Informatics and Control Problems 43 Issue 1 (2023)
journal homepage: www.icp.az

# Methods and ways for improving the exchange of information in the flight control system

**I.M. Ismayilov*, R.N Garayev**

*National Academy of Aviation, Baku, Azerbaijan*

**ARTICLE INFO**

*Article history:*
Received 22.07.2022
Received in revised form 04.08.2022
Accepted 17.08.2022
Available online 05.04.2023

*Keywords:*
Aircraft avionics
ARINC-429
ARINC-629 interfaces
Fiber-optic data exchange

**ABSTRACT**

*Taking into account the shortcomings of the information exchange system through the ARINC 629 bus, which is widely used in new digital avionics systems (delay of information exchange, program errors, sensitivity to external influences, etc.), the fiber-optic information exchange system proposed in the article reduces the weight of aircraft in aviation systems, it allows solving many problems such as software errors, delays and maintenance problems. This system has a much higher transmission speed than traditional systems, significantly reduces the number of computers and wires, and the transition to modular avionics makes it more compact and easier to maintain.*

## 1. Introduction. The urgency of the problem

In the previous analog avionics system, transmitting information between different system components required at least one pair of wires for each signal. which determines the repair of used cables and their installation (ARING 429). Such a system was considered too slow for the new generation of avionics systems, so new digital avionics were replaced to overcome the problem. Information was transferred from one system to another by magnetic pairs rather than by any physically connected wire (ARINC 629). However, as in all systems, certain problems and shortcomings were revealed in this system. Examples of these are information delay, software errors, exposure to external influences, and so on. Working with the aforementioned, as a result of eliminating the shortcomings installed above, there was a need to create a system with a higher level of use speed, which can be used for a longer period of time, and which provides the transition to modular avionics, facilitating additional maintenance.

## 2. Problem statement

There is an increasing demand on the use of computers, Fly-By-Wire (FBW) and Integrated Modular Avionics (IMA) in aircraft. As a result, avionics systems integration is playing an important role in the design of modern aircraft. To achieve this aim, avionics multiplexed data buses should be used to efficiently provide command and control communications among most airborne subsystems and computers. We know that today's civil telecommunication networks

*Corresponding author.
*E-mail addresses:* ismayil.maa@gmail.com (I.M. Ismailov), garayev.razi@gmail.com (R.N. Garayev).

www.icp.az/2023/1-08.pdf https://doi.org/10.54381/icp.2023.1.08

possess a high throughput in the range of 10 Mbits to 100 Gbits. But present avionics applications still need relatively low transmission speeds when compared with civil telecommunications. However, the progress in aircraft avionics data buses lags behind that of civil telecommunications. For example, the widely used aircraft avionics buses are the Arinc 429/629 data buses, developed about 50 years ago and are still operating at a serial data bit rate of 2 Mbps only. The next-generation avionics networks may have an improved transmission speed, which can be based on the Fiber-optic communication standard. The new avionic systems need high transmission speed and wide system bandwidth to efficiently support broadband and multimedia communication services. In the latter case, a special design is required to guarantee both high reliability and a long lifetime for avionics data buses in the severe environment. In this article, we give an overview of avionics data buses and their applications, with an emphasis on optical fiber data buses; then we discuss the evolution of avionics data buses, and we also describe recent progress in avionics networks.

## 3. Problem solving

The integration of fiber optic information exchange systems into aircraft avionics will play an important role in eliminating many shortcomings of traditional and currently used information exchange systems. First, let's take a look at the shortcomings of the ARINC 429 system. Transmission of information exchange with one-way wires is unacceptable in modern aircraft systems. Our proposed fiber optic system fundamentally solves this problem, so that there is no longer a need for five wires to transmit and receive information. It is possible to exchange information with only one pair of fiber optic cables. The exchange of information with this method will play an important role in significantly reducing the weight of the aircraft. The current ARINC 629 information exchange bus is very different from the traditional ARINC 429 system. Thus, the exchange of information is no longer based on physical connection but is transmitted by magnetic pairs. This system, in turn, presents a new problem in the avionics system. Information delays, external influences, technical service difficulties, expensive equipment, etc. The system we propose for solving current problems is considered very effective. Information delay is considered to be fully resolved in the fiber optic exchange system, so information transmission and speed are Since it is completely different from the 629 system, it is impossible to encounter this kind of problem in our proposed system. In the ARINC 629 system, the transmission of information exchange without physical connection can cause it to give certain errors when exposed to external electromagnetic influences. It is impossible for such errors to occur in the fiber optic system. Because the information is transmitted from system to system through the light stream, external effects from this transmission do not create any problems. The integration of the fiber optic system into the avionics system will play an important role in reducing the number and complexity of certain systems. Reducing the number of computers will help to reduce the future maintenance costs of the operators. Also, during the installation of the fiber optic exchange system, the more compact and reduced number of computers will make it possible to decrease the maintenance costs and improve modification possibilities.

## 4. Methods and ways for improving the exchange of information in the flight control system

In modern times, it is impossible to imagine aircraft without avionics. Avionics systems not only provide safety at any stage of the flight, but also play an exceptional role in reducing the load on the flight crew of the aircraft. The constant development of technology has not gone unnoticed by aircraft avionics. The new generation of aircraft is equipped with more sophisticated avionics systems. The reason for this is the maximum automation of aircraft and minimizing the number of accidents due to human error. Given that the vast majority of plane crashes are caused by human error and it was impossible to avoid this automation. The rapid development of avionics systems has created other problems:

**1.** Fast information exchange

**2.** Maintenance problems

**3.** Reliability

**4.** Reducing weight of Aircraft

In order to solve the above-mentioned problems, an information exchange system based on the Arinc 429 protocol was initially established. This serial topology evolved into the ARINC 429 Specification, first released as ARINC 429-1 in April 1978, and currently exists as ARINC 429-15. The ARINC 429 Specification establishes how avionics equipment and systems communicate on commercial aircraft. The specification defines electrical characteristics, word structures and protocol necessary to establish bus communication. ARINC 429 defines both the hardware and data formats required for bus transmission. Hardware consists of a single transmitter or source connected to from 1-20 receivers or sinks on one twisted wire pair [1]. Data can be transmitted in one direction only simplex communication with bi-directional transmission requiring two channels or buses. The devices, line replaceable units or LRUs, are most commonly configured in a star or bus-drop topology as shown in Figure 1 [2]. Each LRU may contain multiple transmitters and receivers communicating on different buses. This simple architecture, almost point-to-point wiring, provides a highly reliable transfer of data. A transmitter may ‘talk only’ to a number of receivers on the bus, up to 20 on one wire pair, with each receiver continually monitoring for its applicable data, but does not acknowledge receipt of the data [3].

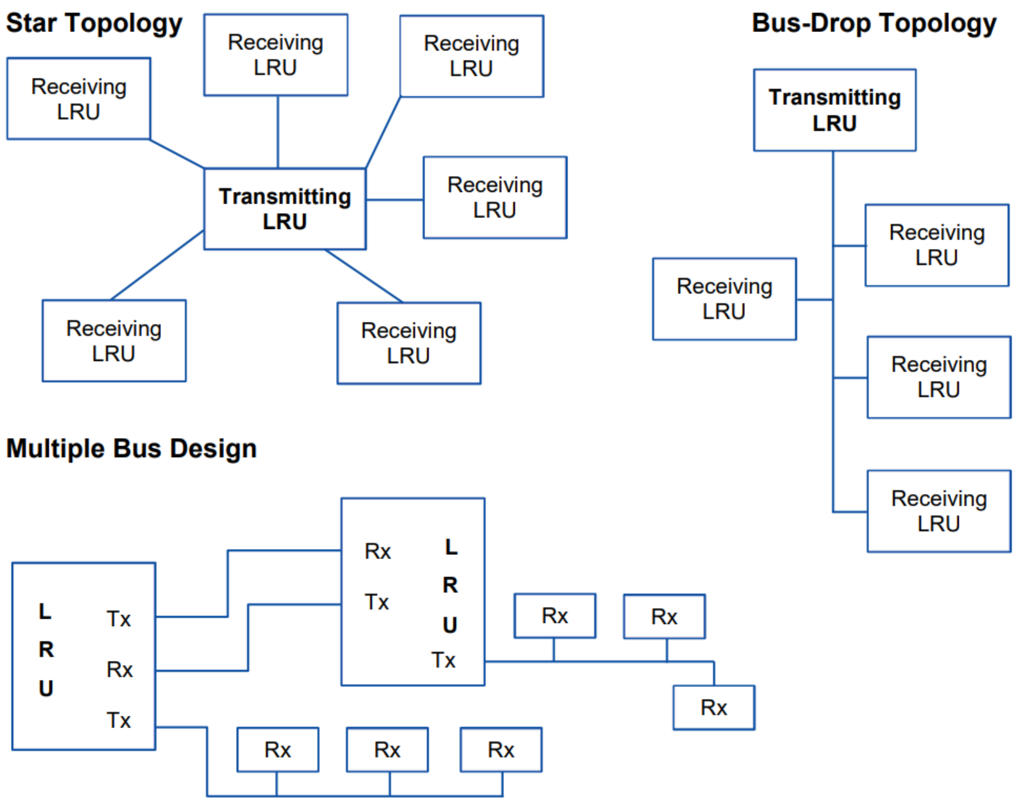


**Figure 1.** Arinc 429 bus connection topology

Based on the above information, it can be said that while ARINC 429 solves the problems posed by its production history, the shortcomings of modern aircraft are clearly visible. In modern aircraft systems, low speed, one-way transmitting, and the number of terminals (20) are almost unacceptable. To overcome these shortcomings, each piece of equipment installed on the aircraft causes an increase in weight. To find a solution to these problems, the ARINC 629 protocol information exchange system was proposed. ARINC 629 was introduced in May 1995 and is currently used on the Boeing 777,787,747-8,Airbus A330,A340,A350,A380 aircrafts [4]. The ARINC 629 bus is a true data bus in that the bus operates as a multiple-source, multiple sink system as shown in Figure 2 [5].

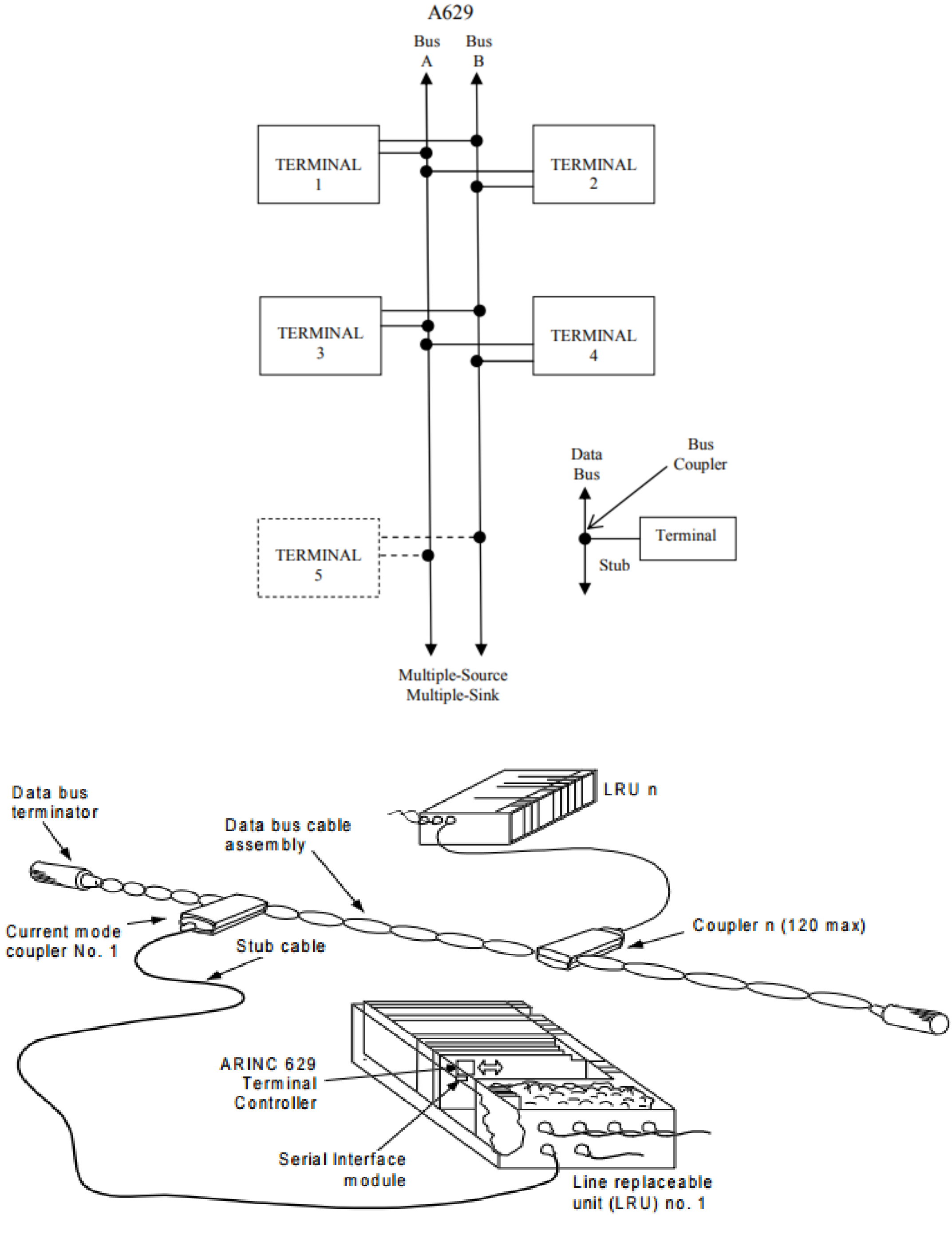


**Figure 2.** ARINC 629 Data bus topology

That is, each terminal can transmit data to, and receive data from, every other terminal on the data bus. This allows much more freedom in the exchange of data between units in the avionics system [6]. The true data bus topology is much more flexible in that additional units can be fairly readily accepted physically on the data bus. The protocol utilized by ARINC 629 is a time-based, collision-avoidance concept in which each terminal is allocated a particular time slot to access the bus and transmit data on to the bus [7]. Each terminal will autonomously decide when the appropriate time slot is available through the use of several control timers embedded in the bus interfaces and transmit the necessary data. Data transmission methods had developed with the rapid development in technology and because of the increase in requirements electronic communication had begun to be insufficient. Basically electronic communication is realized by changing the position of the electrons. So, the factors like the type, structure and dimensions of the conductor (copper, etc) that is used affect the speed of the communication. Light is known as the most rapid existence in universe. As a result of investigations, light is begun to use for communication besides the sound and electricity. On the aircraft, physical parameters (temperature, pressure, position information) taken from different points and the information carried with electromagnetic waves are converted into electrical signals is transmitted to the related systems. Although the ARINC 629 protocol information exchange bus has fulfilled all its obligations, it has created other shortcomings and problems. Examples include sudden delays, maintenance problems, software errors that cannot be recovered by any procedure, and 2 Mbps speeds that are not sufficient for modern avionics systems [8].

The proposed fiber-optic information exchange system will play a major role in solving many problems in avionics systems, such as aircraft weight loss, software errors and maintenance problems. A system with a very high transmission speed, unlike traditional systems, it is possible to use this system for a longer period of time by making small modifications in the coming years[8]. Also, a significant reduction in the number of computers,wirings, as well as the transition to modular avionics will make it compact and easier to solve maintenance problems. This information exchange system is managed by zoning like other systems. Certain shortcomings that may arise for the system to work properly have been investigated. For example, the use of fiber-optic information exchange systems in moving parts is undesirable, but given that the vast majority of the aircraft's main systems are located in stationary parts, it is unlikely that any failure will occur during the application of this system. Figure 3 shows the block diagram of the exchange system and the structure of the modular avionics system using the proposed fiber-optic transmission. Figure 4 shows the modular avionics unit Dassault Falcon aircraft [9].

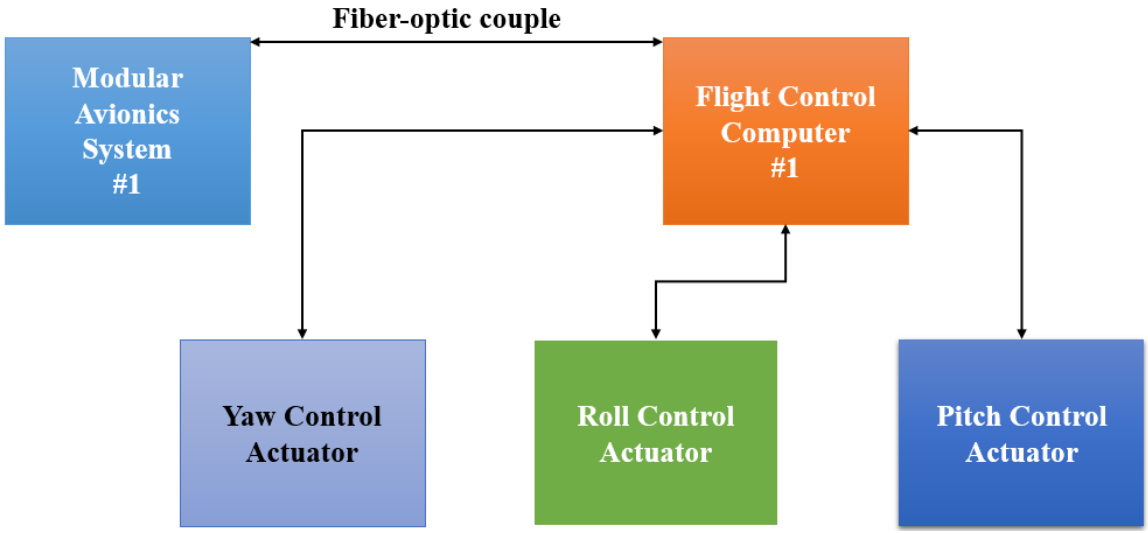


**Figure 3.** Fiber-optic information exchange system structure

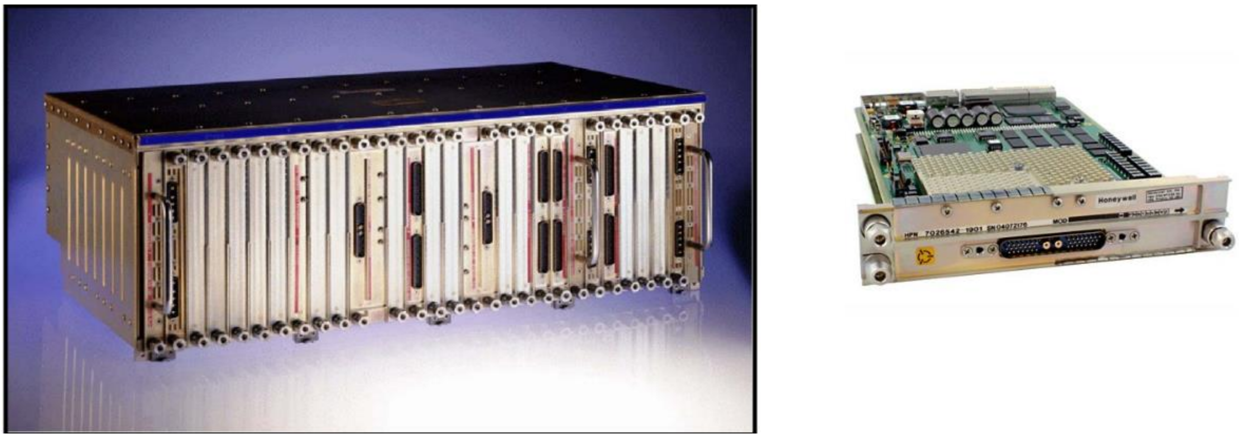

**Figure 4.** Modular avionics system

The application of this system in the aircraft will play an important role in further compacting the avionics systems. If the traditional (Boeing 757/767 Airbus A319 family) systems covered 80-90% of the avionics section of the aircraft, this system will be a maximum of 40-50%. will have a serious impact on weight, both payload and fuel economy.

**Fiber optic cables intended for this system and their technical characteristics**

MIL-STD-1773 will be used in the main systems.

| | | |
|---|---|---|
| Thermal Shock | SAE-AS-13441 | -55C /+100C |
| Temperature Life | TIA/EIA 455-20A | 500h @ +100C |
| Vibration | TIA/EIA 455-11 | Hz 0.2g2/Hz 43 G rms |
| Shock | TIA/EIA 455-14A | 50G - 11ms |
| Humidity | TIA/EIA 455-5 | RH 90% |

HDPE G652D will be used for secondary systems

Multi Loose Tube Unarmoured

• Enhance low water peak single mode fibers in full compliance with ITU-T-G 652D

• Water swellable yarns

• Standard: IEC 60794

• Temperature Range Norms : IEC 60794-1-2-F1

• Laying and Installation -40° to +70°C

• Operation -40° to +70°C

• Fiber type: Singlemode G652 D IEC/ITU standards

## 5. Conclusion

The proposed fiber-optic data exchange system will play a major role in solving many problems in aviation systems such as weight reduction of aircraft, software errors, delays and technical minor maintenance problems. A system with a very high transmission speed, unlike traditional systems, can be used for much longer in the coming years with modifications. In addition, a significant reduction in the number of computers and wiring, as well as the transition to modular avionics, will make it more compact and easier to maintain.

## References

[1] https://www.ueidaq.com/arinc-429-tutorial-reference-guide
[2] aim-online.com/wp-content/uploads/2019/07/aim-tutorial-oview429-190712-u.pdf
[3] I.Moir, A. Seabridge, Civil Avionics Systems, AIAA, U.S.A, 2003
[4] Boeing 777-200/300 traning manual
[5] Arinc 629 Protocol tutorial
[6] I. Moir, A. Seabridge, Aircraft Systems mechanical, electrical, and avionics subsystems integration, AIAA, U.S.A, 2001.
[7] https://www.logic-fruit.com/blog/arinc-standard/arinc-629-digital-data-bus-specifications/
[8] M. Tooley, Aircraft Digital Electronic and Computer Systems:Principles, Operation and Maintenance, Elseiver, U.SA.,33-44, 2007
[9] Dassault Falcon flight deck manual.pdf