Research and implementation of communication system optical fiber interconnection of airborne IMA platform

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Abstract. On the IMA platform of airborne avionics system, optical fiber interconnection has become a trend. Aiming at the problems that must be solved in the realization of optical fiber interconnection of airborne IMA platform, such as optic-electric conversion, high-density and reliable connection and Anti-Harsh environment, this paper adopts optical modules, high-density optical backplane and other solutions, introduces high-density optical interfaces standard and ARINC series optical connectors standard, and realizes the optical fiber network interconnection of airborne IMA platform.

Keywords: optical fiber interconnection; optic-electric conversion; high-density and reliable connection; high-density standard.

1. Introduction

As the development of airborne avionics system to integrated, modular and open architecture, more and more COTS technologies are widely used in airborne avionics system. Processor technology is developing rapidly at GHz level, which also puts forward higher requirements for bandwidth, delay and transmission distance of airborne avionics network. High bandwidth optical fiber interconnection technology \cite{1} (>10 GHz) is considered to meet the needs of the next generation. Optical fiber interconnection technology has been successfully applied in the ICP rack of JSF to provide unified optical fiber network interconnection. It is particularly important to complete the design and implementation of airborne IMA platform optical fiber interconnection, and solve the engineering problems such as optic-electric conversion, high density, high reliability and anti-harsh environment \cite{2}.

2. Problems in optical fiber interconnection

The optical fiber interconnection application of airborne IMA platform must solve the problems of optic-electric conversion, high-density optical fiber interconnection and optical signal transmission.

2.1. optic-electric conversion

In airborne IMA platform, the high performance processing module of standard LRM should convert the data into optical signal for transmission. Optical module is the core device that completes the conversion of optic-electric and electro-optic, and the conversion function must be completed in an
extremely limited space, and ensures normal operation under severe temperature, vibration and other environmental conditions at the same time. These are the problems that must be considered by the optical module.

2.2. High density optical interconnection
The optical fiber interconnection of airborne IMA platform will inevitably face the problem of parallel multi-channel transmission, so the problem of high-density optical fiber interconnection is an important problem to be solved. In the field of optical fiber communication, high-density interconnection must be realized through high-density interface and high-density optical backplane. Therefore, it is necessary to research the engineering application of high-density interface and optical backplane in airborne IMA platform.

2.3. Optical signal transmission
Optical signal transmission includes high-density and reliable transmission within the platform and between the platform and external equipment.

The optical signal in the IMA platform requires high transmission density, short transmission distance and low optical loss. The frequency of assembly and maintenance is also low, so it mainly solves the problem of high-density interconnection. The optical signal transmission between equipment requires long distance and low optical loss. In addition, considering the convenience of assembly and maintenance, the space is generally abundant, focusing on solving the problem of high reliable interconnection. Therefore, optical signal transmission focuses on interface selection and transmission medium.

3. Implementation of optical fiber interconnection

3.1. Optical module application
The optical module in airborne IMA platform requires small volume, high reliability and anti harsh environment. Therefore, the optical module using SIP technology can meet the application requirements of airborne IMA platform and greatly simplify the system composition of the module [3]. There are two kinds of mature optical modules now.

3.1.1. SFP optical module. SFP optical module is small in size and can be configured with a large number of ports on a small panel. In addition, SFP optical module can also support hot plug and other functions. In order to meet the growing needs of the system, optical modules are developing towards standardization, miniaturization and intelligence. The SFP optical module is shown in Figure 1, which is generally an LC interface. SFP optical module has good economy, but its ability to resist harsh environment is weak. It is mainly used in airborne simulation and verification environment, and the actual airborne products are less used.

Figure 1 SFP optical module

3.1.2. Optical module based on LCC package. The optical module based on LCC package generally adopts lc48 package, and the size is only 16.4×16.4×4.0 mm. It can work normally in a wide working temperature range. The product can be applied to various parallel transmission fields, such as parallel optical interconnection, HD audio and video optical transmission, etc. It can be divided into three
categories: multi-channel parallel optical transceiver module and multi-channel parallel optical transmitter and optical receiver module. Each channel of this optical module can reach the transmission rate of 10 Gbps, the transmission distance of multi-mode optical fiber is at least 300m, and the temperature range meets the application requirements of airborne IMA platform. It is designed with MT/MPO interface pigtail, which can carry out high-density interconnection. At present, this LCC encapsulated optical module has been widely used in airborne LRM module to complete optic-electric conversion.

![Figure 2 LCC packaged optical module](image)

3.2. Implementation of high density optical backplane

The high-density optical backplane is mainly realized in the following ways:

1. Optical electronic circuit board (EOCB), in short, is a packaging substrate required for a new generation of high-speed computing that integrates light and electricity, uses light as signal transmission and uses electricity for computing. It adds a light guide layer to the currently developed very mature printed circuit board, therefore, the use of circuit board is extended from the existing electrical connection technology to the field of optical transmission. The printed optical circuit board is compatible with the standard PCB technology and surface mount technology SMT, and can easily realize the high-density miniaturization of electronic equipment.

   For the printed optical circuit board, Panasonic electric developed a film with optical transmission characteristics on January 10, 2008. The important indexes of the printed optical circuit board made by using the film material and the manufacturing process of the board are: the thickness of the upper and lower film is 10μM above, the waveguide loss is 0.1 dB/cm, and the transmission of 10 Gbps can be realized [4]. The optical electrical interconnection PCB manufacturing project of UCL in the UK can not only be compatible with the low-cost waveguide manufacturing process compatible with traditional PCB processing; Moreover, 10GB/s multimode waveguide is realized on 19 inch PCB [5]. This technology has good reliability, but due to the problem of economy, it has not been verified on a large scale in the airborne environment.

2. Optical fiber circuit technology. It is characterized by packaging the optical fiber circuit (ribbon optical fiber) into the flexible plate after wiring, so as to realize the optical fiber interconnection between each module on the backplane and the backplane, so as to achieve the management of high-density optical fiber interconnection. This is a relatively mature optical backplane interconnection technology. Tyco, Molex, HRS and other companies have the ability to provide corresponding technologies. Optical fiber circuit technology and printed circuit board (PCB) are independent of each other. The high-density optical backplane is better made by Amphenol company [6]. The research on the optical backplane of Amphenol has been updated several times. Figure 3 shows the upgraded optical backplane architecture of Amphenol. The upgraded architecture supports eight functional modules and one switching module. Compared with the first generation optical backplane, the upgraded optical backplane can not only support more modules, but also do better in scalability and scalability.
Now, adopting the mature practices of foreign countries, domestic Aeronautical Computing Institute has taken the lead in applying optical backplane technology to airborne avionics system and carried out experimental verification [7]. The designed optical backplane is shown in Figure 4. This design can meet the requirements of high density and high reliability of optical fiber interconnection of IMA platform of airborne avionics system.

3.3. Optical signal transmission scheme

3.3.1. Optical cable selection. There are two types of optical cable media used in fibre channel, one is multimode fibre and the other is single-mode fibre. Multimode fibre is the most common medium type, and its laser wavelength is 850 nm. Light at 850 nm wavelength is visible and harmless to human eyes. The effective transmission range of multimode fibre is 0-500m. Single mode fibre is one of the most expensive media, but it is suitable for long-distance signal transmission. The laser wavelength used is 1300 nm, which is invisible and harmful to human eyes. The diameter of single-mode fibre is 9 microns, and the small diameter makes light not easy to lose. In long-distance transmission, single-mode fibre is the best solution. In addition, its potential transmission speed is also the highest, the theoretical limit speed is 25Tb/s, and the theoretical limit transmission speed of multimode fiber is 10Gb/s. Single mode fibre itself is not much more expensive than multimode fibre, and the increase in price mainly lies in its transceiver components. In the airborne environment, combined with transmission distance, cost and reliability, the optical fiber mode is generally multimode 62.5/125, and the optical fiber transmission wavelength is 850nm. This kind of optical cable is also suitable for cooperation with optical module products.

3.3.2. Optical connector interface selection. Optical fiber connector interfaces mainly include MPO, MT and 38999 standard interfaces.

MPO optical fiber connector interface is a multi-core and multi-channel pluggable connector. It is a structure of MPO optical fiber connector in IEC standard, as shown in Figure 5. MPO connector consists of a pair of MT sleeves, two guide pins, two housings and an adapter. The MPO connector is easily connected and disconnected through an MPO adapter [8].
The typical style of MT connector is shown in Figure 6. 12 core fiber channel can be integrated on a single interface, and the performance has been comparable to that of a single fiber connector. The maximum insertion loss is less than 0.3dB, the nominal loss range is 0.1 ~ 0.2db, and the overall dimensions of both single-mode and dual-mode MT interfaces are standard, which also ensures their interchangeability. Therefore, from the perspective of application and performance, high-density MT optical fiber interface is an interface that can meet the high-density interconnection requirements of airborne avionics system [9].

The optical module generally adopts MT/MPO interface, so these two interfaces are generally selected for high-density interfaces in the equipment.

Considering the airborne environment, the optical fiber connectors in the equipment room generally adopt products conforming to the shape of 38999 series [10]. Arinc80 series standard optical fiber interconnection components meet the requirements. Arinc80 series standards define a specification for the design, installation, testing and maintenance of optical fiber interconnection components (including connectors, optical cables and optical fiber terminals). The key hole diameter of its connector is compatible with 38999 standard. Its main purpose is to reduce the system interconnection cost by standardizing and serializing the connectors with the same functions in airborne products, so as to reduce the scale, save the actual maintenance cost and the training cost of technical maintenance personnel. The optical fiber interconnection components defined in arinc80 series standards are mainly based on a standard optical fiber terminal (collectively referred to as optical fiber contact), and then designed with differentiated hole locations. Arinc80 series standards include a series of specifications for optical fiber interconnection components, optical fiber system design, optical fiber test and optical fiber maintenance.

4. Summary
The optical module and high-density optical motherboard mentioned in this paper, combined with MT/MPO interface and arinc80 series standards, can effectively solve the problems of high density, high reliability and anti harsh environment faced by the optical fiber interconnection of airborne ima platform, meet its application environment and performance requirements, and have been verified by application, which is worthy of promotion.

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