function: \((C + D) \pm (A \times B)\)
• Optional SEU-protected registers on inputs and outputs (including \(C\) input)

Memory Blocks
Radiation-Tolerant built-in optional EDAC (SECDED)
• Resistant to multi-bit upset
• LSRAM up to 24.5 KBit
• Dual-port and two-port option
• High-performance synchronous operation
• Example usage—large FFT memory
• uRAM up to 1.5 KBit
• Three port memory—synchronous write port, two asynchronous or synchronous read ports
• Example usage—folded FIR filters and FFT twiddle factors

SpaceWire Receiver Interface
SpaceWire clock and data recovery
• Up to 16 hardwired clock and data recovery circuits
• Up to 200 Mbps SpaceWire data rate under optimum conditions
• Delay compensation for optimum alignment of clock and data
• Supports LVDS and LVTTL inputs

For the latest DLA cross-reference information, see
Radiation-Tolerant FPGA Alternative to Radiation-Hardened ASICs

RTAX-S/SL radiation-tolerant FPGAs offer industry-leading advantages for designers of spaceflight systems. High-performance, low-power consumption, true single-chip form factor and live-at-power-up operation all combine to make RTAX-S/SL devices the FPGAs of choice for space designers.

- Single event latch-up (SEL) immune to LET\textsubscript{TH} in excess of 117 MeV-cm\textsuperscript{2}/mg
- Single event upset (SEU) less than 1E\textsuperscript{-10} errors per bit-day (worst-case geosynchronous orbit)
- Total ionizing dose (TID): 300 krad functional, 200 krad parametric
- Pin-compatible commercial devices for easy and inexpensive prototyping
- Ceramic package offerings (CQFP, CCGA, CLGA)
- Prototype units with same footprint and timing as flight units
- Up to 840 user-programmable I/Os
- Screening:
  - B Flow: MIL-STD-883B
  - E Flow: Microchip Extended Flow
  - V Flow: MIL-PRF-38535 QML Class V

RTAX-S/SL Devices

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Register (R-cells) Modules</td>
<td>1,408</td>
<td>6,048</td>
<td>10,752</td>
<td>20,160</td>
</tr>
<tr>
<td>Combinatorial (C-cells) Modules</td>
<td>2,816</td>
<td>12,096</td>
<td>21,504</td>
<td>40,320</td>
</tr>
<tr>
<td>Embedded RAM/FIFO Blocks (without EDAC)</td>
<td>12</td>
<td>36</td>
<td>64</td>
<td>120</td>
</tr>
<tr>
<td>Embedded RAM/FIFO (without EDAC) (k = 1,024 bits)</td>
<td>54k</td>
<td>162k</td>
<td>288k</td>
<td>540k</td>
</tr>
<tr>
<td>Hardwired Clocks (segmentable)</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Routed Clocks (segmentable)</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>I/O Banks</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>User I/Os (maximum)</td>
<td>248</td>
<td>618</td>
<td>684</td>
<td>840</td>
</tr>
<tr>
<td>I/O Registers</td>
<td>744</td>
<td>1,548</td>
<td>2,052</td>
<td>2,520</td>
</tr>
<tr>
<td>CG/LG Package Pins</td>
<td>624</td>
<td>624</td>
<td>624, 1152</td>
<td>1272</td>
</tr>
<tr>
<td>CQ Package Pins</td>
<td>208, 352</td>
<td>352</td>
<td>256, 352</td>
<td>352</td>
</tr>
</tbody>
</table>

I/Os per Package

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CQ208</td>
<td>7</td>
<td>41</td>
<td>13</td>
<td>115</td>
</tr>
<tr>
<td>CQ256</td>
<td>2</td>
<td>98</td>
<td>0</td>
<td>198</td>
</tr>
<tr>
<td>CQ352</td>
<td>2</td>
<td>98</td>
<td>0</td>
<td>198</td>
</tr>
<tr>
<td>CG624</td>
<td>0</td>
<td>124</td>
<td>0</td>
<td>248</td>
</tr>
<tr>
<td>CG1152</td>
<td>0</td>
<td>342</td>
<td>0</td>
<td>684</td>
</tr>
<tr>
<td>CG1272</td>
<td>0</td>
<td>420</td>
<td>0</td>
<td>840</td>
</tr>
</tbody>
</table>

For more information, see www.microsemi.com/products/fpga-soc/radtolerant-fpgas/rtax-s-sl
Industry’s Most Reliable Spaceflight FPGAs With DSP Capabilities

RTAX-DSP spaceflight FPGAs add embedded radiation-tolerant, multiply-accumulate blocks to the tried-and-trusted industry standard RTAX-S/SL product family. The result is a dramatic increase in device performance and utilization when implementing arithmetic functions (such as those encountered in DSP algorithms) without sacrificing reliability or radiation tolerance. RTAX-DSP integrates complex DSP functions into a single device without any external components for code storage or multiple-chip implementations for radiation mitigation.

- Highly reliable, nonvolatile antifuse technology
- 2,000,000 to 4,000,000 system gates
- Up to 120 DSP mathblocks with 125 MHz 18 × 18 bit multiply-accumulate
- Up to 540 Kbits of embedded memory with optional EDAC protection
- Up to 840 user-programmable I/Os
- RTAX-DL version with low static power
- Total dose: 300 Krad (functional) and 200 Krad (parametric)
- SEU less than 1E-10 errors per bit-day (worst-case GEO)
- SEL immune to LET_{TH} in excess of 117 MeV-cm²/mg
- Enhanced SET for R-cells: 0.12 events/RTAX2000D device/100 years at 120 MHz
- Advanced CCGA and LGA packaging for space applications
- Screening:
  - B Flow: MIL-STD-883B
  - E Flow: Microchip Extended Flow
  - V Flow: MIL-PRF-38535 QML Class V

RTAX-DSP Devices

<table>
<thead>
<tr>
<th>RTAX-DSP Devices</th>
<th>RTAX2000D/DL</th>
<th>RTAX4000D/DL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equivalent System Gates Capacity</td>
<td>2,000,000</td>
<td>4,000,000</td>
</tr>
<tr>
<td>Register (R-cells) Modules</td>
<td>9,856</td>
<td>18,480</td>
</tr>
<tr>
<td>Combinatorial (C-cells) Modules</td>
<td>19,712</td>
<td>36,960</td>
</tr>
<tr>
<td>Embedded Multiply-Accumulate DSP Mathblocks</td>
<td>64</td>
<td>120</td>
</tr>
<tr>
<td>Embedded RAM/FIFO Blocks (without EDAC)</td>
<td>64</td>
<td>120</td>
</tr>
<tr>
<td>Embedded RAM/FIFO (without EDAC) (k=1,024 bits)</td>
<td>288k</td>
<td>540k</td>
</tr>
<tr>
<td>Hardwired Clocks (segmentable)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Routed Clocks (segmentable)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>I/O Banks</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>User I/Os (maximum)</td>
<td>684</td>
<td>840</td>
</tr>
<tr>
<td>I/O Registers</td>
<td>2,052</td>
<td>2,520</td>
</tr>
<tr>
<td>CG/LG (DSP)* Package Pins</td>
<td>1272</td>
<td>1272</td>
</tr>
<tr>
<td>CQ Package Pins</td>
<td>352</td>
<td>352</td>
</tr>
</tbody>
</table>

Note: The body size of the 1272-pin CCGA and LGA packages used on the RTAX4000D/DL FPGAs are slightly larger than the body size of the 1272-pin CCGA and LGA used on the RTAX4000S/SL devices.

I/Os per Package

<table>
<thead>
<tr>
<th>RTAX-DSP Devices</th>
<th>RTAX2000D</th>
<th>RTAX4000D</th>
</tr>
</thead>
<tbody>
<tr>
<td>CQ352</td>
<td>166</td>
<td>166</td>
</tr>
<tr>
<td>CG1272/LG1272</td>
<td>684</td>
<td>840</td>
</tr>
</tbody>
</table>

Note: The user I/Os include clock buffers.

For more information, see www.microsemi.com/products/fpga-soc/radtolerant-fpgas/rtax-dsp
Low-Power, Reprogrammable FPGAs for Space

Radiation-Tolerant (RT) ProASIC®3 FPGAs are the first to offer designers of spaceflight hardware a radiation-tolerant, reprogrammable, nonvolatile logic integration vehicle. They are intended for low-power space applications requiring up to 3,000,000 system gates.

- Ceramic column grid array with Six Sigma™ copper-wrapped lead-tin columns
- Supports single-voltage system operation
- Total ionizing dose: 25 krad to 30 krad with less than 10% propagation delay change at standard test dose rate; up to 40 krad at low-dose rate
- Up to 504 Kbits of true dual-port SRAM

RT ProASIC3 Devices

<table>
<thead>
<tr>
<th>RT ProASIC3 Devices</th>
<th>RT3PE600L</th>
<th>RT3PE3000L</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Gates</td>
<td>600,000</td>
<td>3,000,000</td>
</tr>
<tr>
<td>VersaTiles (D-flip-flops)</td>
<td>13,824</td>
<td>75,264</td>
</tr>
<tr>
<td>RAM (k = 1,024 bits)</td>
<td>108k</td>
<td>504k</td>
</tr>
<tr>
<td>RAM Blocks (4,608 bits)</td>
<td>24</td>
<td>112</td>
</tr>
<tr>
<td>FlashROM (Kbits)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Secure (AES) ISP</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Integrated PLL in CCCs</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>VersaNet Globals</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>I/O Banks</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Maximum User I/Os</td>
<td>270</td>
<td>620</td>
</tr>
<tr>
<td>CG/LG Package Pins</td>
<td>484</td>
<td>484,896</td>
</tr>
<tr>
<td>CQ Package Pins</td>
<td>256</td>
<td>256</td>
</tr>
</tbody>
</table>

I/Os per Package

<table>
<thead>
<tr>
<th>RT ProASIC3 Devices</th>
<th>RT3PE600L</th>
<th>RT3PE3000L</th>
</tr>
</thead>
<tbody>
<tr>
<td>I/O Type</td>
<td>Single-Ended I/Os</td>
<td>Differential I/O Pairs</td>
</tr>
<tr>
<td>CG/LG484</td>
<td>270</td>
<td>135</td>
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<tr>
<td>CG/LG896</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>CQ256</td>
<td>166</td>
<td>82</td>
</tr>
</tbody>
</table>

Flight-Proven in Space—Time After Time

RTSX-SU radiation-tolerant FPGAs are enhanced versions of Microchip's commercial SX-A family of devices specifically designed for enhanced radiation performance. Featuring SEU-hardened D-type flip-flops that offer the benefits of Triple Module Redundancy (TMR) without requiring cumbersome user intervention, the RTSX-SU family is a unique product for space applications.

- Very-low power consumption (up to 68 µW at standby)
- 3.3V and 5.0V mixed voltage
- Configurable I/O support for 3.3V/5V PCI, LVTTL, TTL and CMOS
- Secure programming technology protects against reverse engineering and design theft
- 100% circuit resource utilization with 100% pin locking
- Unique in-system diagnostic and verification capability with Silicon Explorer II
- Low-cost prototyping option
- Deterministic, user-controllable timing
- JTAG boundary scan testing in compliance with IEEE Standard 1149.1—dedicated JTAG reset (TRST) pin
- Highly reliable, nonvolatile antifuse technology
- 32,000 to 72,000 ASIC gates (48,000 to 108,000 system gates)
- Up to 360 user-programmable I/Os
- Hermetically-sealed packages for space applications (CQFP, CCGA/CLGA, CCLG)

RTSX-SU Devices

<table>
<thead>
<tr>
<th>RTSX-SU Devices</th>
<th>RTSX32SU</th>
<th>RTSX72SU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical Gates Capacity</td>
<td>32,000</td>
<td>72,000</td>
</tr>
<tr>
<td>System Gates Capacity</td>
<td>48,000</td>
<td>108,000</td>
</tr>
<tr>
<td>Combinatorial Cells Logic Module</td>
<td>1,800</td>
<td>4,024</td>
</tr>
<tr>
<td>SEU-Hardened Register Cells (D-Flip-Flops) Logic Module</td>
<td>1,080</td>
<td>2,012</td>
</tr>
<tr>
<td>Maximum Flip-Flops Logic Module</td>
<td>1,980</td>
<td>4,024</td>
</tr>
<tr>
<td>Maximum User I/Os Logic Module</td>
<td>227</td>
<td>360</td>
</tr>
<tr>
<td>Clocks Logic Module</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Quadrant Clocks Logic Module</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Speed Grades Logic Module</td>
<td>Std., –1</td>
<td>Std., –1</td>
</tr>
<tr>
<td>CQ Package Pins</td>
<td>84, 208, 256</td>
<td>208, 256</td>
</tr>
<tr>
<td>CG Package Pins</td>
<td>624</td>
<td></td>
</tr>
<tr>
<td>CC Package Pins</td>
<td>256</td>
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</tbody>
</table>

I/Os per Package

<table>
<thead>
<tr>
<th>RTSX-SU Devices</th>
<th>RTSX32SU</th>
<th>RTSX72SU</th>
</tr>
</thead>
<tbody>
<tr>
<td>CQ84</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>CQ208</td>
<td>173</td>
<td>170</td>
</tr>
<tr>
<td>CQ256</td>
<td>227</td>
<td>212</td>
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<tr>
<td>CC256</td>
<td>202</td>
<td></td>
</tr>
<tr>
<td>CG624</td>
<td>–</td>
<td>360</td>
</tr>
</tbody>
</table>

Note: The user I/Os include clock buffers.

### FPGA Packages

**CQ352**  
- b.s. 1.890" x 1.890" (48 mm x 48 mm)  
- h. RTAX—105 mils (2.67 mm)  
- h. RTG4—89 mils (2.25 mm)  
- p. 20 mils (0.50 mm)

**CQ256**  
- b.s. 1.417" x 1.417" (36 mm x 36 mm)  
- h. 105 mils (2.67 mm)  
- p. 20 mils (0.50 mm)

**CQ172**  
- b.s. 1.18" x 1.18" (29.972 mm x 29.972 mm)  
- h. 105 mils (2.67 mm)  
- p. 25 mils (0.64 mm)

**CQ132**  
- b.s. 0.95" x 0.95" (24.13 mm x 24.13 mm)  
- h. 105 mils (2.67 mm)  
- p. 25 mils (0.64 mm)

**CQ84**  
- b.s. 0.65" x 0.65" (16.51 mm x 16.51 mm)  
- h. 90 mils (2.29 mm)  
- p. 25 mils (0.64 mm)

**CG1152/LG1152**  
- RTAX2000S and RTAX2000SL only  
- b.s. 1.378" x 1.378" (35 mm x 35 mm)  
- h. CCGA—218 mils (5.535 mm)  
- h. LGA—129 mils (3.28 mm)  
- p. 39 mils (1.00 mm)

**CG896/LG896**  
- b.s. 1.220" x 1.220" (31 mm x 31 mm)  
- h. CCGA—218 mils (5.535 mm)  
- h. LGA—129 mils (3.28 mm)  
- p. 39 mils (1.00 mm)

---

**Note:** b.s. is nominal package body size excluding leads, h is package thickness, and p is pin/ball pitch.

FPGA Packages

CQ208
b.s. 1.15" x 1.15" (29.21 mm x 29.21 mm)
h. 105 mils (2.67 mm)
p. 20 mils (0.50 mm)

CQ196
b.s. 1.35" x 1.35" (34.29 mm x 34.29 mm)
h. 105 mils (2.67 mm)
p. 25 mils (0.64 mm)

CB1657/CG1657/LG1657
RT4G150
b.s. 1.693" x 1.693" (43 mm x 43 mm)
h. CBGA—156 mils (3.97 mm)
h. CCGA—213 mils (5.42 mm)
h. CLGA—126 mils (3.21 mm)
p. 39 mils (1.00 mm)

CG624/LG624
b.s. 1.27" x 1.27" (32.50 mm x 32.50 mm)
h. CCGA—194 mils (4.94 mm)
h. LGA—90 mils (2.30 mm)
p. 50 mils (1.27 mm)

CG484/LG484
b.s. 0.91" x 0.91" (23.00 mm x 23.00 mm)
h. CCGA—225 mils (5.72 mm)
h. LGA—138 mils (3.51 mm)
p. 7.5 mils (0.19 mm)

CG1272/LG1272
RTAX4000S, RTAX4000SL, only
b.s. 1.457" x 1.457" (37 mm x 37 mm)
h. CCGA—218 mils (5.535 mm)
h. CLGA—129 mils (3.28 mm)
h. CLGA—126 mils (3.21 mm)
p. 39 mils (1.00 mm)

CC256
b.s. 0.67" x 0.67" (17 mm x 17 mm)
h. 72 mils (1.847 mm)
p. 7.5 mils (0.19 mm)

Note: b.s. is nominal package body size excluding leads, h is package thickness, and p is pin/ball pitch.

For more information, see www.microsemi.com/products/fpga-soc/radtolerant-fpgas/military-aerospace-radiation-reliability-data
Libero® IDE for Microchip System-Critical Devices

Libero® IDE Should be Used for Designing With Antifuse and Legacy Flash FPGAs

Libero IDE supports:

- SX/SX-A (including RTSX/-S/-SU)
- Axcelerator (including RTAX-S, RTAX-DSP)

Microchip system-critical FPGAs are fully supported by Libero Integrated Design Environment (IDE) software. Libero IDE is an integrated design manager that integrates design tools while guiding the user through the design flow, managing all design and log files and passing necessary design data among tools. Libero IDE allows users to integrate both schematic and HDL synthesis into a single flow and verify the entire design in a single environment. Libero IDE includes Synplify Pro® AE from Synopsys®, ModelSim® HDL Simulator from Mentor Graphics and design implementation software from Microchip.

Designer software includes sophisticated place-and-route features plus a comprehensive suite of backend support tools for timing constraints, timing and power analysis, I/O attribute and pin assignment, and much more.

Our SmartDesign tool simplifies the use of Microchip’s IP in user designs and offers a simple way to build on-chip processors with custom peripherals. Most IP cores are now included by default in Libero IDE as either obfuscated or RTL versions, depending on the license selected.

For embedded designers, we offer SoftConsole Eclipse-based IDE for use with Arm® Cortex®-M1 and Cortex-M3, and Core8051s, as well as evaluation versions from Keil™ and IAR Systems®, full versions are available from the respective suppliers.

FPGA Design Support

<table>
<thead>
<tr>
<th>Libero® IDE Licenses</th>
<th>Gold</th>
<th>Platinum</th>
<th>Standalone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device Support</td>
<td>All families</td>
<td>Up to 1,500,000 gates</td>
<td>All devices</td>
</tr>
<tr>
<td>Microchip IP</td>
<td>Libero IP bundle obfuscated and selected RTL IPs</td>
<td>RTL for Libero IP bundle cores</td>
<td>RTL for Libero IP bundle cores</td>
</tr>
<tr>
<td>Synthesis</td>
<td>Synplify® Pro ME</td>
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<td>✓</td>
</tr>
<tr>
<td>Simulation</td>
<td>ModelSim® ME</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Debug</td>
<td>Identify® ME</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Microchip Debug</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Program File</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Note: FPGA programming is only supported in Windows® XP Pro, Windows Vista and Windows 7.

Operating System Support

<table>
<thead>
<tr>
<th>Tool</th>
<th>Libero® IDE</th>
<th>SoftConsole</th>
<th>Keil</th>
<th>IAR</th>
<th>FlashPro</th>
<th>FlashPro USB Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows® XP Professional</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Now (32-bit and 64-bit)</td>
</tr>
<tr>
<td>Windows 7 Professional</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Now (32-bit and 64-bit)</td>
</tr>
<tr>
<td>RHEL 5 (Tikanga)1</td>
<td>✓</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
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<tr>
<td>RHEL 6 (Tikanga)2</td>
<td>✓</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

For more information, see www.microsemi.com/products/fpga-scc/design-resources/design-software/libero-ide
RTG4 Development Kit

The RTG4 Development Kit provides space customers with an evaluation and development platform for applications such as data transmission, serial connectivity, bus interface and high-speed designs using the latest radiation-tolerant, high-density, high-performance FPGA family, RTG4. The development board features an RT4G150 device offering more than 150,000 logic elements in a ceramic package with 1,657 pins.

The RTG4 Development Kit board includes the following features:

- Two 1 GB DDR3 synchronous dynamic random access memory (SDRAM)
- 2 GB SPI Flash memory
- PCI Express Gen1 ×1 interface
- PCIe x4 edge connector
- One pair of SMA connectors for testing of the full-duplex SERDES channel
- Two FMC connectors with HPC/LPC pinout for expansion
- RJ45 interface for 10/100/1000 Ethernet
- USB micro-AB connector
- Headers for SPI, GPIOs
- FTDI programmer interface to program the external SPI Flash
- JTAG programming interface
- RVI header for application programming and debug
- Embedded FlashPro5 programmer
- Flashpro programming header available if external programmer is used
- Embedded Trace Macro (ETM) cell header for debug
- Dual In-Line Package (DIP) switches for user application
- Push-button switches and LEDs for demo purposes
- Current measurement test points

For more information, see [www.microsemi.com/products/fpga-soc/design-resources/dev-kits/rtg4-development-kit](http://www.microsemi.com/products/fpga-soc/design-resources/dev-kits/rtg4-development-kit)

RTG4 Design Software—Libero SoC

Microchip’s Libero System-on-Chip (SoC) Design Suite offers high productivity with its comprehensive, easy-to-learn, easy-to-adopt development tools for designing with Microchip’s RTG4 FPGAs. The suite integrates industry-standard Synopsys Synplify Pro® synthesis and Mentor Graphics ModelSim® simulation with best-in-class constraints management and debug capabilities.

Features

- Design entry—multiple approaches using SmartDesign, HDL, or embedded design flows
- Simulation—functional, gate-level, and timing verification using Mentor Graphics ModelSim ME
- Synthesis—design optimization for power and performance using Synopsys Synplify Pro ME and Synphony Model Compiler ME
- Place and route—advanced, incremental, power-driven, and multi-pass layout options
- Power analysis—in-depth visualization of power consumption for each individual design element using SmartPower
- Timing analysis—support for multiple constraint scenarios to optimize timing using SmartTime
- Programming—complete solution with industry’s first Secure Production Programming Solution (SPPS)
- Debug—best-in-class debug solution with SmartDebug and Synopsys Identify ME

Easy to Learn

- Intuitive design flow
- GUI wizards guiding through the design process

Easy to Adopt

- Rich IP library of DirectCores and CompanionCores
- Availability of complete reference designs and development kits

For more information, see [www.microsemi.com/products/fpga-soc/design-resources/design-software/libero-soc](http://www.microsemi.com/products/fpga-soc/design-resources/design-software/libero-soc)
Intellectual Property Cores for System Critical FPGAs

Microchip has more than 180 Intellectual Property (IP) products designed and optimized to support communications, consumer, military, industrial, automotive and aerospace markets. Microchip IP solutions streamline designs, enable faster time-to-market, and minimize design costs and risk. Microchip IP cores are accessible through the Libero design suite of development tools through the SmartDesign IP design interface. Many cores feature firmware drivers accessible through the firmware catalog tool. Integrated solutions are also available, featuring IP and highlighting the advantages of Microchip’s intrinsically low-power FPGAs.

**MIL-STD-1553B IP Cores**

MIL-STD-1553 is a command/response, dual-redundant, time-multiplexed serial data bus used in severe environments. Microchip Core1553 IP cores provide robust, fully tested MIL-STD-1553A and B implementations that are compatible with legacy 1553 solutions. We provide everything needed to incorporate one or more 1553B cores into a system design. Core1553BRM, Core1553BRT, Core1553BRT-EBR, and Core1553BBC are available.

**Core1553BRM**
- Compliant to MIL-STD-1553A and B
- Bus Controller (BC), Remote Terminal (RT), and Monitor Terminal (MT)
- Simultaneous RT/MT operation
- 12, 16, 20, or 24 MHz clock operation
- Built-in test capability

**Digital Signal Processing IP Cores**

Microchip Digital Signal Processing (DSP) cores deliver digital filtering and signal processing capabilities. Cores taking advantage of on-chip multiplier blocks in Microchip’s RTAX-DSP and new RTG4 devices offer outstanding performance in spaceflight applications.

**CoreFFT**
- Highly parameterizable DirectCore RTL generator optimized for the RTAX-DSP and RTG4 families support forward and inverse complex FFT
- Transforms sizes from 32 to 8,192 points
- 8-to 32-bits I/O real and imaginary data and twiddle coefficients
- Two’s complement I/O data
- Bit-reversed or natural output order
- Selection of unconditional or conditional block floating point scaling
- Embedded RAM-block-based twiddle LUT
- Built-in memory buffers with optional extensive or minimal memory buffering configurations
- Handshake signals to facilitate easy interface to user circuitry

**CoreFIR**
- Highly parameterizable DirectCore RTL generator optimized for the RTAX-DSP and RTG4 families implement a range of filter types, including single rate fully enumerated (parallel), single-rate folded (semi-parallel) filter and multi-rate polyphase interpolation FIR filter
- Performance up to 124 MHz
- Supports up to 1,024 FIR filter taps
- Run-time reloadable coefficients, multiple coefficient sets, or fixed coefficients
- 2-bit to 18-bit input data and coefficient precision
- Signed or unsigned data and coefficients
- Full precision output
- Coefficient symmetry optimization (on the fully enumerated filters)

For more information and additional IP cores, see [www.microsemi.com/products/fpga-soc/design-resources/ip-cores](http://www.microsemi.com/products/fpga-soc/design-resources/ip-cores)
With the introduction of Microchip’s RTAX-S/SL devices, you now have access to the most powerful FPGAs available for aerospace and radiation-intensive applications. Prototype verification is an important step in system integration where accurate behavioral simulation and static timing analysis are crucial. Since the enhanced radiation characteristics of radiation-tolerant devices are not required during the prototyping phase of the design, we have developed various prototyping options for RTAX-S/SL for early design development and functional verification.

Prototyping with Axcelerator Units
The prototyping solution using the commercial Axcelerator devices consists of two parts.

- A well-documented design flow that allows the customer to target an RTAX-S/SL design to the equivalent commercial Axcelerator device
- A set of extender circuit boards that map the commercial device package to the appropriate RTAX-S/SL package footprint

This methodology provides the user with a cost-effective solution while maintaining the short time-to-market associated with Microchip FPGAs.

Prototyping with RTAX-S/SL/DSP or RTSX-SU PROTO Units
The RTAX-S/SL/DSP or RTSX-SU PROTO units offer a prototyping solution that can be used for final timing verification of the flight design. The RTAX-S/SL/DSP or RTSX-SU PROTO prototype units have the same timing attributes as the RTAX-S/SL/DSP or RTSX-SU flight units. Prototype units are offered in non-hermetic ceramic packages. The prototype units include PROTO in their part number, and PROTO is marked on devices to indicate that they are not intended for space flight. They also are not intended for applications that require the quality of spaceflight units, such as qualification of spaceflight hardware. RT-PROTO units offer no guarantee of hermeticity, and no MIL-STD-883B processing. At a minimum, you should plan on using class B level devices for all qualification activities. The RT-PROTO units are electrically tested in a manner to guarantee their performance over the full military temperature range. The RT-PROTO units will also be offered in –1 or standard speed grades, so as to enable customers to validate the timing attributes of their space designs using actual flight silicon.

RTAX-S/SL Prototyping with Flash Devices
Aldec’s RTAX-S/SL prototyping solution allows customers to take advantage of Flash-based reprogrammable ProASIC3 devices. Aldec provides software that remaps antifuse primitives to Flash, which reduces design time and cost. In addition, the hardware adapter is footprint compatible with RTAX-S/SL; therefore, you do not need to redesign a new board for prototyping.

For more information, see www.microsemi.com/products/fpga-soc/radtolerant-fpgas/prototyping-solutions
Prototyping With RTG4 PROTO Units

RTG4 PROTO FPGAs offer a development and prototyping solution for development and final timing validation of the flight design. As the RTG4 PROTO units use the same reprogrammable Flash technology as the flight units, the PROTO devices can be reprogrammed many times without removing them from the development board. The RTG4 PROTO prototype units have the same timing attributes as the RTG4 flight units, including support for the same speed grades as the flight parts. The RT-PROTO units are electrically tested in a manner to guarantee their performance over the full military temperature range. Prototype units are offered in non-hermetic, ceramic packages. The prototype units include PROTO in their part number, and PROTO is marked on devices to indicate that they are not intended for space flight. They are also not intended for applications that require the quality of spaceflight units, such as qualification of spaceflight hardware. RT-PROTO units offer no guarantee of hermeticity, and no Mil-STD-883 class B processing. At a minimum, users should plan on using class B devices for all qualification activities.

Package Prototyping Solutions

Microchip has developed multiple low-cost prototyping solutions for RTAX-S/SL devices that ultimately are packaged in CQFP or CCGA for the production system. These solutions utilize the Axcelerator family Fine Pitch Ball Grid Array (FBGA) or Ceramic Land Grid Array (CLGA) packages as prototyping vehicles:

- CQFP to FBGA adapter socket
- CQFP to CLGA adapter socket
- CCGA to FBGA adapter socket
- CCGA to CLGA adapter socket

The CQFP to FBGA adapter sockets have an FBGA configuration on the top and a CQFP configuration on the bottom. The adapter sockets enable customers to use a commercial Axcelerator FG package during prototyping, then switch to an equivalent CQ256 or CQ352 package for production.

<table>
<thead>
<tr>
<th>Adapter Socket</th>
<th>Ordering Part Number</th>
<th>Prototyped and Prototype Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>CQ352 to FG484</td>
<td>SK-AX250-CQ352RTFG484S</td>
<td>For prototyping RTAX250S/L-CQ352 or AX250-CQ352 using AX250-FG484 package</td>
</tr>
<tr>
<td>CQ352 to FG896</td>
<td>SK-AX1-AX2-KITTOP and SK-AX1-CQ352-KITBTM</td>
<td>For prototyping RTAX1000S/L-CQ352 or AX1000-CQ352 using AX1000-FG896 package</td>
</tr>
<tr>
<td>CQ352 to FG896</td>
<td>SK-AX1-AX2-KITTOP and SK-AX2-CQ352-KITBTM</td>
<td>For prototyping RTAX2000S/L-CQ352 or AX2000-CQ352 using AX2000-FG896 package</td>
</tr>
<tr>
<td>CQ256 to FG896</td>
<td>SH-AX2-CQ256-KITTOP and SK-AX2-CQ256-KITBTM</td>
<td>For prototyping RTAX2000S/L-CQ352 or AX2000-CQ256 using AX2000-FG896 package</td>
</tr>
<tr>
<td>CG624 to FG484</td>
<td>SK-SX72-CG624RTFG484</td>
<td>For prototyping RTSX72SU-CG624 or A54SX72A-CG624 using A54SX72A-FG484 package</td>
</tr>
<tr>
<td>CG624 to FG896</td>
<td>SK-AX1-AX2-KITTOP and SK-AX1-CG624-KITBTM</td>
<td>For prototyping RTAX1000S-CG624, RTAX1000SL-CG624, or AX1000-CG624 using AX1000-FG896 package</td>
</tr>
</tbody>
</table>

Daisy-chained Packages

To facilitate the qualification of a target FPGA device socket and board assembly practices without using costly flight-quality parts, Microchip offers certain Ceramic Column Grid Array (CCGA) and Ceramic Land Grid Array (CLGA) packages with adjacent pairs of pins tied together. By assembling these packages onto a qualification PC board that is laid out with adjacent pairs of solder pads tied together but offset by one pin as compared to the package, a single signal can be fed into one pin of the package and routed into and out of the entire package in a serial daisy chain fashion so all pins of the package are used. This is useful for performing continuity and impedance tests to validate board assembly techniques with surface-mount grid array packages. Microchip’s daisy chain packages feature metal routing tracks between adjacent pairs of package pins, internal to the package. For package qualification, an unbonded silicon die is included in the package.

<table>
<thead>
<tr>
<th>Microchip Part Number</th>
<th>Mechanical Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>LG624 DAISY CHAIN-1</td>
<td>624-pin CLGA</td>
</tr>
<tr>
<td>LG1152 DAISY CHAIN</td>
<td>1152-pin CLGA</td>
</tr>
<tr>
<td>LG1272 DAISY CHAIN</td>
<td>1272-pin CLGA</td>
</tr>
<tr>
<td>LG1657 DAISY CHAIN</td>
<td>1657-pin CLGA</td>
</tr>
<tr>
<td>CG484 DAISY CHAIN</td>
<td>484-pin CCGA</td>
</tr>
<tr>
<td>CG624 DAISY CHAIN SIX</td>
<td>624-pin CCGA</td>
</tr>
<tr>
<td>CG896 DAISY CHAIN</td>
<td>896-pin CCGA</td>
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<tr>
<td>CG1152 DAISY CHAIN</td>
<td>1152-pin CCGA</td>
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<tr>
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</tr>
<tr>
<td>CG1657 DAISY CHAIN</td>
<td>1657-pin CCGA</td>
</tr>
</tbody>
</table>
Device Programming

Silicon Sculptor 3
The Silicon Sculptor 3 programmer, which supports both antifuse and Flash FPGAs, delivers high data throughput and promotes ease-of-use, while lowering the overall cost of ownership. The Silicon Sculptor 3 programmer includes a high-speed USB 2.0 interface that enables customers to connect multiple programmers to a single PC. This enables an easily expandable, low to medium volume production programming system to be dynamically assembled. Through the use of universal Microchip socket adapters, the Silicon Sculptor 3 programs Microchip packages, including PLCC, PQFP, VQFP, TQFP, QFN, PBGA, FBGA, CSP, CPGA, CQFP, CCGA and CLGA.

FlashPro4 and FlashPro5
The FlashPro4 and FlashPro5 programmers for Flash FPGAs utilize a JTAG interface, where a single JTAG chain can be used for multiple Flash devices on a JTAG chain. In-system programming using the JTAG port adds the flexibility of field upgrades or post-assembly production-line characterization. The elimination of expensive sockets on the board results in significantly-reduced production costs.

All FlashPro programmers use JEDEC-standard STAPL files, meaning there are no algorithms built into the software. The FlashPro software and user interface support FlashPro4, and FlashPro5 programmers, eliminating the need to learn new software to switch from one hardware programmer to another.

For more information, see www.microsemi.com/products/fpga-soc/design-resources/programming-debug or https://soc.microsemi.com/Portal/Default.aspx
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Tel: 86-769-8702-9880

China - Guangzhou
Tel: 86-20-8755-8029

China - Hangzhou
Tel: 86-571-8792-8115

China - Hong Kong SAR
Tel: 852-2943-5100

China - Nanjing
Tel: 86-25-8473-2460

China - Qingdao
Tel: 86-53-890-7355

China - Shanghai
Tel: 86-21-3326-8000

China - Shenyang
Tel: 86-24-2334-2829

China - Shenzhen
Tel: 86-755-8864-2200

China - Suzhou
Tel: 86-186-6233-1526

China - Wuhan
Tel: 86-27-5980-5300

China - Xi’An
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India - Pune
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Korea - Daegu
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Korea - Seoul
Tel: 82-2-554-7200

Malaysia - Kuala Lumpur
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Malaysia - Penang
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Philippines - Manila
Tel: 63-2-634-9065

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Tel: 65-6334-8870

Taiwan - Hsin Chu
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Vietnam - Ho Chi Minh
Tel: 84-28-544-2100