CSP: High Performance Reliable Computing for SmallSats

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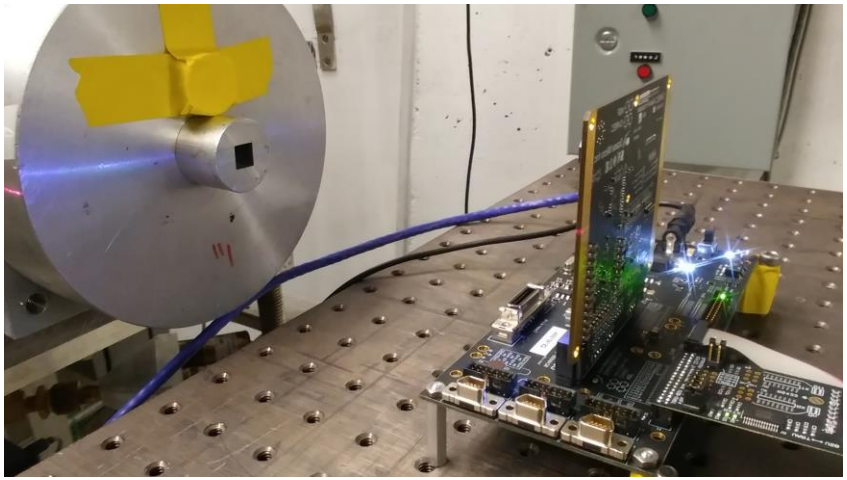
CubeSat Developers' Workshop 2017
Cal Poly San Luis Obispo
April 26-28, 2017

Hybrid Product Design Philosophy

- Combines industrial and space grade parts
- Superior performance and reliability are achieved while staying within typical CubeSat program cost constraints
- Radiation tolerant devices monitor and manage COTS devices
- Fault tolerant computing (Hardware, software, information, networking, and time redundancy)
- Customized parts selection is applied to achieve configurations for different reliability requirements and radiation environments (up to 100 krad)



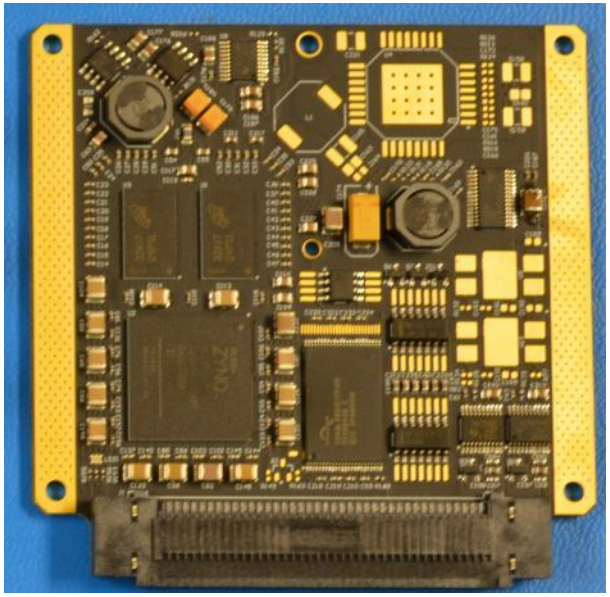
CSP Radiation Testing

CubeSat Space Processor Overview

- **CubeSat Space Processor (CSP) single board computer**
  - **Hybrid Product Design Strategy**
  - **Designed to meet space environments**
    - Vibe, Shock, Conduction cooled
    - Parts selected for TID resilience
    - Embedded soft error mitigation
  - **Powered by Xilinx Zynq-7020**
    - Dual ARM cores
    - 7-series FPGA fabric
  - **DDR3 SDRAM**
  - **Flash Memory**
- **Extensive Software Options**
- **Modularity**
- **Heritage**
  - **Currently flying on ISS**
  - **Selected for five Space Missions**

CSP Key Attributes

Processor	Xilinx Zynq-7020 2.5 DMIPS/MHz per CPU CPU frequency: Up to 667 MHz (-1) Up to 866 MHz (-3)	
FPGA Programmable Logic	33 MHz or 100 MHz Clock 24 differential pairs, 12 single ended 140 - 36Kb Block RAM (4.9 Mb) Programmable I/O Blocks Supports LVCMOS, LVDS, and SSTL, with 1.2~3.3 V I/O 12 bit ADCs up to One Million Samples per Second	
Total IO	24 LVDS and 38 Single-ended	
Operating Systems	Wumbo GNU/Linux, RTEMS, VxWorks, ThreadX	
Supported Interfaces	8 Channels DMA SpaceWire 10/100 Ethernet USB 2.0 OTG CAN 2.0B (1 Mb/s) SPI (3 chip selects) JTAG	I2C (external 3.3 V pull-ups required) UART (Max baudrate of 921600 bps) Hardware & Software Watchdog timer Camera Link
Memory	8 Gbit NAND Flash (EM) RadTolerant 32 Gbit NAND Flash (FM) Two 1 Gbit DDR3 SDRAM	
Connector	Samtec SEAF-RA-RA 4 x40 Designed to be Connected to a Samtec SEAM 4 x 40 Backplane	
Power Consumption	1.6 – 2.85 Watts	
Temperature Rating	CSP-EM: 70 ℃ CSP-FM: -40 ℃ to +85 ℃	
Thermal	Conduction cooled	
Mechanical Size	Designed in a 1U CubeSat form factor (8.8 cm x 8.9 cm) Thickness: 1.65 cm (tallest component)	
Mass	60 grams	

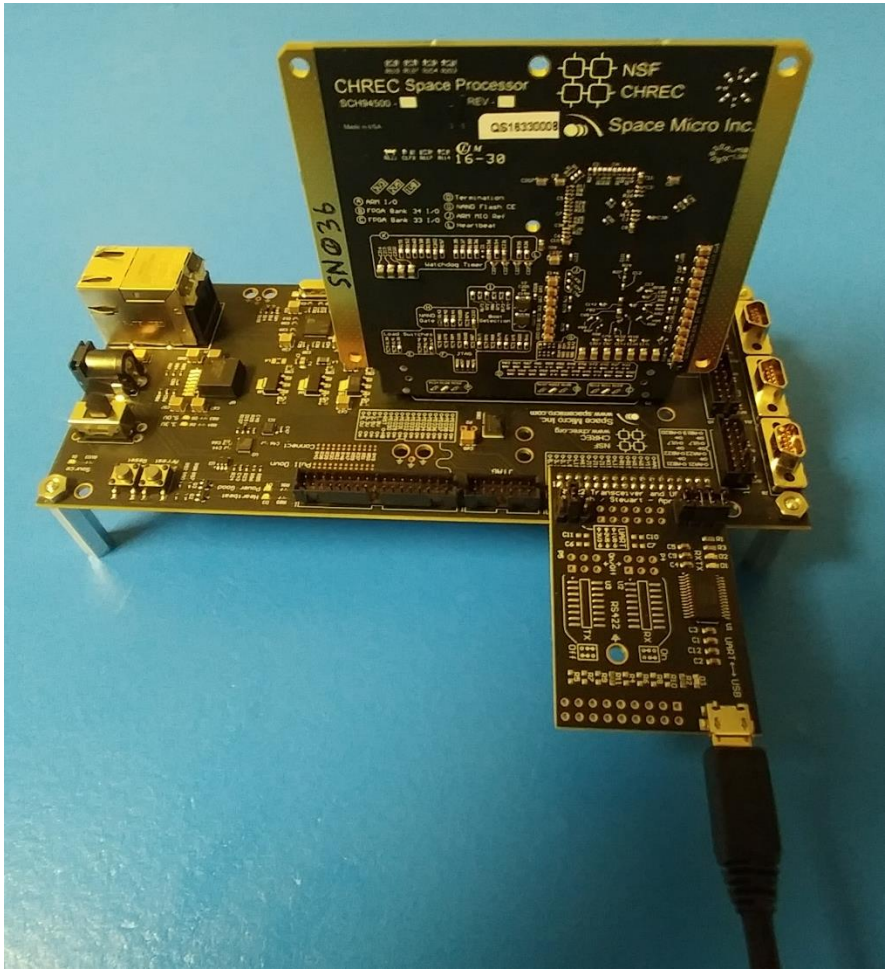


CSP

CSP Development Kit

- **Solution for Interface and Software Testing**

- **Development Kit Contents:**
  - **CSP Engineering Model**
  - **CSP Evaluation Board**
    - JTAG programming support
    - 10/100 Ethernet
    - MIO and EMIO breakout
    - 3 SpaceWire breakouts
    - Cameralink breakout
  - **USB to UART Board**
    - USB to UART Converter (1.8, 2.5, 3.3V logic supported)
  - **Software**
    - Access to CSP software and firmware repository



CSP Software

- **Operating Systems**
  - Wumbo GNU/Linux, RTEMS, VxWorks, ThreadX
- **Interfaces**
  - 8 Channels DMA
  - SpaceWire
  - 10/100 Ethernet
  - USB 2.0 OTG
  - CAN 2.0B (1 Mb/s)
  - SPI (3 chip selects)
  - JTAG
  - I2C (external 3.3V pull-ups required)
  - UART (Max baudrate of 921600 bps)
  - Hardware & Software Watchdog timer
  - Camera Link
- **Applications**
  - Multiple open source and third party IP
  - Core Flight Executive/Core Flight System

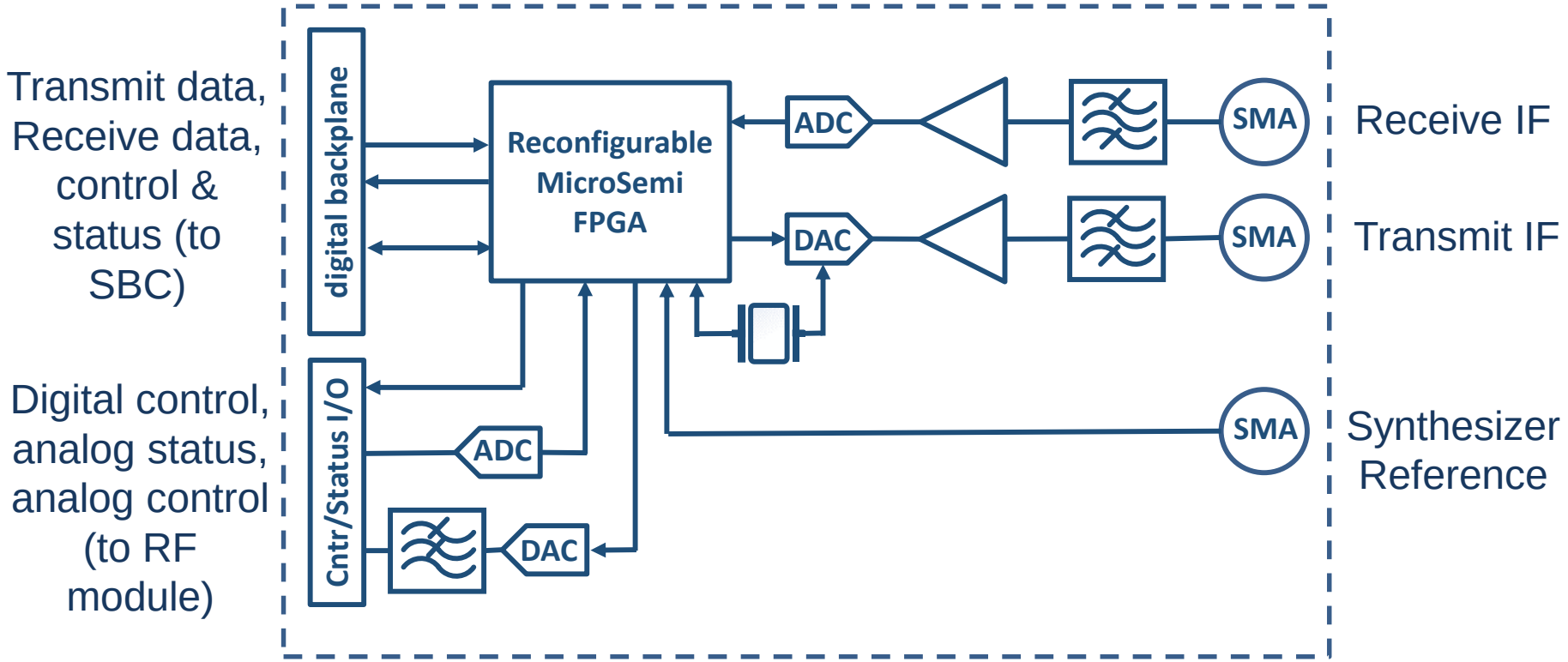
Modularity and Expansion

- **Backplane**
  - **Dense, high-speed 160-pin backplane connector**
  - **24 LVDS and 38 Single-ended IO**

- **Examples**
  - **Multiple CSPs (e.g. Super-CSP)**
  - **Modem Board**

SDR Modem Expansion Card

- **Radiation tolerant Software Defined Modem in 1U form factor**
- **Supports IF frequencies up to 150 MHz**
- **Occupied bandwidth up to 25 MHz**
- **Typical configuration is 5-10 MHz occupied bandwidth at 70 MHz IF**



Industry Standard Design Practices

Configuration Management

Design Analyses

- Structural, Mechanical & Thermal analysis
- Reliability, Part Stress & Worst Case analysis
- Radiation (destructive events, TID, SEE, SEU, SEFI)
  - Standard space products typically targeted to 30 or 100 krads(Si)
  - Use many parts databases
  - Routinely conduct radiation testing
  - Shielding can be provided for extra TID margin

Parts, Materials and Processes

- Traceability with MRP and travelers
- Counterfeit (CF) parts avoidance
- No pure tin
- Capable of working to NASA Level 1/Class “S” or TOR (Level 2 & Commercial Space are most common)
- In-house parts screening capability
- Regular participation in various industry groups (SPWG)

Industry Standard Manufacturing Practices

- **Parts Procurement**
  - Strong relationship with manufacturers and distributers of parts
  - Purchase from authorized distributers or OEM's
  - Quality clauses
  - Ability to purchase larger quantities of long lead parts
- **Manufacturing and Test**
  - Sub-tier Management
  - Acceptance Testing
- **Documentation**
  - End Item Data Package (EIDP)
  - Certificate of Conformance

Mission Assurance

- We are an ISO 9001 registered house since 2008
  - Undergone two re-certification audits
  - Last was October 2014

- Quality Policy
  - Space Micro Inc. is committed to customer satisfaction by producing defect-free products that conform to customer requirements and expectations, through systematic and controlled operations, on-time deliveries, and a culture of continuous process improvement.

- Quality Manual

- Standard Operating Procedures address Space Micro processes

- Workmanship Standards

bsi.

By Royal Charter

Certificate of Registration

QUALITY MANAGEMENT SYSTEM - ISO 9001:2008

This is to certify that:

Space Micro Inc.
10237 Flanders Court
San Diego
California
92121
USA

Holds Certificate No: **FM 525932**

and operates a Quality Management System which complies with the requirements of ISO 9001:2008 for the following scope:

Design and development, inspection, testing, and distribution of advanced electronics systems, microelectronics, and materials for space, military, and performance critical applications worldwide.

For and on behalf of BSI:

Gary Fenton, Global Assurance Director

Originally registered: 10/24/2008 Latest Issue: 09/07/2014 Expiry Date: 10/23/2017

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...making excellence a habit.

This certificate remains the property of BSI and shall be returned immediately upon request.
An electronic certificate can be authenticated online. Printed copies can be validated at www.bsigroup.com/ClientDirectory
To be read in conjunction with the scope above or the attached appendix.
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BSI Assurance UK Limited, registered in England under number 7805321 at 389 Chiswick High Road, London W4 4AL, UK.
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Quality & Supply Chain Management

Purchased Parts and Materials

- MAM reviews Purchase Requests & Inserts Appropriate Quality Clauses
  - Quality clauses also adapted from customer flow downs
  - Applicable command media (SCDs, MI's, Drawings) accompanies Purchase Order
  - Purchased Items are verified at Source and/or Receiving Inspection

Contracted Supplier Processes

- MAM reviews Purchase Requests & Inserts Appropriate Quality Clauses
  - Applicable command media (SCDs, MI's, Drawings) accompanies Purchase Order
  - Source Inspection:
    - PCB Assembly House: Placement, orientation, workmanship
    - Conformal Coat/Staking House: Workmanship

Internal Processes

- Applicable command media (Travelers, BOM's, MI's, Drawings) accompany kitted/built up assemblies
- In-Process inspection verifies command media and workmanship
- Space Micro Standard Operating Procedures (SOPs) apply
- Non-Conformance Management

Quality Assurance Participation

Perform Inspections to Ensure Compliance to Workmanship Requirements

- IPC-A-610 Acceptability of Electronic Assemblies
- J-STD-001 Requirements of Soldered Electrical and Electronic Assemblies
- J-STD-001 Space Addendum
- NASA-STD-8739 workmanship standards

Ensure Facilities Compliance

- Equipment Calibration
- Facilities Cleanliness
- ESD Safeguards

Audit Manufacturing Documentation

- Proper Revisions, Approvals, Sign-offs, Stamps
- Operations Completed Correctly and Signed-Off
- Oversight/Review Contract Manufacturing Workmanship and Documentation
- End-Item Data Package (e.g. Test Data, Travelers, Photos/X-Rays, etc.)
- Provide Certificate of Conformance