

GR712RC: RH Dual Core LEON3FT

qualifications and radiation testing

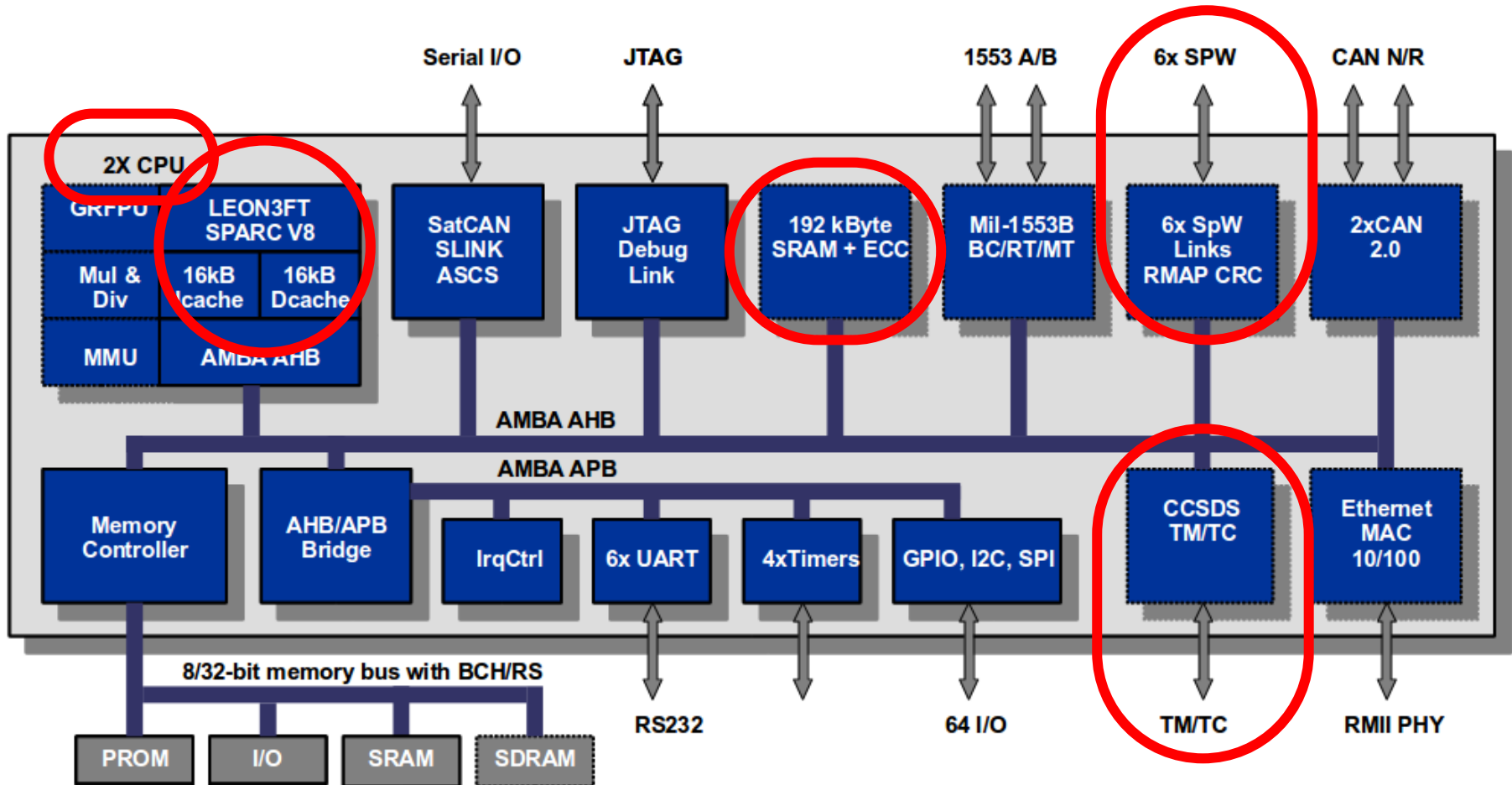
Prof. Ran Ginosar
CEO, Ramon Chips [Israel]

MAPLD 2011

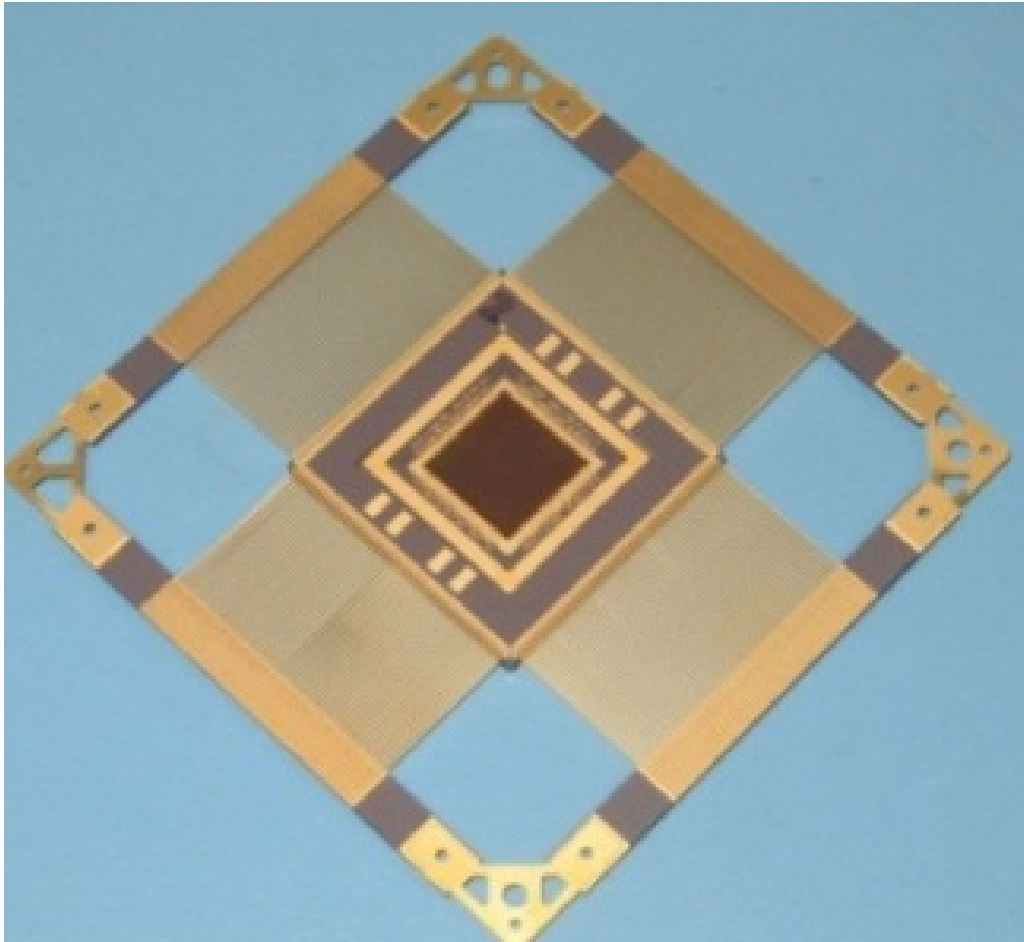
GR712RC: RH Dual Core LEON3FT

- Made in collaboration by Aeroflex Gaisler (Sweden) and Ramon Chips (Israel)
 - Funded (in part) by Israel Aerospace Industries (IAI)
 - Fabricated as a single batch in 2010
 - Passed all tests and radiation tests
 - Qualification by 2012
 - Already adopted for some space missions
- Marketed globally by Aeroflex Gaisler
- ITAR free

GR712RC: complex SoC, rich I/O



GR712RC: Robust Package



- CQFP 240
- 0.5 mm pitch
- 32x32 mm
- Hermetic seal
- Safe at temp cycles
- Easy to solder

GR712RC: Die

- 12 x 12 mm
- 600 kGates
- 36 Mtransistors
- 3 Mbit SRAM in 108 cores
- 2 all digital DLLs



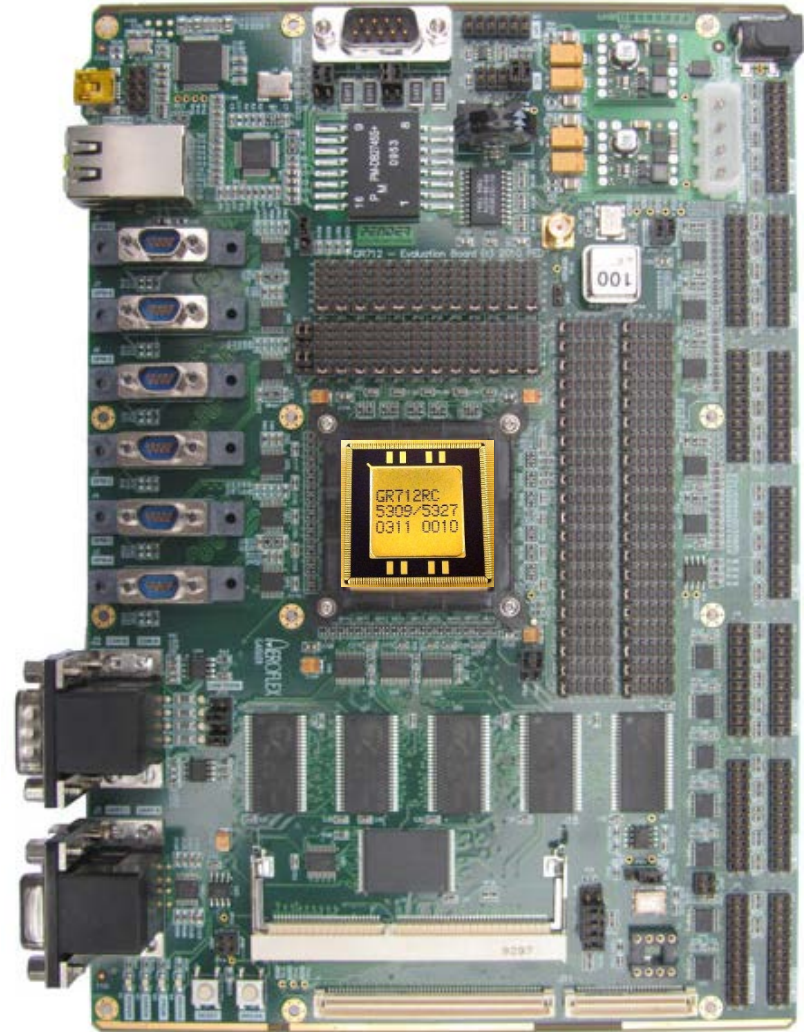
RadSafe™ Design-for-Reliability

Rad / Rel	Effect	Mitigation
Radiation effects	TID	layout
	SEL	layout
	SEU/SET in flip-flops	SEP FFs, layout
	SEU in SRAM	EDAC , layout
	SEFI caused by PLL/DLLs	All digital DLL, clock tree ckt & layout
Reliability effects	Electro-migration	Enhanced power grid
	Temperature cycling	Slots, double seal ring, thick wires
	Process marginalities	Thick wires and spacing, double via, screening
	Chemical effects	hermetic package
	Mechanical (shock , vibration)	wide & short wires

Implementation

- Ramon Chips' RadSafe™ RHBD cell library
- Tower Semi 180 nm CMOS
- Freq.: 100+ MHz
- SpW: 200 Mbps
- Power: 0.5—1.5 Watt

Development board



GR712RC: Qualification

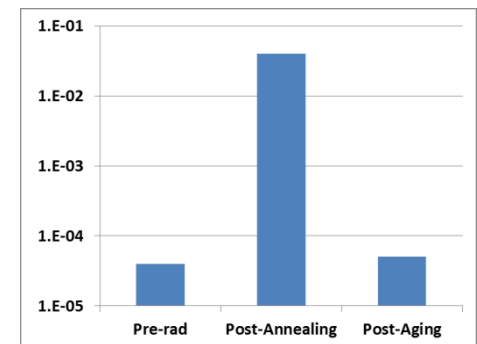
- Manufactured according to MIL-PRF-38535 App. A
- SELF-qualified to MIL-STD-883 Class S
 - Similar to QML-V and ESCC-9000
- Tests include
 - All tests required by MIL-STD-883 Class S
 - Radiation tests
 - Extended electrical tests: HVS and I_{DDQ}
 - High Voltage Stress, Quiescent Supply Current
 - Extended evaluation: ETC
 - Extended Temperature Cycles

GR712RC: MIL-STD-883 Class S Tests

Standard Tests	Standard Tests	Extended Tests
Temp Cycles	Solderability	ESD-Human Body Model
Burn In	Steady State Life	ESD-Charged Device Model
Fine / Gross Leak	Physical Dimensions	Electric Latch-up
Radiographic	Lead Integrity	High Voltage Stress
Constant acceleration	Thermal Shock	IDDQ
PIND	Moisture Resistance	
Solvents	Mechanical Shock	
Bond Strength	Vibration	
Die Shear	Salt Atmosphere	
Internal Water Vapor	External Visual Inspection	
Adhesion of Lead Finish	Internal Visual Inspection	

GR712RC: Radiation Tests (I)

- Ramon Chips RadSafe™ RHBD library provides TID mitigation in every cell
- TID test completed April 2011
 - **Irradiation**: ^{60}Co , 300 kRad @6.5 kRad/h, room temp, bias/clock
 - **E-tests**, **annealing** (room temp, 168h),
e-tests, **aging** (125°C, 168h),
e-tests
- TID test results: **passed** at 300 kRad
 - No functional effects. No I/O leakage
 - I_{DDQ} : 40uA \rightarrow 40mA \rightarrow 50uA



GR712RC: Radiation Tests (II)

- Ramon Chips RadSafe™ RHBD library provides SEL/SEU/SET mitigation in every cell
- Aeroflex Gaisler FT architecture provides SEU error correction in all memory structures (caches, register files, on-chip SRAM)
- SEL test completed July 2011: **passed**
 - No latch-up at LET 106 MeV-cm²/mg, 125°C
- SEU test performed July 2011: **data being analyzed**
 - Performed at full speed of 100 MHz
 - Raw data appears as expected
 - SET hardening of logic, DLL and clock networks appears successful
 - Error correction in memories appears successful

GR712RC: Additional e-Tests

- High Voltage Stress (HVS) test
 - Applied voltage much higher than max operating voltage
 - Accelerates failures related to oxide breakdown and marginal conductivity
 - Significantly enhances expected quality
- Quiescent Supply Current (I_{DDQ}) test
 - Measure I_{DDQ} (supply current at quiescent mode)
 - Enables detection of defects including metal shorts, leaky gate oxides and discontinuities.
- HVS and I_{DDQ} are combined: First apply HVS, then test I_{DDQ}
- High correlation between HVS+ I_{DDQ} failures and other failures
 - Validating the desirability of these tests
- HVS+ I_{DDQ} typically employed in high-volume commercial products

GR712RC: Extended Temperature Cycles

- MIL-STD-883 Class S requires
 - 50 screening cycles
 - 100 qualification cycles
- Commercial components in plastic packages are typically qualified at 1,000 cycles
- Certain missions incur over one million small-amplitude temp cycles
 - Coffin Manson acceleration formula less than satisfactory
- GR712RC die (and RadSafe™ RHBD library) includes novel proprietary mitigations of damage by extreme thermal expansion fatigue
- To evaluate, several dies are being tested far beyond 1,000 cycles

GR712RC: Summary

- Dual core SoC for versatile usage
 - Computer, controller, router, interface
- SELF-qualified to MIL-STD-883 Class S
 - During 2010-2012
- Passed all tests
 - Class S, radiation, extended
- Adopted by some space missions
- Marketed globally ITAR free by Aeroflex Gaisler