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Distributed Wiring Harness

Agenda

- Design Problem
- Hardware and Software Solution
- Prototype
- ICD Tracking Tool
- Built-In Simulator
- Future/Limitations
- Conclusion

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Background

- Space Gadgets assisting with the: 1st Student Build Mission to Mars!!!

- Five lead universities will build hardware
  - C&DH: University of Colorado
  - ADCS: Arizona State University
  - Orbital Control: University of Alabama
  - Science: Auburn University
  - EPS: University of Arizona
Design Problem

- C&DH needs to coordinate all interfaces
- Interface Testing
  - verifying data protocols
  - verify commands
  - verify responses
  - verify power draws
- Bring all components together(?)
- Similar to industry problems
- Need a Distributed Wiring Harness
Brief Overview

Distributed Wiring Harness (DWH)

- A tool/method for “pre-integration” testing of:
  - electrical interfaces
  - data interfaces
- while components are still at different locations
- Goal: reduce development costs
- Goal: allow more responsive products
DWH Example

C&DH Commanding
Science Instruments
DWH Example

Local Wiring Harness

Flight Computer

Science

Serial

I2C

Battery

3.3V

5V

28V

Electrical Power Subsystem

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DWH Example

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Universal Power and Data Controller

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Hardware

- Universal Power and Data Controller (UPDC)
  - Power Distribution Unit (PDU)
    - 3.3V output
    - 5V output
    - 2x variable voltage outputs (0-28V)
    - current and voltage sensors
    - optional power sinks
  - Data Distribution Unit (DDU)
    - 2x USB
    - Serial
    - 2x I2C
    - RJ45 (ethernet)
Hardware (cont)

DDU

PPU

DC Outputs
- 3.3V: 0.29
- 5V: 0.66
- Variable 0-28V: 0.23
- 0-28V: 0.10

Data Connectors
- Serial
- USB
- Ethernet
- I2C
PDU Prototype

- 1x AC input (ATX power supply)
- 3x DC outputs (3.3V, 5V, 1x 0-12V)
  - Switch-mode regulators
  - Adjustable buck converter
- Current and voltage sensors on I2C bus (soon)
  - Remotely read sensors
- Digital potentiometers on I2C bus (soon)
  - Remotely adjust voltages on outputs and sinks
- No power sinks yet
DDU Prototype

- Linksys NSLU2
  - XScale ARM processor
  - 2x USB, 2x I2C, 1x serial, 1x Ethernet
  - Linux
  - <$100
- Internal I2C bus = sensor info and controlling potentiometers
- Software to read ICD information
  - protocol.xml & messages.xml
DWH Example

Distributed Wiring Harness

(Alabama)

(Florida)

Serial

5V

Serial

UPDC

Science

UPDC

UPDC

UPDC

Tracking Tool

Electrical Power Subsystem

(Florida)

(Arizona)

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ICD Tracking Tool

- Development and tracking tool
  - Generates Interface Control Documents

- DWH Control Center
ICD Tracking Tool (cont)

MODIFY POWER INTERFACE

Subsystem: science
Component: magnetometer
Data or Power: power

Inputs

Connector type: NATC
Optimal Voltage: 5 (volts)
Current: 10 (mA)

Pin description:

1: 5V
7: GND

Minimum voltage: 4.5 (volts)
Maximum voltage: 5.5 (volts)
Minimum current: 8 (mA)
Maximum current: 12 (mA)
MODIFY DATA INTERFACE

Subsystem: science
Component: magnetometer
Data or Power: data

Inputs

Connector type: serial
Pin description: blank
Format: byte sequence
Protocol outline: header w/ fixed length
Length: variable - reference byte # 2
Device address: byte # 1 must equal 2 (hex)

Commands

Ping [1a,2,5,08,ff]
Turn off [1a,2,5,00,ff]
Turn on [1a,2,5,01,ff]
Start taking science [1a,2,5,02,ff]
Diagnostic [1a,2,5,04,ff]

Outputs

Connector type: serial
Pin description: blank
Find: blank
ICD Tracking Tool

- Development and tracking tool
  - Generates Interface Control Documents
  - Change Notifications and version control
  - Define the interface “protocols” needed for:
    - in-flight = DWH testing
    - test cases = simulation

- DWH Control Center
  - Distribute ICD-based DWH code (XML)
  - Record all messages being transferred
  - Ping components and start test or simulation
Varying the size of DWH
- Example: 2 subsystem test
- All subsystems
- No subsystems?

ICD Tracking Tool will generate “virtual” components/responses:
- C&DH sends out SCI_ON cmd
  - [1a,2,5,01,ff]
- UPDC simulates response based on test cases
  - [1a,1,5,01,ff]
  - [1a,1,7,aa,ab,ac,ff] (within X seconds)
Limitations and Future

- Timing
  - Internet latency
  - “very reactive” watchdogs or software
    - No solution yet = limitation of DWH
  - I2C needs immediate response
    - Solution: “local” I2C master within UPDC

- Variable power draws
  - Simulating an unexpected situation
    - Partial solution = limited reaction time

- Other connectors: SpaceWire, 1394, MILSTDs
Conclusion

- Benefit for the University Partners
- A possible benefit to industry satellites
- Standardizes ICDs and test cases
  - Combines testing with design => enhanced I&T strategy
- Reduces integration costs by providing “pre-integration” stage
Questions?

Distributed Wiring Harness

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