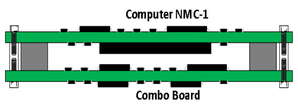
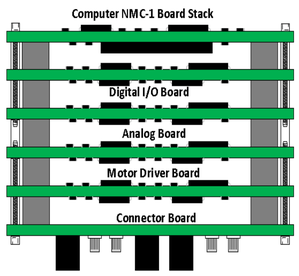
NMC-1
An Innovative Avionics System for CubeSat and SmallSat Missions

Don Golding - Nextage, LLC

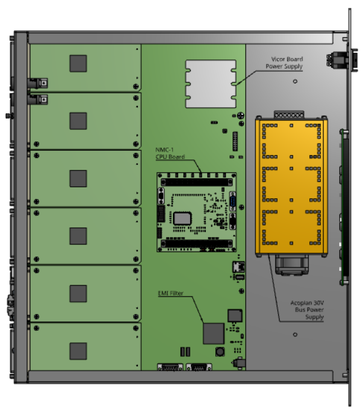
Abstract

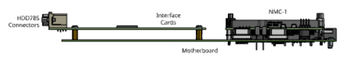
The space industry is in a transformative period, attempting to balance cost, performance and reliability. Nextage is addressing this issue through our development of a robust, low cost, fully space qualified, FPGA based computer for CubeSat and SmallSat platforms. The Nextage NMC-1 utilizes the state-of-the-art, low power, high performance PolarFire® FPGA. Our architecture incorporates embedded CORE I parallel processing, along with a RISC V soft core that enables C/C++ programming. This architecture supports heritage applications and enables highly deterministic, real-time algorithms at speeds beyond real-time processing performance of even the most advanced microprocessors. Additionally, the NMC-1 offers massive parallel processing capability, extensive expandability, real-time incremental compilation, and ability to relocate code. The NMC-1 space computer is available in the CubeSat 1U form factor to accommodate any mission risk posture and budget. Nextage offers COTS peripheral cards to add features, capabilities and interfaces, along with custom, mission specific combination cards to optimize for SWAP. Our rack mounted units can be used as Special Test Equipment (STE), Engineering Development Units (EDU), simulators or FlatSat test beds for any mission specific application, allowing early development and testing for flight hardware and software.



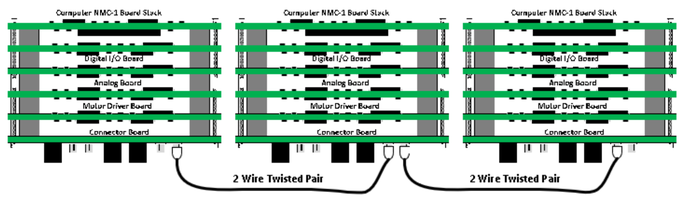


SWAP Optimized & Expandable to mission needs
Two-board Mission Specific configuration & Multi-board COTS I/O configuration





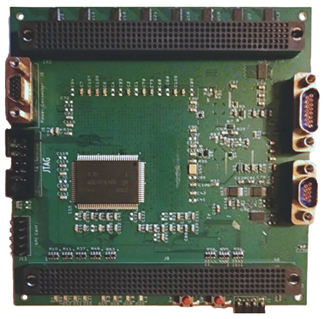
Accommodates Early Development
Rack Mounted FlatSat or EGSE Configuration

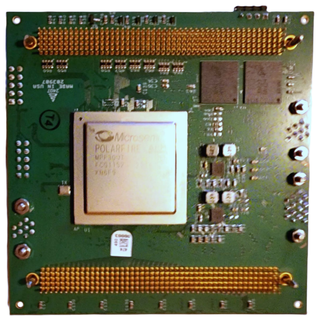


Scalable to Large Complex Applications
Token Ring Networked Configuration

Introduction

As humankind ventures farther into the solar system and interstellar space, the ability to adapt to unexpected challenges is impeded by serial autonomous reaction and low bandwidth, light speed communications links. More intelligent, parallel processing solutions are needed for robotic application, and where swift human operator interaction is unavailable or impractical. Further, the ability to correct or modify behavior though code updates while still performing critical functions is severely limited. Current computer architectures, whether RISC or CISC based, are largely limited by serial instruction execution, practical number of processors, and clock speed. Additionally, code upgrades and modifications result in significant downtime of the system to compile the new code in its entirety. Our innovation in processor architecture and design provides massive parallel processing capability and in-situ incremental compiling with no appreciable downtime.





NMC-1 Board

- Low Cost, Low Power, High Reliability
- Reprogrammable On-Orbit
- Incremental Compilation
- Modular, Scalable, Customizable
- Massive Parallel Processing

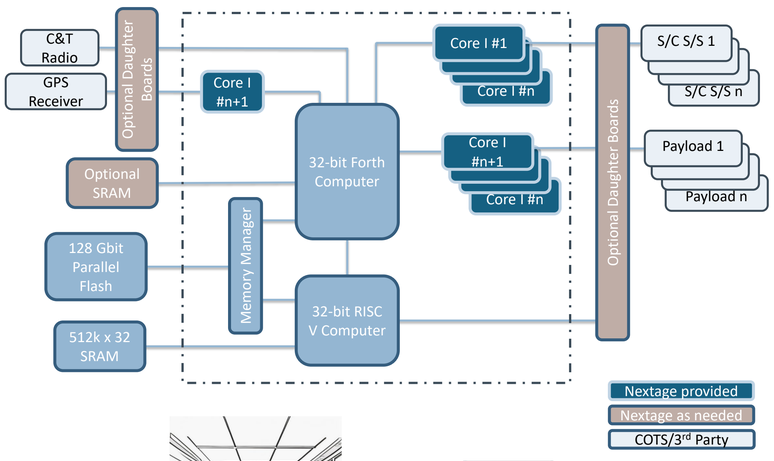
Machine Learning Capabilities

The NMC-1 is essentially a Virtual Machine, capable of machine learning and artificial intelligence. The technology is implemented in a FPGA, via System Verilog, creating a CISC Over RISC Engine (CORE I). Similar to a RISC V in function, the CORE I is differentiated by its high-level primitive opcodes, inherently reducing the number of opcodes to write a program and resulting in one-tenth the FPGA fabric demanded by a RISC V core. This manifests as massive parallel processing that allows the user to dedicate individual or sets of CORE I processors to components, subsystems or functions suited to the specific mission needs. The multitude of CORE I processors, RISC V computer and memory manager are coordinated and orchestrated by the embedded Forth computer system resulting in a massively parallel machine.

NMC-1 Features

- Most advanced, most radiation tolerant (100 KRAD), space-rated, reconfigurable FPGA on the market[1]:
  Microchip RT PolarFire®
- 1U CubeSat (96mm x 96mm) form factor
- Multicore capable for added processing and efficiency
- FORTH enabled Incremental On-Orbit Compiling
- Versatility and processing power of RISC V
- Full support for C applications and programming
- 512K x32 high-speed SRAM (scrubbing+EDAC)
- Substantial logic resources with 481 kLUTs
- Myriad of use cases supported with 462 GPIO
- Stacking connectors allow modularity and ease assembly
- Two standard EIA-422 transceivers
- 8G to 128Gbit x8 high-speed parallel flash memory (60 KRAD)
- Customizable I/O using our daughter Cards
- 3 SERDES 2-wire twisted pair 250 Mbit/s token ring network channels for expansion and data transfer (1.2 Gbit/s high-speed version available)

Microchip
RT PolarFire® FPGA



MICROCHIP PolarFire® FPGA

RISC-V®

Conclusions

The NMC-1 provides an economical, high reliability solution to space computing. The highly adaptable, expandable and user-friendly architecture and design enables ease of development, verification, and validation for a wide range of missions, tailorable to risk posture and budget. Nextage offers COTS and custom peripheral cards for subsystem and payload interfaces, along with mission specific engineering support. While targeted for SmallSat and CubeSat missions, the NMC-1 may be expanded to any mission size or complexity.

1. https://www.microchip.com/en-us/products/fpgas-and-plds/radiation-tolerant-fpgas/rt-polarfire-fpgas

Don Golding
Nextage, LLC
dgolding@nextage-llc.com
310.691.4312
www.nextage-llc.com

Patent Pending

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