

Research on Spacecraft Integrated Electronic System Architecture Based on Information Fusion

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Abstract. This paper has designed the integrated electronic system and protocol architecture based on the standard of Consultative Committee for Space Data Systems (CCSDS) and European Communication Satellite System (ECSS). The application layer, application support layer, transport layer and sub network layer in the architecture can be described in detail, and the functions can be realized through the combination of various business and protocols. The architecture can provide technical support for the intellectualization and networking of spacecraft, standardize the spacecraft interface and protocol, it can promote the generalization of spacecraft equipment and software, and provide more flexible and powerful functions for the spacecraft.

Keywords: Spacecraft avionics system; Space communication protocol; Information fusion.

1 Introduction

In order to improve the design level and R & D capability of our spacecraft, it is necessary for us to use the idea of information fusion design, to make use of standard interface and protocol specification to interconnect the satellite borne electronic equipment, and to create an integrated integrated electronic system with internal information sharing and comprehensive utilization, functional integration and resource reorganization and optimization. The system can achieve telemetry, remote control, energy management, heat control, attitude and orbit control, unlocking and driving control, intra satellite communication, time management, data management, load management, autonomous task planning, image location registration and motion compensation, which can achieve the purpose of general hardware modules, reasonable information flow, function density promotion and total optimization of body performance.

Avionics refers to the general term of spacecraft electronic system, which is the brain and nerve of spacecraft. The design of the integrated electronic system of spacecraft breaks the relative independent boundary of traditional subsystem. According to the information flow and energy flow in the subsystem and load subsystem, and the system architecture, the system realizes the function synthesis, software synthesis and hardware synthesis for electronic system products. In order to solve this problem,

this paper focuses on how to selectively apply CCSDS standards and ECSS standards in Chinese spacecraft, establish a standardized service and protocol architecture, form a unified information network service, and provide a technical basis for the intelligent and networked spacecraft.

2 Design of integrated electronic system business and protocol architecture

By analyzing the needs of remote sensing, navigation, communication, manned spaceflight and deep space exploration, we can conclude that the general requirements of integrated electronic system include 7 top level functions, which are remote control, telemetry, time management, internal affairs management, heat control management, power supply management, unlocking and rotating mechanism control.

(1) Remote control is an important way to control the spacecraft on the ground, including earth communication, real-time instructions distribution, the delay instruction distribution, and data injection channel for other applications.

(2) Telemetry is an important way to obtain various operating state data of the spacecraft and the results of remote control operation, including telemetry collection, telemetry organization, telemetry and so on.

(3) Time management is used to synchronize the

satellite and ground time, and the time synchronization between devices, including the functions of centralized time, uniform time, GPS time, time release, time code generation, etc.

(4) The internal management is used to realize the health management for spacecraft, including the monitoring of load parameters, event reporting, event action, memory management, on orbit maintenance, important data preservation and recovery, self testing, system reconfiguration and other functions.

(5) Thermal control management includes open loop control, closed loop control, fault detection and disposal, thermal control parameter setting and other functions.

(6) Power management includes power regulation, power distribution, voltmeter control, and over temperature protection for battery group.

(7) Unlocking and rotating mechanism control includes initiating control of explosive device, and driving and controlling mechanism of antenna and solar wing.

In addition to the general requirements mentioned above, the spacecraft in different fields have some special requirements for integrated electronic systems, such as autonomous task planning, autonomous navigation, interdevice routing, emergency return and environmental control management.

According to the decomposition of above general functions, it is known that most of top layer functions communicate with ground or other equipment by interface protocol and interface protocol between various subsystems in the device. At the same time, the functions also need some common business, such as remote control, internal affairs management, thermal control management, power management and so on to send instructions, telemetry, internal affairs management, thermal control management, power management to obtain telemetry data to identify. For some functions related to intelligentization, such as autonomous task planning, autonomous decision, and so on, telemetry and sending instructions should be obtained, and message communication between different functions should be carried out in order to achieve collaboration. These common services and protocols can be used by standardization for top level functions, so it can separate the top layer function from the underlying business and protocol, make the business and protocol to be in common use for each spacecraft, facilitate the interconnection of the spacecraft in the future, and the interconnect between different spacecrafts.

The integrated electronic system configuration and interface relationship is shown in Figure 1.

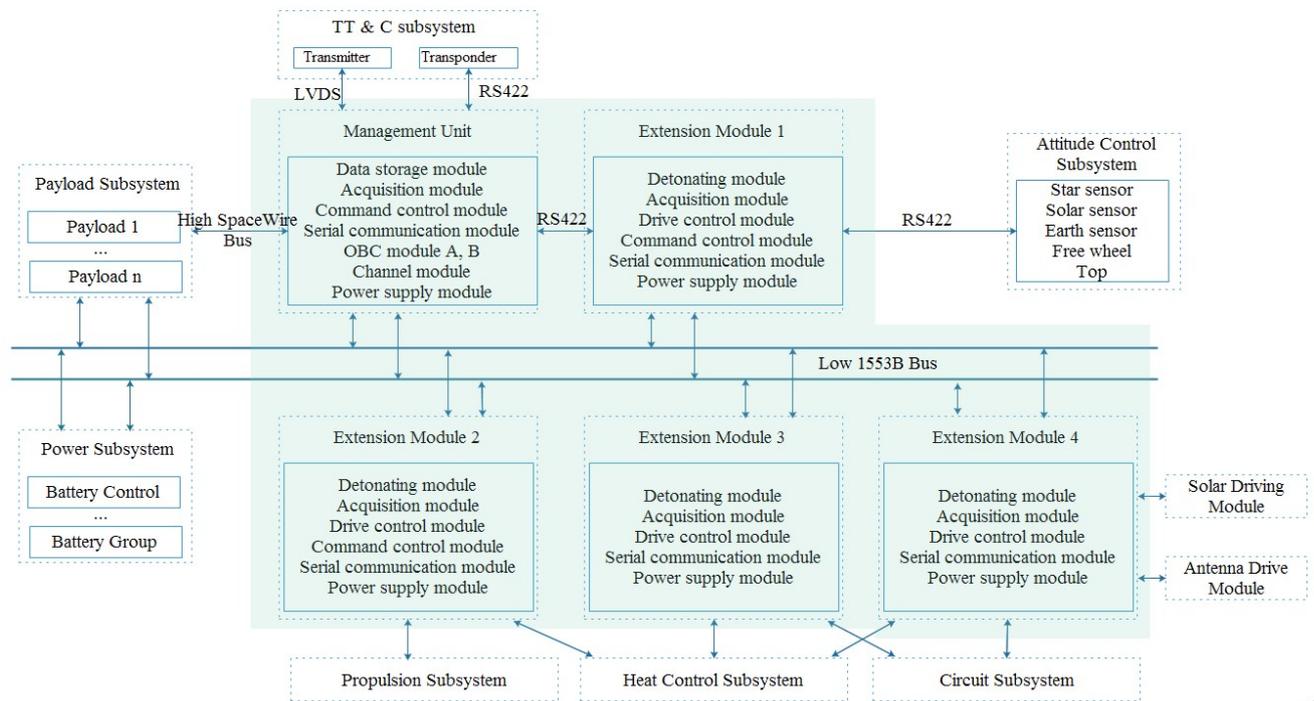


Figure 1. Frame diagram of integrated electronic system.

3 Information flow design based on data fusion

3.1 Data packet format for Science Source

All the high and low speed loads and telemetry data to be transmitted are unified into the scientific data source package (AOS standard package CP_PDU) with CCSDS AOS, and the different load APID number is different. The scientific data source package is shown in Table 1.

Table 1. The basic format of load scientific data source package.

Main Header							Packet Vice Header	User Data	
Packet Flag			Packet Order Control		Packet Length				
Version	Type	Auxiliary Flag	Process Flag	Group Flag	Packet Sequence Counter	Data Field Length	Time Flag	Auxiliary Data	Process Data
3bits	1bit	1bit	11bits	2bits	14bits	16bits	48bits	Variable	

3.2 The format of SPW data packet

The physical layer, link layer and network layer protocol of the SpaceWire bus network conforms to the ESA ECSS-E-50-12A protocol specification. The transport layer protocol refers to the ESA ECSS-E-ST-50-11C

protocol specification (RMAP protocol) and the GOES-R satellite SpaceWire related protocol standard (RDDP protocol). We have formulated the SpaceWire network transmission protocol of the integrated electronic system. The SpaceWire packet format is shown in Table 2.

Table 2. Load SpaceWire data packet format.

SPW Address	Logic Address	Protocol identification number	Channel	Transmission identification number	Header CRC
2 Octets	1 Octet	1 Octets	2 Octets	3 Octets	1 Octet

Insert Area	Effective data length	User Data	Data CRC	EOP
2 Octets	1 Octet	1010 Octets	1 Octet	4 bits

3.3 Load data recognition unit

High-speed load data are routed to the target port via SpaceWire bus network, and then, the load data are divided according to the different APID numbers in the load data science source package, finally a virtual channel flag (VCID) is allocated for VCDU assembly.

3.4 Multiplexing process

The multiplexing process connects multiple CCSDS packets in series and is organized in the same virtual channel data unit. The format of the M_PDU is shown in Table 3.

Table 3. Format of multiplexing protocol data unit (M_PDU).

M-PDU Header		M-PDU packet area				
Backup	Header Pointer	K packet	k+1 packet	...	m packet	m+1 packet
5bits	11bits	1010 Octets				

3.5 Standard bit stream business process

The standard bit stream service is similar to the bit stream business defined by CCSDSAOS, Only the standard bit stream business data unit is formatted bounded data. Table 4 shows the standard bit stream business data unit format.

Table 4. Standard bit stream data unit format.

B-PDU Header		B-PDU Data Area
Backup	Bit stream data pointer	
2bits	14bits	1010 Octets

3.6 VCDU assembly process

The VCDU assembly process is completed in a virtual channel, each virtual channel has a virtual channel compilation function. The assembler is to place an VCA_SDU (including B_PDU and M_PDU) in the VCDU data domain and generate VCDU leader. The VCDU data frame format is as shown in Table 5.

Table 5. VCDU data frame format.

Version	VCDU-ID		VCDU Counter	Signal Field		Insert Area	VCDU Data Field
	SCID	VCID		Playback Flag	Null		
2bits	8bits	6bits	24bits	1bit	7bits	16bits	1012bits

Version: 01,02...

SCID: Aircraft number;

The virtual channel identifier VCID: if the VCDU is filled, the VCID is all "1". Each high speed load is assigned to one VCID;

VCID counter: The total number of VCDU frames transmitted on each virtual channel is counted sequentially (module 242 operation), which is used together with the VCDU-ID domain to maintain a separate count for each virtual channel.

Signal domain: the first bit in the signal domain is playback identifier in the CCSDSAOS protocol. When set "0" means real-time transmission, and set "1", it means VCDU is delayed. The 7 bits in the information field are all set as "0".

Insert domain: used to encrypt or insert time information;

VCDU data domain: high speed B_PDU data frame or low speed channel multiplexing frame M_PDU.

3.7 VCDU conversion process

In order to ensure that the information output to the physical channel is a continuous, fixed code rate data stream, the VCDU conversion function can fill a VCDU

data from the fill function request, that is, a virtual channel data filling process. The VCID filled VCDU is set to all "1".

3.8 Demarcation function of load data

The delimiting function produces PCA_PDU, which forms a continuous and adjacency CADU data stream by adding each VC_PDU to the synchronized flag prefix. Each CADU occupies a synchronous slot on a physical channel. The synchronization symbol is CCSDS standard ASM, which is represented by sixteen symbol: 1ACFFC1D. Low speed load data CADU frame format and high speed load data CADU frame format are shown in Table 6 and chart 7 respectively.

Table 6. CADU frame format for low rate load data.

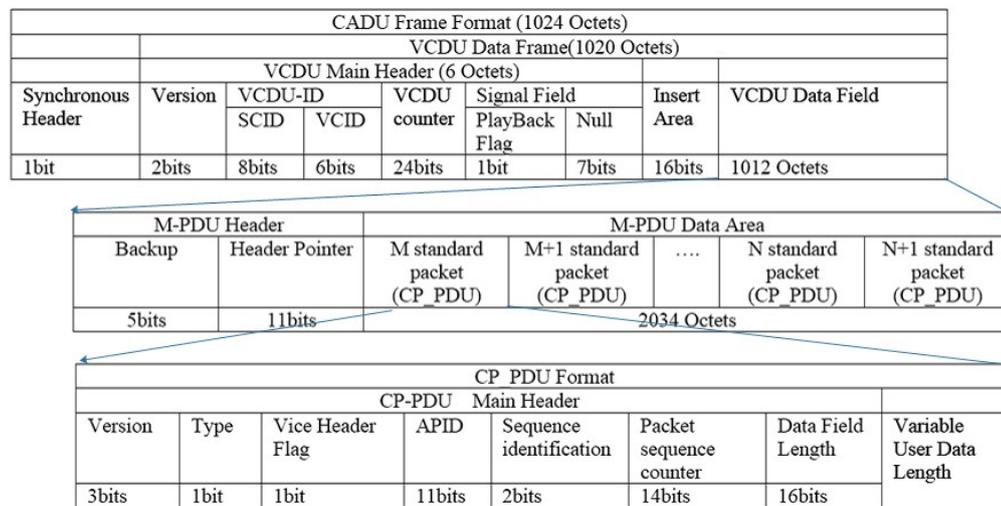
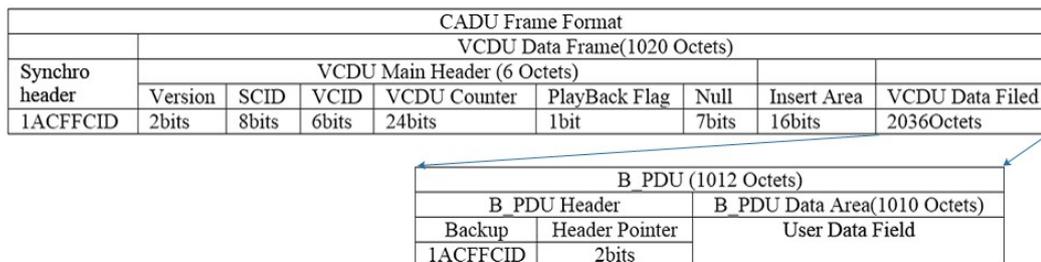


Table 7. CADU frame format for high rate load data.



4 Application effect analysis

In order to verify the design feasibility of business and protocol architecture mentioned above, all the services and protocols in the application layer architecture are implemented by software, and the assembly and test verification are carried out according to the requirements of hardware platform in integrated electronic system. The test and verification show that the service and protocol architecture designed in this paper can provide more abundant, practical and powerful functions than traditional spacecraft, which is mainly reflected in the following aspects.

- 1) The data transmission mechanism is more flexible
 When the traditional spacecraft transmits data through a

serial data interface, the time interval, the length of the data and the destination of the transmission are mostly fixed, and it is difficult to change flexibly. In the architecture of this paper, CCSDS's Space packet protocol, SOIS subnetwork packet service and aggregation layer are used. The system supports the time interval of serial data interface transmission by user on demand, and the data length and destination are transmitted on demand.

- 2) System support interface replacement.

If the traditional spacecraft has replaced the interface, the spacecraft generally needs to modify the software and re-set the data. The CCSDS space package protocol, SOIS sub-network layer package service, and convergence layer are applied in this article's architecture. Users can access the system through different interfaces.

3) The system supports demand expansion

In this paper, CCSDS message transmission service, device access service, device virtualization service, and device data pool service are applied. After the cooperation with the underlying space packet protocol, sub-net layer packet service and convergence layer, the system can extend the number of processors flexibly.

4) System support standardized bulk data transmission

In this paper, CCSDS's remote control protocol, AOS protocol, COP 1 protocol, Space packet protocol, subnetwork packet service and aggregation layer are used to provide standardized transmission mechanism for ground users. The user can make the maximum 65542byte Space packet at one time and automatically segment it by the remote control protocol, and automatically confirm the transmission results of the frame according to the COP 1 protocol. This can not only provide a friendly interface to the user, but also greatly improve the efficiency of the upper injection. Rate, thus avoiding the past two major drawbacks.

5 Conclusion

The spacecraft integrated electronic system business and protocol architecture is proposed in this paper, it fully absorbs the latest achievements of CCSDS and ECSS

standards, and uses the architecture to design space communication protocols for spacecraft, this will help to standardize the interface between the ground / device and subsystems in the device. It will provide a powerful support for the intelligent and networked follow-up spacecraft.

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