A Low-Power Dual-Processor Computing System for Advanced Nanosatellite Missions

Nathaniel Colson
Purdue University
ncolson@purdue.edu

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Overview

Two Processors:

- **DSP**
  - 500 MHz
  - 1 W

- **Microcomputer**
  - 8 MHz
  - <10 mW
Overview

- Very large computational power available
- Low average power consumption
Attitude Determination and Control

• Primary engineering mission:
  – Attitude determination within 1 degree
  – Attitude control within 5 degrees

• Algorithm:

  Sun vector → Attitude Estimation Algorithm → Attitude matrix
  Magnetic field vector

  LQR Controller → PWMs → Magnetic Torquers

  • Matrix / vector multiplications
  • Matrix inversions
  • Floating point variables
ZMobile DSP System

- Zmobile Mixed Signal board from Schmid Engineering:
  - Graphical DSP programming with Embedded LabVIEW
  - Four 14-bit A/D channels
  - Five UARTS
  - Programmable self-shutdown
Host Computer

• Tasks:
  – Generating wakeup signals for ZMobile DSP
  – Generating PWMs to drive torque coils
  – Performing all Command and Data Handling

• Communications On Board system
  – Generic C&DH system from Taylor University
  – Supports I2C, SPI, RS232
  – Based on ultra low-power MSP430
Microcomputer Upgrade:

- **MSP430-1611**
  - 10 KB RAM
  - 48 KB Flash Memory
  - 2.5 mA Supply Current
  - 2 Serial Interfaces
  - 6-layer PCB
  - 4”x4” board size

- **MSP430-5438**
  - 16 KB RAM
  - 256 KB Flash Memory
  - 1.55 mA Supply Current
  - 4 Serial Interfaces
  - 4-layer PCB
  - 4”x2.4” board size
System Operation

Overview
Attitude D & C
ZMobile DSP
Host Computer

Operation
Results
Conclusion

ZMobile DSP System
Sensors
Host Computer
COB Data Routing Software
COB Command Handler
Flash Memory
Ground Communication System
Torque Coils

Flash Memory
COB Command Handler
Ground Communication System

Torque Coils
System Operation

Overview
- ZMobile DSP
- Host Computer

Attitude D & C
- Sensor
- Torque Coils

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System Operation Diagram:
- **ZMobile DSP System**
- **Host Computer**
  - COB Data Routing Software
  - COB Command Handler
  - Flash Memory
- **Sensors**
- **Ground Communication System**
- **Torque Coils**
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Average Power Consumption

1.0 W * 10% Duty cycle 
+ 
10 mW * 100% Duty cycle 
= 
< 125 mW
Design Verification

- Computational Performance
- Power Consumption
- Inter-processor Communication

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Nathaniel Colson
ncolson@purdue.edu

Paul Moonjelly
pmoonjel@purdue.edu

Facility advisor: Prof. David Filmer
filmer@purdue.edu

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