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Command and Data Handling using the Tyvak Intrepid

Introduction

The Tyvak Intrepid board is an inexpensive main flight computer used to guide satellites, and provide processing power to the spacecraft bus and payload. The demand for low-power, compact, and space-tolerant computer systems to control them has increased due to the rise in popularity of low-cost satellites in recent years. This paper reviews the functions and specifications, components, along with the use of the Tyvak Intrepid system pertaining to the application of CubeSat satellite.

Underlying Technology

Specifications

Intrepid is equipped with a AT9I Sam9G20 processor at 400 MHz with 512 MB of flash memory and 32 MB Phase Change memory [1]. The board is accompanied by a 1GB Micro SD to store/back-up collected data. Intrepid comes with a real-time clock, 3-axis gyro, 3-axis magnetometer and accelerometer, 6 power sensors, and 3 temperature sensors [2]. It also has a fault tolerance architecture providing latch-up protection and a recovery system coupled with a software watchdog [2]. This feature is useful for the harsh environment beyond Low Earth Orbit (LEO).

Functions

The current overall design for the Tyvak Intrepid computer systems utilizes a distributed architecture with multiple on-board processors, each specifically tasked with providing mission critical capabilities. Some of these capabilities would include tasks such as altitude determination to the control of the entire system. When the Intrepid is integrated with a satellite, the Intrepid is given control of latera translation thrusters which is used for controlling flight, and RF which ensures the system is compatible with all commercial radios currently available or in development. This system is designed to accommodate payload mounting, thermal routing, deployable arrangement, aperture locations, and ease of assembly, while also allowing for configuration of the solar arrays, star trackers, coarse sensors, antennas, and payload faces [3].

Intrepid comes pre-programed with flight software, and has its own Linux distribution and ground operations software for all programs. Intrepid is responsible for Command and Data Handling (C&DH) house-keeping and radio interfaces, complex formation flight, rendezvous and docking algorithms, Guidance Navigation and Control, vehicle orientation control, and propulsive operations [3].

Components

The components of flight computers for low Earth orbit are typically commercial components that are hardened by design rather than process. A common pattern is to include both hardware and software mechanisms [4]. The Intrepid system makes use of Linux as primary OS using a time sharing system designed for fair scheduling [5]. The Linux network allows for stack and support of the utilities. Tyvak Intrepid computers come with an embedded operating system, which is typically an embedded version of Linux. This version of Linux operates upon a hardware abstraction layer (HAL) to allow for the use of a set of common libraries that can be deployed to multiple satellite systems [4]. The Core Flight Executive (cFE) is one such open source platform for the development of flight software, it utilizes a variety of pre-existing robust modules tested for other embedded applications [5].

Commercial Applications

The Tyvak Intrepid computer systems can be used in applications such as the CubeSat Satellite. A CubeSat is a nanosatellite with strict standards for size, mass, power, and launch configurations [6]. CubeSat standards allow for the deployment of satellites in low Earth orbit at low cost and short development times. Tyvak Nano-Satellite Systems LLC offers an Intrepid Pico-Class CubeSat system that includes a 400 Mhz ARM processor, non-volatile memory systems, and peripheral interfaces for communication with satellite subsystems [4].

It has a base cost of $30,000 and has a set of additional features such as GPS that can be included at additional cost. The system board for CubeSat basic functionality only uses a few percent of the systems full capability which allows for utilization of ADCS algorithms, image capture and payload software [4]. Integration of the CubeSat system allows for lower power bus solution (less than 400mW), takes advantage of ample spare processing and memory, and allows for volume optimization which translates to dramatically increased payload volume [7]. The low cost, relative simplicity, and availability of CubeSat compatible components make these satellites increasingly popular [6].

References

[1] L. Zubair, J. Lee, S. Virani, T. Murphy, and M. Holzinger, "HARDWARE-IN-THE-LOOP COMPARISON OF SPACE OBJECT DETECTION AND TRACKING METHODOLOGIES," 2016. [Online]. Available: http://www.ssdl.gatech.edu/sites/default/files/papers/conferencePapers/AAS-16-266.pdf. [Accessed: Mar. 4, 2017].

[2] "System design of a miniaturized distributed occulter/telescope for direct imaging of star vicinity - IEEE Xplore document," 2017. [Online]. Available: http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7500783. [Accessed: Mar. 4, 2017].

[3] T. Inc, "Custom projects," 2016. [Online]. Available: http://www.tyvak.com/capabilities/. [Accessed: Mar. 5, 2017].

[4] B. Bukovics, "Compact Computer Systems for Miniature Satellites" 2017. [Online]. Available: http://www2.ece.gatech.edu/academic/courses/ece4012/16fall/sd16f20/assets/docs/Bukovics_Brennen_TRP.pdf. [Accessed: Mar. 5, 2017].

[5] S. Fitzsimmons, "Open-source Software for CubeSat Satellites," 2012. [Online]. Available: http://mstl.atl.calpoly.edu/~bklofas/Presentations/SummerWorkshop2012/Fitzsimmons_Open_Source_Software.pdf. [Accessed: Mar. 4, 2017].

[6] A. Marinan and K. Cahoy, "From CubeSats to Constellations: Systems Design and Performance Analysis," M.S thesis, Dept. Aeronautics and Astronautics., Massachusetts Inst. of Technology., Cambridge, MA, 2013.

[7] S. MacGillivray, "Highly Integrated Design Approach For High Performance CubeSats," 2011. [Online]. Available: http://mstl.atl.calpoly.edu/~bklofas/Presentations/SummerWorkshop2011/MacGillivray_Advanced_CubeSats.pdf. [Accessed: Mar. 4, 2017].