Application of Multiple system on a chip technology systems in micro-nano satellite integrated electronic systems

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Abstract

This paper mainly describes the way that using (multiple chip module)MCM technology to optimize and improve design of small satellite's electronic system from application requirement view. Research on MCM based on Silicon wafer is carried out, combined with software and IC integration technology. Finally, the ultimate realization is Miniaturization, integration, standardization of the design of the small satellite. The research finding will produce a new idea for design of the small satellite which is small size, low power consumption, high level of integration and performance.

Keywords

NanoSat, Multiple system on-chip module, 3D-MCM, Co-design, MEMS, integrated software platform

1. Introduction

The main features of the micro-nano satellite development is functional density, short development cycle, cheap and flexible means of transmission ,and mass production, so as to greatly reduce costs and meet the diverse needs. With the development of microelectronics technology, it is essential to provide the necessary technical foundation for the development of small satellites especially micro-nano satellites, and even pico satellites. Take advantage of LSI in integrated circut design, not only the mechanical components using MEMS technology and integrated in the silicon, but the sensors, microprocessors and other electronic, optical and micro-mechanical systems integration in a 3D package inside, forming specific functions electromechanical integration of satellite electronic systems. The centralized design method based on multiple system on chip technology can make the device lightweight，dramatically improve system reliability，and the use of IC manufacture technology, you can use the same fabrication to product thousands of devices, thereby significantly reducing the cost of micro-nano satellites and their components.

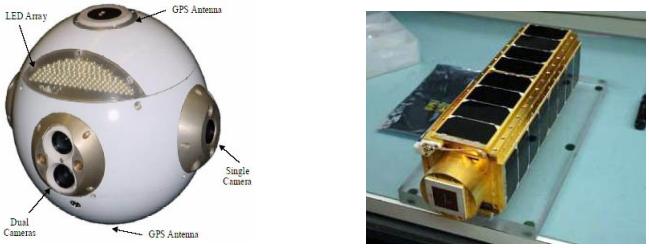

Figure 1 The latest US satellite system satisfied

The micro-nano satellite concept was proposed by the United States in 1993, micro-electromechanical (MEMS) technology and integrated micro-instruments composed by a number of MEMS is the basis of the satellite, satellite weighs less than 10Kg. In the USA Defense Advanced Research Projects Agency (DARPA) has been on the development of small satellites and have yearly development investment of $ 35 million for small satellite. NASA also attaches great importance to the development of small satellites, has proposed a "Small Satellite Technology Innovation Program" and "new prosperity plan," a series of small satellite development program.

The representative of micro-nano satellites is America's "Vanguard TV3." The USA starts deep space exploration by micro-nano satellite in 2000, called X2000 plan. The first spacecraft with integrated electronic systems, integrated power management, sensors, communications module, CPU and memory functions on a single silicon chip. In 2000, the United States with the "orbiting satellite automatic launcher" (OPAL) launched DARPA's the two pico satellites used for verification MEMS technology, satellites released in orbit, pico satellite positioning and tracking technology. Future in 2020 the United States will achieve "thinking spacecraft", the aircraft flying with independent, high integration and low power consumption.

2. Research

A. Satellite Electronic System

Modern small satellites has not only small size, light weight, high technology, good performance, high reliability, short development cycle, but also adaptability, ease of management, low risk, and thus has a broad development and application prospects. It can be used as a single satellite, but also satellites constellation. The integrated design of micro-nano satellite technology Use multiple system on chip, SoC, MEMS, 3D multi-system integration technology to integrate the all functions into a chip or multi-chip package. depended on the virtue of a good coherence and reliability microelectronic manufacture, reduce the cost of the satellite.

Use of multiple system on chip technology for the design of micro-nano satellites, we must first clear the basic functions and tasks for satellites, the second the satellite electronic platform is the best entry for using of multiple system on chip technology to design satellite. Standardized microsatellite platform helps the system integration and miniaturization, so later in the analysis focuses on the satellite electronic platform and peripheral bus interface standard.

Micro-nano satellite platform can be divided by function: on-board computer, attitude and orbit control, monitoring and control, thermal control, promotion, construction and power management seven aspects.

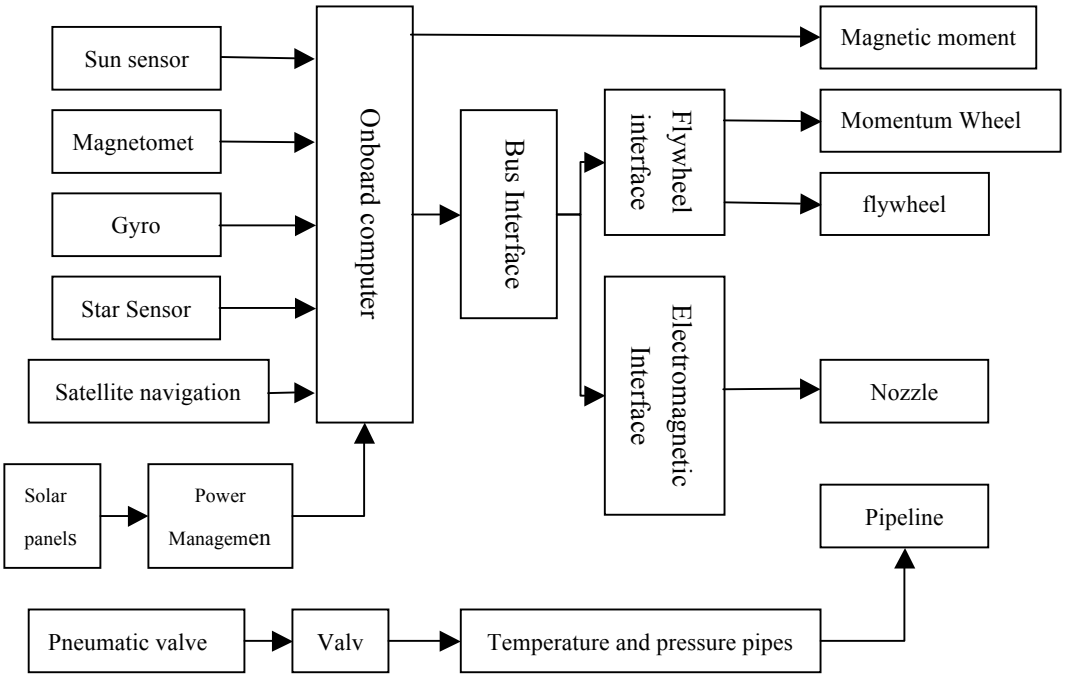

Figure 2 The overall block diagram of the micro satellite electronic systems

B. Multiple system on chip technology

The multiple system on chip technology is a combination of microelectronics technology trends and system miniaturization demands. The core of the technology is micro-systems integration technology will be applied to the design of board, subsystem or even the entire satellite. A high-performance 32-bit processor is kernel in this technology. The core of multiple system on chip technology is multi-system assembly platform.

Multi-system assembly platform for system miniaturization mention effective optimization capabilities. It can integrate heterogeneous chips into a package without the constrain of technique and manufacture. Multi-system assembly platform utilizes a variety of sophisticated packaging techniques such as multi-chip package, three-dimensional packaging, chip stack and module assembly technology, to integrate multiple LSI in a limited space.

C.Satellite electronic system optimization based on silicon integrated

The use of multi-system integration technology to optimize the design of electronic systems for micro -nano satellite platforms, can effectively reduce the volume of micro-nano satellites, improve system integration, computation and capability of payload.

Centralized computer unit. The use of centralized data processing mode, will merge computing resources ,such as attitude, orbit control, on-board management and ambient temperature, using a single high-performance computing unit for centralized management. Currently chose processor computing performance has been 100MIPS, embedding more than 1M memory, which fully meet the data processing requirements of micro-nano or small satellites. Centralized data processing unit based on the localization of the processor, all computing resources are derived from the unit, using a centralized processing unit to bring the whole electronic data processing systems. Centralized data management to reduce the complexity of the

system, redundant design increases the system reliability.

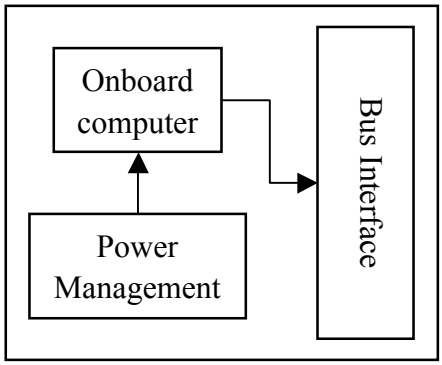

Figure 3 centralized data processing unit

The optimization of navigation system. application of MEMS technology can be effectively optimized for navigation guidance sensors, such as gyroscope and accelerometers, MEMS technology designed gyroscope area has been reduced to a few centimeters, monolithic integrated three-axis gyroscope gradually realized, and significantly reduce the satellite navigation sensor size and power consumption. MEMS systems can replace some of the existing machinery and equipment, to achieve the sensing of environmental and location.Therefore, the design of micro-nano satellites can be used the Local MEMS devices, for laying the foundation for an multi-system integrated assembly in the future.

Chip-based satellite navigation receivers effectively reduce the size and cost of the required navigation, algorithm implemented in hardware front end, the front end can be greatly improved data processing capability, to achieve high dynamic satellite positioning, PVT settlement is completed using the mature domestic processors, the satellite navigation multimode, multi-constellation positioning, reflecting the flexibility of the processor software. GPS receivers currently installed on the satellite especially the micro-satellite are abroad. Localization performance of GPS / BD2 receiver reaches 5 meters (CEP 95), if the current localization of the receiver to replace foreign products can also be integrated into the latter part of the system to provide more preparation.

For navigation, guidance sensor optimization, first of all you need to complete the localization of substitution, after localization to complete the miniaturization design systems based on existing multi-chip integration technology. Currently in the multiple system on chip integration technology, you can provide the mainstream MEMS components and satellite navigation for users to choose and integrate. If the system uses integration technology to optimize the micro-nano satellites can be achieved as shown as the follow:

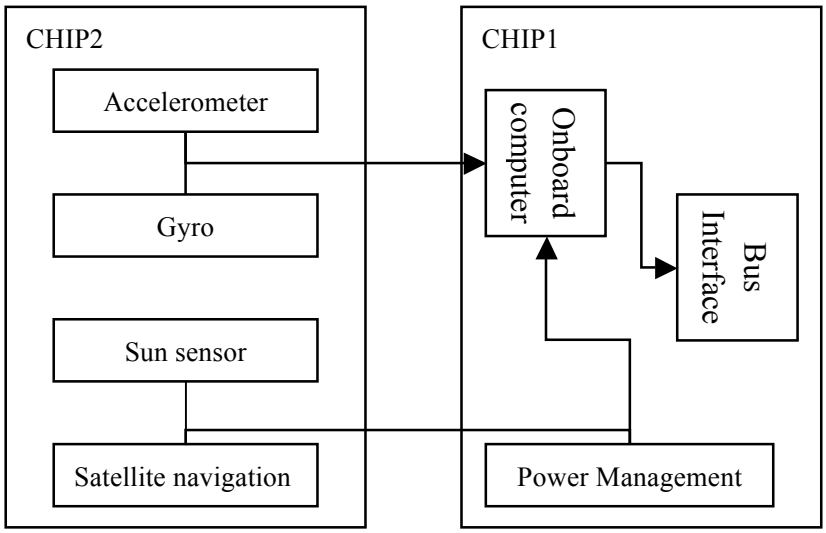

Figure 4 a sensor unit and the data processing unit

Multi-system assembly technology, breaking the traditional monolithic IC limitations, in a multi-system assembly can not consider the process size, voltage types, interface types, and other restrictions for system integration. Multi-system assembly techniques, composed of a sensor unit, a data processing unit and a FPGA (implement diversity peripheral interface or bus), use 3D packaging technology to achieve integration. Multiple chips of the electronic systems are integrated or assembled in a single package, so that you can effectively achieve minimum micro-nano satellites. Multi-system technology assembly technology uses of micro-nano assembly technology, system in package(SiP) technology and other assembly techniques, completing multi-system interconnect and communicate.

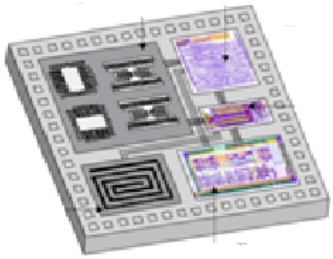

Figure 5 on the integrated effect diagram

3. SoPC Flight Control Design and Implementation

On-chip multi-system integration technology as a technology platform has now completed a chip for the function of control, data processing and navigation, mainly for the application of small satellites and onboard flight control.

Design objectives and requirements: 100MIPS computing power, storage space is greater than 10M, programmable space, I2 bus, satellite navigation, inertial platform interface, high speed digital to analog conversion. The general requirements for flight control, there must be a high-performance computing power and flexible software and hardware programming capabilities, navigation and positioning capabilities. Using multi-chip integration technology for the design and implementation. Completion of a flight control SoPC chip, below is a photo of the flight control

SoPC.

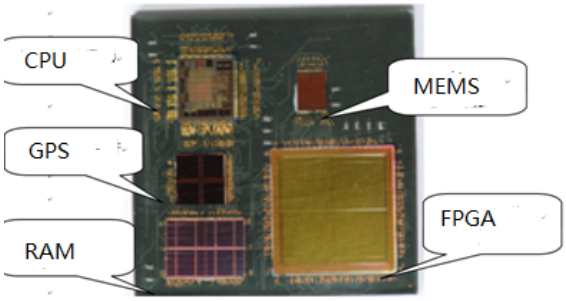

Figure 6 a photo of the flight control chip SOPC

Flight control SoPC dual-core + programmable architecture, flight control processor to complete flight-related solver, flight control processor has a rich peripheral interfaces, for receiving the data of inertial navigation and peripheral device sending instructions. GPS satellite data processor to complete PVT solver, providing location information, programmable part, provide hardware real-time processing capabilities, to provide users with flexible hardware design.

Table 1 GNC system comparison table

	Traditional GNC	The GNC based on SoPC
Operational Performance	ARM7 60MIPS no-fpu	SPARC V8 150MIPS 50FLOPS
Weight	6kg	240g
Power	10W	1.6W
Peripheral circuits	16 kinds, 45 chips	3 kinds，5 chips

Flight Control SoPC of distinct characteristics, flight Control SoPC chip based entirely on intellectual property rights, chip from the hardware design to software based entirely on its own technology, and save the required boot PROM programmable part by using the embedded FLASH. Chip embedded cryptographic modules to increase system security, avoiding exposing bit files on electricity. Internal processor and programmable of the SoPC achieve tight coupling, processor can fully control all the actions of programmable components, including load, update, program execution, because of this it can automatically load the program for programmable portion, besides the programmable parts online upgrade.

4. conclusion

Application analysis from a small control system module (flight control SoPC), SoPC replace the existing flight control systems are greatly reduced from the weight, volume and power multiple aspects. In the original system functions and provides a variety of peripheral interfaces and FPGA interfaces for system integration and flexible expansion.

System design based on multiple-system on-chip, from the beginning of the design, takes advantage of integrated microelectronics technology to achieve a single silicon chip integration, assembly integration and hybrid integration. Combined with design software and application software, the designer can easily develop a standardized, small size, low power system chip.

Above techniques provides an effective technical approaches and solutions for system design.

5.References

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