RTG4 Radiation Tolerant FPGA Update
Ken O’Neill
Director of Marketing, Space and Aviation
Microsemi – a Microchip Company
Microchip Corporate Overview

- Headquartered in Chandler, AZ
- ~ $6 Billion revenue run rate
- ~19,000 employees
- Leading Total Systems Solutions provider
End-Market Diversification

**Microchip**
- Communication: 5%
- Computing: 9%
- Consumer: 24%
- Automotive: 25%
- Industrial: 35%
- Aerospace & Defense: 2%
- Other: 2%

Total: $3.9bn

**Microsemi**
- Industrial: 11%
- Computing: 20%
- Communications: 31%
- Aerospace & Defense: 29%
- Other: 9%

Total: $1.8bn

**Combined**
- Industrial: 27%
- Computing: 12%
- Data Center: 13%
- Communications: 16%
- Automotive: 17%
- Consumer: 16%
- Other: 3%
- Aerospace & Defense: 11%

Total: $5.7bn

Note: Reflects non-GAAP financials and end market diversification is based on management estimates.
## Delivering A Comprehensive Space Portfolio

<table>
<thead>
<tr>
<th><strong>Rad-Tolerant &amp; RHBD</strong></th>
<th>Pin for pin, COTS equivalent – QML rad tolerant &amp; RHBD 8-bit &amp; 32-bit AVR &amp; ARM core microcontrollers, ADC, SpaceWire Routers, Gbit PHY &amp; switch, CAN, memory</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MCUs, Comm &amp; Mem</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Radiation-Tolerant</strong></td>
<td>High Performance, High Density, Low Power TID up to 300 Krad, SEL Immune RTG4 FPGAs up to 300 MHz and 150K LE RTProASIC3, RTAX and RTSX-SU QML Qualified</td>
</tr>
<tr>
<td><strong>FPGAs</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Rad-Hard</strong></td>
<td>Telemetry and Motor Control Space System Managers High Side Drivers Regulators and PWMs Extensive Custom IC Capability</td>
</tr>
<tr>
<td><strong>Mixed Signal</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Integrated Circuits</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Space</strong></td>
<td>Ovenized Quartz Oscillators Hybrid Voltage Controlled and Temperature Compensated Crystal Oscillators Cesium Clocks</td>
</tr>
<tr>
<td><strong>Qualified Oscillators</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Rad-Hard</strong></td>
<td>Rad-hard JANS Diodes, Bi-Polar Small Signal Transistors Rad-hard Isolated DC-DC Converter Modules Custom Power Supplies 2 W to &gt; 5 KW Point of Load Hybrid Solutions Electromechanical Relays</td>
</tr>
<tr>
<td><strong>Power Solutions</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Space Screening for</strong></td>
<td>Surface Acoustic Wave (SAW) Filters Packaged and Chip Si Diodes Si Bipolar Transistors &amp; GaAs pHEMT MMICs</td>
</tr>
<tr>
<td><strong>RF Products</strong></td>
<td></td>
</tr>
</tbody>
</table>
RTG4 Reliability and Radiation Update
# RTG4 Product Overview

## Resources

<table>
<thead>
<tr>
<th>Resources</th>
<th>RT4G150</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic Elements (TMR Register + 4-Input C Logic)</td>
<td>151,824</td>
</tr>
<tr>
<td>18x18 Multiply-Accumulate Blocks</td>
<td>462</td>
</tr>
<tr>
<td>RAM Mbits (1.5 Kbit and 24 Kbit Blocks, with ECC)</td>
<td>5.2</td>
</tr>
<tr>
<td>UROM Kbits</td>
<td>381</td>
</tr>
<tr>
<td>DDR2/3 SDRAM Controller (with ECC)</td>
<td>2 x 32</td>
</tr>
<tr>
<td>PCI Express Endpoints</td>
<td>2</td>
</tr>
<tr>
<td>Globals</td>
<td>24</td>
</tr>
<tr>
<td>PLLs (Rad Tolerant)</td>
<td>8</td>
</tr>
<tr>
<td>SpaceWire Clock and Data Recovery Circuits</td>
<td>16</td>
</tr>
<tr>
<td>User IO (excluding SERDES)</td>
<td>720</td>
</tr>
<tr>
<td>SERDES lanes (3.125 Gbps)</td>
<td>24</td>
</tr>
<tr>
<td><strong>Hermetic, Ceramic Packages</strong></td>
<td></td>
</tr>
<tr>
<td>CG1657 (Ceramic Column Grid Array, Six Sigma Columns)</td>
<td>Available Now</td>
</tr>
<tr>
<td>LG1657 (Ceramic Land Grid Array, No Solder Termination)</td>
<td></td>
</tr>
<tr>
<td>CB1657 (Ceramic Ball Grid Array, For Prototyping Only)</td>
<td></td>
</tr>
<tr>
<td>CQ352 (Ceramic Quad Flat Pack)</td>
<td>Samples Now</td>
</tr>
<tr>
<td>Package Body Size</td>
<td>42.5 mm x 42.5 mm</td>
</tr>
</tbody>
</table>

## Package Body Size

- **Available Now**: CG1657, LG1657, CB1657
- **Samples Now**: CQ352
- **Flight Units Mid 2019**: None
QML Class Q and Class V qualification completed

SMD 5962-16208

SMD has been approved and is posted on DLA web site

RTG4 FPGAs can be ordered using SMD number or Microsemi part number

RTG4 FPGAs are now dual marked with SMD number and Microsemi part number

SMD numbers on Microsemi web site in DLA Cross Reference Guide

Plan to pursue QML Class Q and Class V for CQ352
  • RT4G150 in CQ352 B and E flows will be added to SMD after MIL-STD-883B qualification completes in mid 2019
  • RT4G150 in CQ352 QML Class Q and Class V qualification in 2020
The Long Road to Qualification

- Design Kick-Off
- Tape Out
- Fab Out
- First Customer Shipments
- First Commercial G4 Software (Early Access)
- First RTG4 Software (Early Access)
- First Commercial G4 Software (Production)
- First RTG4 Software (Production)
- Mil Std 883B Qualification
- QML Class Q Qualification
- QML Class V Qualification
- RTG4 Software Update
- Production Software Update
Low power grade (–L) for RTG4 standard speed (-STD) available NOW

- 25% quiescent supply current reduction: from 4.1 A to 3.1 A at 125 °C
- RT4G150L device setting available in Libero SoC v12.0 and power calculator
- RTG4 continues to be **best in class**
RTG4 Radiation Summary

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Ionizing Dose</td>
<td>Stays within parametric limits &gt; 125 Krad (Si)</td>
</tr>
<tr>
<td>Single Event Latch-Up</td>
<td>No failure at facility limit of 103 MeV-cm²/mg, 100 °C</td>
</tr>
<tr>
<td>Configuration Upset</td>
<td>No failure at facility limit of 103 MeV-cm²/mg, 100 °C</td>
</tr>
<tr>
<td>Flip-Flop Single Event Upset</td>
<td>2.6E-12 errors/bit-day, GEO solar minimum, 1 MHz</td>
</tr>
<tr>
<td>LSRAM Single Event Upset</td>
<td>2.0E-7 errors/bit-day, GEO solar min (no EDAC)</td>
</tr>
<tr>
<td>uSRAM Single Event Upset</td>
<td>3.1E-8 errors/bit-day, GEO solar min (no EDAC)</td>
</tr>
</tbody>
</table>
## RTG4 Radiation Effects Update

<table>
<thead>
<tr>
<th>Test</th>
<th>Environment</th>
<th>Test Schedule</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabric, SRAM and PLL SEE</td>
<td>Proton</td>
<td>Complete</td>
<td>Report available on Microsemi Web</td>
</tr>
<tr>
<td>SERDES SEE</td>
<td>Proton</td>
<td>UCD in 10/2018</td>
<td>Less link loss than previous HI testing Report in progress</td>
</tr>
<tr>
<td>SERDES SEE</td>
<td>Heavy Ion</td>
<td>LBNL in 10/2018</td>
<td>Report in progress</td>
</tr>
<tr>
<td>In-Beam Programming</td>
<td>Proton</td>
<td>UCD in 10/2018</td>
<td>Data available – contact Microsemi</td>
</tr>
<tr>
<td>In-Beam Programming</td>
<td>Heavy Ion, Low dose rate Heavy Ion</td>
<td>LBNL in 2016 TAMU in 9/2018</td>
<td>Data available – contact Microsemi Additional report in progress</td>
</tr>
<tr>
<td>PLL SEE including TMR</td>
<td>Heavy Ion</td>
<td>TAMU in 2016 TAMU in 11/2018</td>
<td>Report available on Microsemi Web Additional report in progress</td>
</tr>
<tr>
<td>Fabric DDR Controller SEE</td>
<td>Heavy Ion</td>
<td>Completed, LBNL 2018</td>
<td>Report available on Microsemi Web</td>
</tr>
<tr>
<td>MSIO SEE</td>
<td>Heavy Ion</td>
<td>Complete</td>
<td>Report available on Microsemi Web</td>
</tr>
<tr>
<td>POR</td>
<td>Heavy Ion</td>
<td>Complete</td>
<td>Data available – contact Microsemi Report in progress</td>
</tr>
<tr>
<td>CCC blocks (Div, Mux, etc)</td>
<td>Heavy Ion</td>
<td>To be scheduled</td>
<td>Pending facility schedule</td>
</tr>
<tr>
<td>TID (leakage current and propagation effects)</td>
<td>Gamma, X-ray</td>
<td>Complete (X-ray) Ongoing / per wafer lot (Gamma)</td>
<td>Reports available on Microsemi Web</td>
</tr>
<tr>
<td>TID (retention effects)</td>
<td>Gamma, HTOL</td>
<td>Complete</td>
<td>Reports available</td>
</tr>
</tbody>
</table>
RTG4 Availability and Qualification Schedule

- QML class Q and V qualification: **Completed!**
  - RTG4 can be ordered to DLA SMD part number
  - DLA SMD part numbers on [Microsemi web site](#)
- RT4G150 PROTO FPGAs: Now
- RT4G150 development kit: Now
- CG1657 B, E, and V-flow flight units: Available to lead time now
- CG1657 daisy chain packages: Now
- CQ352 B-flow flight units: mid 2019
- CQ352 engineering models: Available to lead time now
Sub-QML FPGAs
Objective
- Create versions of RT FPGAs that can meet aggressive price targets to win business in New Space programs that would not use traditional B / E / V flow FPGAs

Requirements
- Reduction in cost and price
- Faster lead-time / cycle-time

Sub-QML RT FPGAs
- Ceramic – R Flow (Reduced Flow) and Mil Temp Hermetic
- Plastic Package – Industrial temperature, Military temperature
Cost and COTS

- Satellite operators are seeking lower acquisition cost and faster service entry
- Commercial Off The Shelf (COTS) components to reduce cost and lead-time
- The cost of COTS – lower component cost, higher cost of ownership

<table>
<thead>
<tr>
<th></th>
<th>General Industry COTS</th>
<th>QML Rad Tolerant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Cost</td>
<td>✓ Low</td>
<td>✗ High</td>
</tr>
<tr>
<td>Leadtime</td>
<td>✓ Short</td>
<td>✗ Long</td>
</tr>
<tr>
<td>Space-flight Heritage</td>
<td>✗ No</td>
<td>✓ Yes</td>
</tr>
<tr>
<td>Supplier Tech Support</td>
<td>✗ No</td>
<td>✓ Yes</td>
</tr>
<tr>
<td>Radiation Data and Support</td>
<td>✗ No</td>
<td>✓ Yes</td>
</tr>
<tr>
<td>Reliability Data and Support</td>
<td>✗ No</td>
<td>✓ Yes</td>
</tr>
<tr>
<td>Lot Traceability, Homogeneity</td>
<td>✗ No</td>
<td>✓ Yes</td>
</tr>
</tbody>
</table>

Addressing these shortcomings results in hidden cost for organizations using COTS in space systems.
Significant Gap between QML and COTS

Qualification
Rad Characterization
Traceability
Lot Homogeneity

- Highest Levels of Qualification
- Flight Heritage
- Radiation Support
- Traceability and Homogeneity

QML Class Q
Radiation Hardened
By Design

Commercial
Off The Shelf

- No Flight Heritage Information
- No Radiation Support
- No Traceability and Homogeneity
- High Cost of Ownership

QML Class V
Radiation Hardened
By Design

Component Cost
Sub-QML: Bridging the Gap Between QML and COTS

Qualification
Rad Characterization
Traceability
Lot Homogeneity

Commercial
Off The Shelf

Sub-QML: Bridging the Gap Between QML and COTS

Sub-QML Hermetic Pkg
Radiation Hardened
By Design

Sub-QML Plastic Pkg
Radiation Hardened
By Design

QML Class Q
Radiation Hardened
By Design

QML Class V
Radiation Hardened
By Design

• Flight Heritage / Baselined
• Radiation Support
• Traceability and Homogeneity
• Lower Cost than QML Components

Component Cost
Sub-QML Components

- Reducing or eliminating QML testing and documents removes a lot of cost
- Elimination of solder columns removes cost and reduces lead times
- Plastic packaging reduces cost still further

<table>
<thead>
<tr>
<th></th>
<th>General Industry COTS</th>
<th>QML Rad Tolerant</th>
<th>Sub-QML RT Hermetic</th>
<th>Sub-QML RT Plastic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Cost</td>
<td>✓ Lowest</td>
<td>✗ High</td>
<td>✓ Lower</td>
<td>✓ Lower</td>
</tr>
<tr>
<td>Leadtime</td>
<td>✓ Shortest</td>
<td>✗ Long</td>
<td>✓ Shorter</td>
<td>✓ Shorter</td>
</tr>
<tr>
<td>Space-flight Heritage</td>
<td>✗ No</td>
<td>✓ Yes</td>
<td>✓ Yes</td>
<td>✓ Yes</td>
</tr>
<tr>
<td>Supplier Tech Support</td>
<td>✗ No</td>
<td>✓ Yes</td>
<td>✓ Yes</td>
<td>✓ Yes</td>
</tr>
<tr>
<td>Radiation Data and Support</td>
<td>✗ No</td>
<td>✓ Yes</td>
<td>✓ Yes</td>
<td>✓ Yes</td>
</tr>
<tr>
<td>Reliability Data and Support</td>
<td>✗ No</td>
<td>✓ Yes</td>
<td>✓ Yes</td>
<td>✓ Yes</td>
</tr>
<tr>
<td>Lot Traceability, Homogeneity</td>
<td>✗ No</td>
<td>✓ Yes</td>
<td>✓ Yes</td>
<td>✓ Yes</td>
</tr>
</tbody>
</table>
Update:
RHBD Mixed Signal IC
Chip Scale Atomic Clock
## Microsemi Mixed Signal Space Portfolio Radiation Testing

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Total Dose</th>
<th>Single Event</th>
<th>ELDRS</th>
<th>Prompt</th>
</tr>
</thead>
<tbody>
<tr>
<td>LX7730</td>
<td>RT telemetry controller SSM QML certified Q and V • RADECS 2016 • RADECS 2017</td>
<td>✔ 300krad(Si)</td>
<td>✔ 87 MeV.cm²/mg and 125°C</td>
<td>✔ 50krad(Si)</td>
<td>✔ (contact factory)</td>
</tr>
<tr>
<td>LX7720</td>
<td>RT motor/position controller SSM Q and V quals in process • RADECS 2018 • NSREC 2018</td>
<td>✔ 100krad(Si) (300krad planned)</td>
<td>✔ 87 MeV.cm²/mg and 125°C</td>
<td>planned</td>
<td>planned</td>
</tr>
<tr>
<td>LX7710</td>
<td>RT 8 pair 125V diode array QML certified Q and V</td>
<td>✔ 100krad(Si)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>AAHS298B</td>
<td>RT 8 ch high side driver QML certified Q and V</td>
<td>✔ 100krad(Si)</td>
<td>✔ 117 MeV.cm²/mg and 125°C</td>
<td>✔ 100krad(Si)</td>
<td>✔</td>
</tr>
</tbody>
</table>

Links to product pages

Links to radiation test reports
Space CSAC – Radiation Tolerant

- Only Chip Scale Atomic Clock available for Space
- Offered as a COTS part
- Rad tolerant for wide range of LEO applications
- Tested to 20kRad TID
- Proton tested at 64 MeV-cm²/mg
  - Regains lock after proton bombardment
  - Retains frequency accuracy and aging rate
- Shock, Steady state Life, TVAC tested
- LDC Qualification Process: TID test to 20 kRad of components
- Each Space CSAC build use only LDC qualified parts for TCXO and PBCA combination
- New PTTI Paper and presentation available soon
  - Contact Microsemi to request paper and presentation
Sign up to receive quarterly updates on:
- Parts, packages, screening levels
- Radiation data
- Product qualification
- PCN, CN, PDN
- IP and Software tools
- And much more

RT FPGAs
RHBD Mixed Signal ICs
Power discretes and modules
Clocks and Oscillators
RT and RHBD Microprocessors and Microcontrollers

Sign up here!