Modularization and Parametric Design of Airborne Electronic Equipment Structure

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Abstract: In order to improve the design efficiency and quality of traditional airborne electronic equipment, the structural forms of traditional equipment are summarized. Based on the creation of basic structure modules, the parametric design of series structure modules and access devices is carried out. According to the functional requirements of the equipment, different series of structural modules are selected, combined and installed in the access device to quickly realize the modular design of airborne electronic equipment. A series of structural modules are repeatedly applied on a variety of equipment to improve the design reliability.

1. Introduction to modular design of airborne electronic equipment structure
The modular design of airborne electronic equipment is a design method, based on the functional division of airborne electronic equipment to install functional modules, to combine them into a complete set of equipment according to the performance requirements of products and the application of different series of structural modules. Modular design is the core and frontier of modern standardization and the development direction of standardization principles in the information age[1].

2. Feasibility Analysis of Modular Design of Airborne Electronic Equipment Structure

2.1. Functional Classification of Airborne Electronic Equipment
The airborne electronic equipment can be divided into several series by its function, each of which meets the requirements of the system power supply and distribution, data acquisition and storage, and interface control. The equipment structure is designed according to the specific requirements of electrical performance.

2.2. Classification of Airborne Electronic Equipment Structure
The structure of traditional airborne electronic equipment is divided into the overall frame type shown in Figure 1, the combined type shown in Figure 2, and the special type (barrel type) shown in Figure 3.

Figure 1 Overall frame type   Figure 2 Combined type     Figure 3 Special type (barrel type)
2.3. Analysis of the Function and Structural Design Characteristics of Airborne Electronic Equipment
1) The functions of airborne electronic equipment are designed according to specific requirements, which are highly pertinent and not universal.
2) The external dimensions of the printed boards of the airborne electronic equipment are slightly different.
3) The external interfaces of airborne electronic equipment are the same, most of which use rectangular connectors.
4) To meet the requirements of system installation performance and strength design, most airborne electronic equipment structures adopt a miniaturized design.

2.4. Advantages of Modular Design Methods for Airborne Electronic Equipment[2]
1) Modular design decomposes complex products into generalized and serialized unit modules and combines them into different products.
2) Modular design makes components universal, avoids repeated design work, and improves design efficiency.
3) For faulty modules, the modular design can realize rapid replacement and improve the repairability of the product.
4) The same and similar structural design forms greatly improve the reliability of the product.

2.5. Feasibility Analysis of Modular Design Method for Airborne Electronic Equipment Structure
1) There are many structural design types of traditional airborne electronic equipment, but there are few differences in structure dimensions, which lays a solid foundation for the integration and division of unit modules.
2) The printed boards of various modular products have similar and coordinated appearance dimensions, which is conducive to the exchange and combination of structural modules.
3) The existing overall framework structure of airborne electronic equipment is similar to the structural module, and product test data can be used for reference.

Therefore, through the analysis of the functional classification and structural design characteristics of airborne electronic equipment, the structural modular design method of airborne electronic equipment is feasible in the research and application.

3. Structural Module Design Method
The modular design method of airborne electronic equipment mainly includes three processes of module division, module creation, and module combination[3]. The modular structure design of airborne electronic equipment is based on the division of equipment functions. The modular design of the structure of airborne electronic equipment is realized by creating general basic structural modules and a series of structural modules and then combining them.

3.1. Functional Division of Airborne Electronic Equipment Modules
The basis of the modular design of the airborne electronic equipment structure is to divide the circuit functions of the equipment into modules according to the system requirements. The divided functional modules can be installed on the structural modules as required. After selection, interconnection, and splicing, the performance design requirements of airborne electronic equipment can be realized.

3.2. Generalized Design of Basic Structural Modules
The structural module of an airborne electronic device can be used as the basic structural module of a modular product.
The basic structural module is shown in Figure 4, including the panel part, the guide rail part, and the installation frame part, which is made of aluminum alloy. The width and height of the panel part suit the size of a single rectangular connector. There is one guide rail on the top and bottom of the frame each, which plays a key role in positioning and fixing the structural module. The printed circuit board can be fixed on one side of the mounting frame by screws.

3.3. Structural Modular Design of Modular Product Series

A series of structural modules are designed after analyzing the functional unit modules of the airborne electronic equipment, according to the constant height and size of the basic structural module and the requirements of each functional module, interconnecting the structure design of the frame, changing the panel width parameter size, and adding to the guide rails[4].

a) A-series module structure is based on the basic module structure whose width and height of the panel remain unchanged. The length of the frame is determined according to the size of the printed circuit board that needs to be installed. The frame structure is designed for interconnection structure. The mounting frame part of the series module structure is suitable for installing a single printed circuit board. The printed circuit board can be installed with a connection plug connected to the bus motherboard, and the panel part can be installed with one or two rectangular connectors. The series module structure is shown in Figure 6. Figure 7 is a functional module with the series structural module installed.
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Figure 7 A functional module installed with A-series structural modules

b) B-series structural module is based on the basic structural module whose height of the panel remains unchanged. The length of the frame is determined according to the size of the printed circuit board that needs to be installed. The module components connected with the bus motherboard are in the frame structure. The interconnection structure is designed to meet the installation requirements of multiple connectors for a single printed circuit board module assembly, and the panel width is increased to 1.5 times the panel size of the basic structural module. The B-series structural module is shown in Figure 8. Figure 9 shows the functional modules installed with B-series structure modules.

![Fig. 8 B-series structure module](image)

Fig. 8 B-series structure module

![Fig. 9 A functional module installed with B-series structure modules](image)

Fig. 9 A functional module installed with B-series structure modules

c) C-series module is based on the basic structural module whose height of the panel remains unchanged. The length of the frame is determined according to the size of the printed circuit board that needs to be installed. The width of the panel, the structure volume, and the number of guide rails are all double basic modules. For the module components connected with the bus motherboard, the interconnection structure is designed in the frame structure, and two connected printed circuit boards or electronic components with heat dissipation requirements can be installed. The C-series structural module is shown in Figure 10. Figure 11 shows the functional modules for installing C-series structural modules.
The A, B, and C-series structural modules meet the installation requirements of various functional module components and realize the serial application of structural modules in airborne electronic equipment.

4. Parameterized Design of Access Devices

4.1. Design of Access Devices
The structure of the access device for the installation of structural modules is designed according to the type, length series, and quantity of the series of structural modules selected by the product. According to the type of structural module selected and installed by the product, design the access device frame of the rail slot that matches the module rail, and connect it with the cover structure of the bus printed circuit board to complete the access device design. Figure 12 shows the frame of the access device that can install two A-series structural modules.

4.2. Parameterized Design of Access Device
The frame size of the access device is shown in Figure 13. The frame length L needs to be calculated according to the size type and arrangement order of the series modules selected by the product. The calculation formula is shown in formula (1).
Figure 13 External dimensions of the access device frame

$$L = \text{LEFT1} + (m+n+i-1) \times \text{MIDLE1} + m \times \text{PANELA} + n \times \text{PANELB} + i \times \text{PANELC} + \text{LEFT2} \ldots \ (1)$$

- $L$ —— The distance between the sides of the frame, LEFT1=3.5mm;
- $\text{LEFT1}$ —— The distance between the leftmost side of the module and the frame side, LEFT1=3.5mm;
- $\text{LEFT2}$ —— The distance between the module edge and the frame edge on the far-right side, LEFT2=3.5mm;
- $\text{MIDLE1}$ —— The distance between modules, MIDLE1=3mm;
- $\text{PANELA}$ —— The width of the panel of Type A module, PANELA = 24mm;
- $\text{PANELB}$ —— The width of the panel of the type B module, PANELB =33mm;
- $\text{PANELC}$ —— The width of the panel of C type module, PANELC =48mm;
- $m$ —— the number of type A modules in the product module;
- $n$ —— the number of type B modules in the product module;
- $i$ —— the number of C-type modules in the product module;
- $\text{PANELH}$ —— The height of the frame = the height of the panel.

The structure of the access device frame can be designed using a parametric method based on CREO software. Figure 14 is the procedure for generating the frame length $L$ from the parameter size by the CREO software. [5].
5. Combined Design and Application of Structural Modules

The purpose of modular design is to use as few types and specifications of structural modules as possible to assemble as many types and specifications of product components as possible to meet the needs of diversified products. Structural modular combination design is to select different series of structural modules to install them into functional module components according to the specific functional requirements of the equipment and insert the access device structure suitable for the structural modules to finally complete the product design process[6].

Through reasonable planning of the equipment function, the printed circuit boards with different functions are installed on the three series of modular structures of A, B, and C, combined and installed in the access device, and connected through the bus printed circuit board, to achieve the modular design of the combined airborne electronic equipment. Table 1 shows the modular structure design process of part of the airborne electronic equipment.

| Modular products | Module series combination | Access device frame | Equipment appearance |
|------------------|---------------------------|---------------------|---------------------|
| 1                | A+A                       |                     |                     |
| 2                | C+C                       |                     |                     |
The combined design of missile-borne airborne electronic equipment replaces the traditional overall frame (Figure 1) and modular structural design form (Figure 2). The universal structural series of modules allows each functional module to be combined and applied as required to complete the design requirements of different equipment in the system.

6. Conclusion
The modular and parametric design of the structure of the airborne electronic equipment makes the installation structure of the functional module components of the product universal and avoids repetitive structural design work. The parametric design access device improves the design efficiency, quality, and reliability. Various faulty modules of airborne electronic equipment can be quickly replaced, which is convenient for equipment maintenance and debugging. The product structure design of the combination of series modules has changed the design method of traditional airborne electronic equipment. According to the division of functional modules and different requirements of the project, mature modules and newly developed modules can be applied to combined design. The design of new equipment on the platform is completed through the design in the same structure.

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