Research on the Sensor Network Technology Applying to the Fourth Generation Fighter Plane

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Abstract **- The technologies of advanced data acquisition, analysis, transmission and data processing are the main research directions of China Airline Industry. Optical fiber, which features the characteristics of high speed data transmitting and high performance of interference killing feature, is doomed to using in avion along with the development of integration, intellectualization, modularization and mechanical-electrical integration of airborne equipments and weapons. P. R. China needs to develop its own the fourth generation fighter plane for improving the armament modern level. We studied the web sensor/sensor network technology applying to the avion. The airplane Data Acquisition System(ADAS) mainly adopted the distributed sensor network technology based on ATM-SONET, among which included ATM-SONET OC-3c, ATM-SONET OC-12, Ethernet and Fiber Channel technology. The ADAS can made real time measurement, record, transmission and monitor to the work state of non-aviation electronic syste, it can also make an alarm in an emergency. Besides, the ground command center can make real time long-distance diagnosing to the avion fault.**

Key words: fighter plane; web sensor; sensor network; airplane data acquisition system

I. INTRODUCTION

Airborne equipment is a collective term of the functional system made up of aviation electronics, machine and the electromechanical devices. At present, there is no certain Airplane Data Acquisition System(ADAS) in domestic fighter plane, which takes the processor of machine and electrical system instead in the non-aviation electronics management.

Active discrete on-board data acquisition and marking device is used for measuring flight parameters and equipment parameters when plan flies, which also offers information for airmen or air auto-control system. These parameters are dispersed over visual monitoring, automatic logging, information monitor and controlling, which integrates the characteristics as below:

(1) The number of parameters to be measured is plentiful.
(2) The diversification rule of the parameters in time domain is complex.
(3) The more needs of equipments for the same parameters.
(4) The synthetic display of measured parameters is the bottleneck problem of aircraft instrument. There are some different kinds of cluster gauge firstly designed to reduce the volume, weight and number of the aircraft instrument. Mainly of these instruments are made up of combining several appearances which measures the same parameters in different ways or displaying the parameters of a certain object together, for example, the fighter plane-X uses the appearance display the fuel pressure, lubricating oil pressure and the temperature at the same time. The plane widely adopts the electronic integrated display system at present, several display screens are used to replace the single display instrument all over the aircraft cockpit. The X generation battleplan of our country could display the parameters of fire control, radar and electron, however, it could not display all the flight parameters and not equipped with long-distance real time transmission and failure diagnosis.
(5) The operating environment of measuring instrument is execrable. General data acquirement and recordation system has been used by external fighters. The flight parameters and the airborne equipment usage parameters are analysed with the surface rerecording equipment after landing. The engine and fight attitude is evaluated with the flight parameters to decide whether it can be take off again. The airborne equipment usage parameters is read and analysed according to the mission and its importance, which could be more significant in the reading of the combat-relevant parameters, for example, the parameters of the early warning radar cruising on Taiwan Strait, parameters of the radar target or hostile aircraft, condition of the target zone or the targeting system, video record of the air information and the guiding image of the TV guiding weapon.

II. New generation data acquisition and recording system

The new generation ADAS accomplishes the supervisory control and data acquisition of the functional system made of aviation electronics, machine and the electromechanical devices. It is the fault detection center of the airborne equipment, which also fulfills the data transmission between airborne equipment and weapon system, other airspace systems and groundcontrol center. The interface schematic diagram of ADAS is showing in Fig.1. The primary functions of new ADAS are listed as follows:

(1) Real time acquisition, recording, watching the operating state of airborne equipment and the weapon system, giving an alarm when emergency occurs.
(2) Transmit the data of airborne equipment and the weapon system, for example, the image, the state of undercarriage and so on, when the airman requests.

(3) Transmit flight parameter to evaluate the states of aircraft engine and flying, which optimizes Guidance Navigation and Control System(GNCS).
(4) Transmit the data of malfunction of airborne equipment and the weapon system to be displayed in multiple functional displays(MFD) and Multiplexed Message Proces-sor(MMP). ADAS accepts the airman's operational control, which contains none operation and display of itself.
(5) Transmit the data to data transmission set (DTE) in real time ways, the groundcontrol center analyses the data at the same time and makes the long-range fault diagnosis of the state of plane.

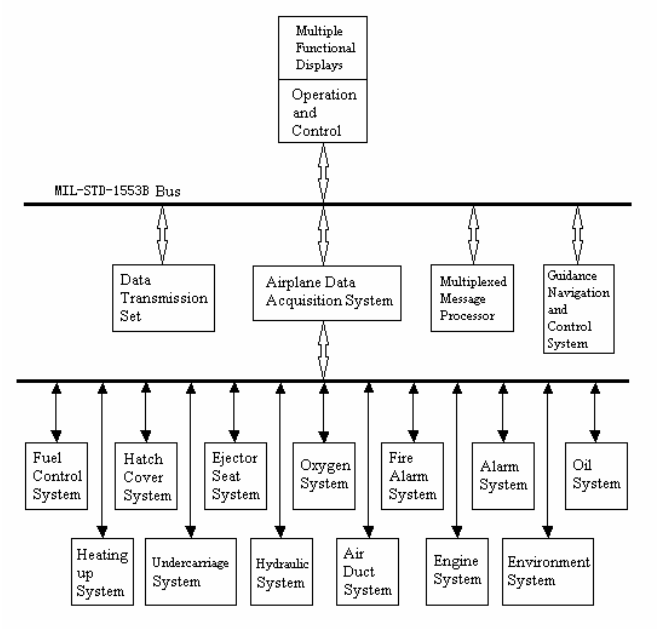

Fig. 1 A interface schematic diagram of the Airplane Data Acquisition System

Outspread the applied research of sensor network in the new generation battleplan, make the new ADAS depending on sensor and sensor network, fulfill the real time acquisition, display, accumulating, long haul data network and fault diagnosis of the flight parameters and airborne equipment parameters, which is of far reaching importance.

Above all, transmit the parameters of the plane in real time ways, using large numbers of human resources and computer resources on ground, it could operate the fault detection and the measurement of flight attitude, which is used for groundcontrol and verify. Secondly, the real time character of the parameters of airborne equipments in war field is more of importance, it could effect the groundcontrol and operational mission directly, especially that the data of early radar warning is the real time data supplement of radar intelligence in partial airspace, which is of far reaching importance of the cooperating of distant early warning in air and ground. The information transmitting of ADAS makes the full use of information platform in air warfare, which also benefits the issue of cooperating groundcontrol.

III The technical proposal of ADAS

The new ADAS, mainly based on the ATM-SONET distributed sensor network, integrates the ATM-SONET OC-3c, ATM-SONET OC-12, Ethernet and Fiber Channel technologies in its network design, is shown in Fig.2. ADAS provides the optional sampling rate from 2kHz to 200kHz. The sensor node adopts the broad based VME engine case, the aim of which is sampling, modulating and transmitting the 128 ways of sensor signals. All of the sensor nodes could make synchronization with the GPS clock. The system usage server is use for system control and data recording. There are 512 sensors, including fuel control system sensor, detecting head heating up sensor, hatch cover system sensor, undercarriage system sensor, ejector seat system sensor, hydraulic system sensor, oxygen system sensor, airscoop system sensor, fire alarm system sensor, alarm system sensor, engine system sensor, lubricating oil system sensor, environmental system sensor and the avionic system sensor, weapon system sensor and fire control system sensor for the further use.

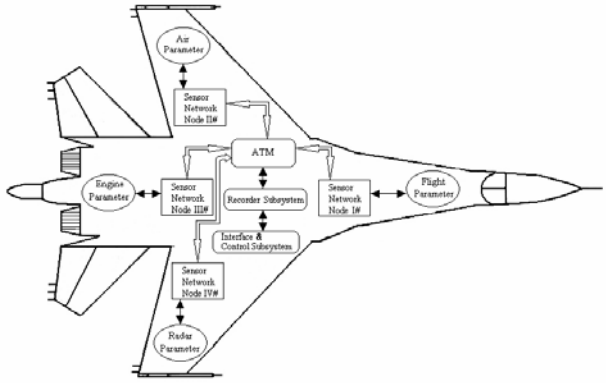

Fig 2 The Airplane Data Acquisition System

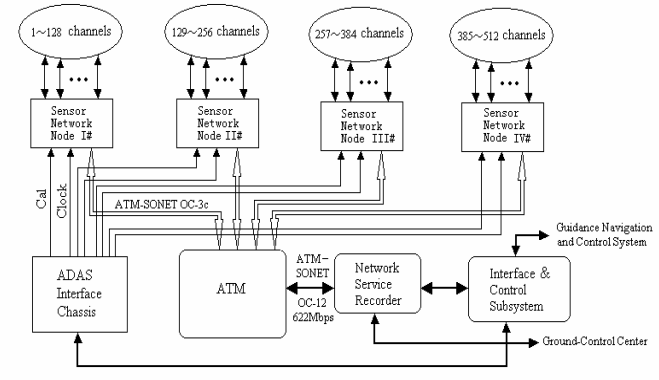

Fig.3 The sensor network of Airplane Data Acquisition System

ADAD sensor network is made up of the ATM-SONET OC-3c star shaped network, which is constituted by sensor

nodes based on VME bus as shown in Fig.3. Each of the 128 ways sensor node has 4 interfaces to OC-3c(155Mbps) of ATM switchboard, it could add sensor node in ATM network if needs. ATM switchboard connects the sensor network and recorder by one or more OC-12 chain circuits. Each of the sensor node has one GPS chain circuit and one UTP pitch chain connect to the ADAS interface Chassis.

IV The design of subsystem

4.1 ADAS Interface Chassis—AIC

AIC is based on VME bus, which provides the interfaces for peripheral equipments, such as the GPS clock of sensor node, different kinds of measuring equipments, interface&control subsystem and recorder subsystem and so on.

4.2 Sensor Network Node—SNN

Each of the network node provides the interfaces of electrical source, data and calibration. The Signal Conditioning Boards—SCB and the Anolog-to-ATM A/D Cards—AtA provide the signal modulating and A/DC for the 32 ways of sensor signals. The SCB card provides electrical source, low noise adjustable amplification and the difference output of low pass filter, high pass filter of the sensor. AtA card provides the 200kHz sampling rate of 16-bit A/D and fiber telemetry.The characteristics of virtual channel and QoS of ATM fit the real time telemetry very well for the data rate of each sensor channel varies widely with the sampling rate and the type of sensor. Timing Receiver Card is used for receiving GPS clock and generating a locked sampling clock for AtA card. The AtA card packages the data of A/D and the GPS timing mark, which produces relationship between ADAD data and other associated GPS sampling data.

4.3 Recorder

Network service recorder could accomplish the high speed record of data of sensor(read: 5.6MB/s, write: 2.9MB/s). The recorder if made up of sever and IDE electronic disk(200GB), which integrates the characteristics of low power dissipation, high speed of read and write, small volume and low weight. The server connects to the ATM network through several OC-12(622Mbps) chain circuits.

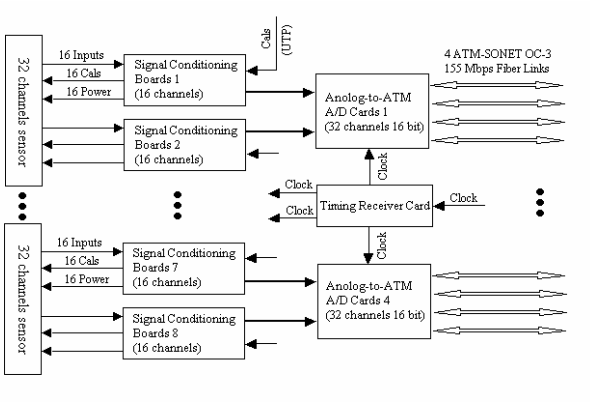

Fig 4 The sensor network nodes

The frame of multithreading and multiprocessor make it extremely suitable for the network application of ADAS which integrates high bandwide, realtime and open end. The sever provides the management of sensor data files and the kinds of control of sensor network by transmitting the sensor data between ATM network and electronic disk through optical fiber link. There is a 100BaseT(100Mbps) chain circuit between sever and data transmission device and the data transmission device mainly aims at the built-in wireless transmission module of digital transmission broadcasting station. The recorded data is downloaded to groundcontrol center after encrypting by wireless data transmission mode, where the sensor data is processed, so the groundcontrol center could fulfill the long-distance failure diagnosis of the state of the plane in real time ways. The surface equipment can get the data directly by connecting to the RJ45 interface of the sever if the data only needs to be get after flight.

4.4 Interface and Control Subsystem（ICS）

The ICS is a computer, which is the interface of ADAS and GNCS. ICS subsystem is used for receiving and carrying out the instructions of GNCS and transmitting status messages. ICS also provides automatic control for data acquiring and recording. ICS subsystem gets the data related to flight by the I/O card of the interface chassis and transmits the data to plane control system at the same time. The graphical user interface of the ICS subsystem is used for system configuration, the setting of related command during flight and system maintenance and diagnosis.

V. Conclusion

The ATM technology, which has network reconstructing ability, abundant flexible and rapid OAM mechanism, could provide QoS and rapid or emergent service for the customers. It also helps simplify the network and improve its performance and existing ability. Besides it is capable of classifying the service according the quality provided and does well in real-time service [1].

The more and more airborne equipments and armaments make it develop to the directions of integration, latticing,

modularization, intelligentize, automation and electromechanical integration. The original data speed is critical when processing data real time acquiring, displaying and storing, however, the data transmission puts higher request of network bandwidth. The bottom equipments of data acquiring adopts the SONET of the optical fiber link, which could transmit the data in high speed [2].

The new ADAS based on sensor network integrates the technologies of communication, information, observe and control, which adopts the distributed sensor network technology based on ATM-SONET, ATM-SONET OC-3c、ATM-SONET OC-12、Ethernet and Fiber Channel.

The new generation of battleplan in China is on its elementary step and the research of sensor network technology could improve the modernization of airarmament equipment in our army.

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