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ARINC 629 Digital Communication System Analysis

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ABSTRACT: The ARINC 629 communication system is the primary means of digital communication between Line Replaceable Units (LRU's) on the modern aircraft. ARINC 629, a multi-user data bus represents the first application of a multi-transmitter digital data bus in the Boeing family of commercial airplanes. This communication system supports new advanced systems on the modern Boeing and Airbus aircraft, such as f'ly-by-wire flight controls and the Airplane information Management System (AIMS).
This article introduces ARINC 629 data bus operation. and describes' supporting hardware. It also examines theARINC 629 communication system architecture for the Boeing 777 and the physical airplane installation.

I. INTRODUCTION

In the middle I970 s. digital avionics was growing rapidly — and so was the need for efficient data transfer between Line Replaceable Units (LRU's). That's why a new commercial digital avionics communication standards was developed: ARINC 429 [1]. The first application of the ARINC 429 was on the Boeing 757 and 767.It was believed by some, even then, that the ARINC 429 single transmitter/multiple receiver concept would ultimately be over-burdened with the amount of inter-system data transfer required for evolving commercial aircraft. This demonstrated a need for a multiple transmitter data bus for commercial aircraft.
The primary advantages of a multi-transmitter data bus include the ability to move more data between LRUs at higher rates using fewer wires. Also. they are generally more reliable and provide an architecture more conducive to integrating complex systems during the development phase. These characteristics translate into improved economy and increased capability for commercial airplane customers.
Before embarking on development of an entirely new bus, other existing multi-transmitter data buses were studied. However, the prevalent multi-transmitter buses at the time MlL-STD—1553[U.S. Military Standard) and Ethernet, did not satisfy all the basic principles desirable for use on a commercial airplanes. Two of these basic principles are not satisfied are terminal independence and guaranteed periodic update rates (Ethernet) [2].
That why a small research and development group at Boeing began working on the control of a multi-transmitter data bus in 1977. The name used for the search project was Digital Autonomous Terminal Access Communication (DATAC). Throughout the next decade DATAC emerged as ARINC 629, the newest avionics industry digital communications standard. Because it had the desirable data bus attributes, ARINC 629 was chosen as the primary digital communication nsystem on the modern airplanes [3].

II. ARINC 629 PHYSICAL AND FUNCTIONAL DESCRIPTION

Physically. the ARINC 629 digital communication system consists of the components shown in Fig.1 and 2. Note that the Terminal Controller, Serial Interface Module and associated hardware are contained within each LRU. The stub and bus cable assemblies and couplers are routed and installed within the airplane fuselage, primarily in the Main Equipment Center. The operation of transferring data from one LRUto one or more other LRUs occurs as follows:
1. 16-bit parallel data is retrieved from the transmitting LRU's memory by the Terminal Controller (TC).
2. The TC determines when to transmit ,attaches the data to a label, converts the parallel data to serial data, and sends it to the Serial Interface Module(SIM).
3. The SIM converts the digital serial at a into analog doublets and sends them t0 the Current Mode Coupler(CMC) via the stub.
4. The CMC inductively couples the doublets onto the bus. At this point, the data is available to all other couplerson the bus.

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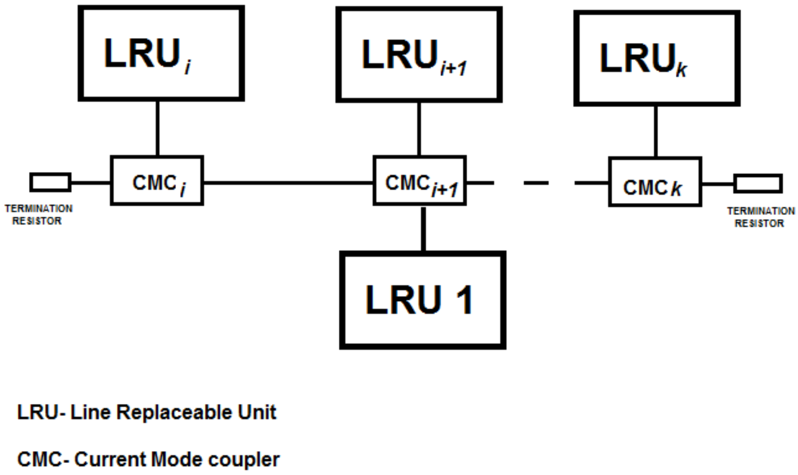

Fig.1.These are the major components or the ARINC 629 Digital Communication system. This figure shows multiple LRUs connected, via couplers to a single data bus.

Receiving terminals perform the above operations in reverse. eventually writing sixteen bit parallel data into their systemmemories and, thus, completing the transfer.

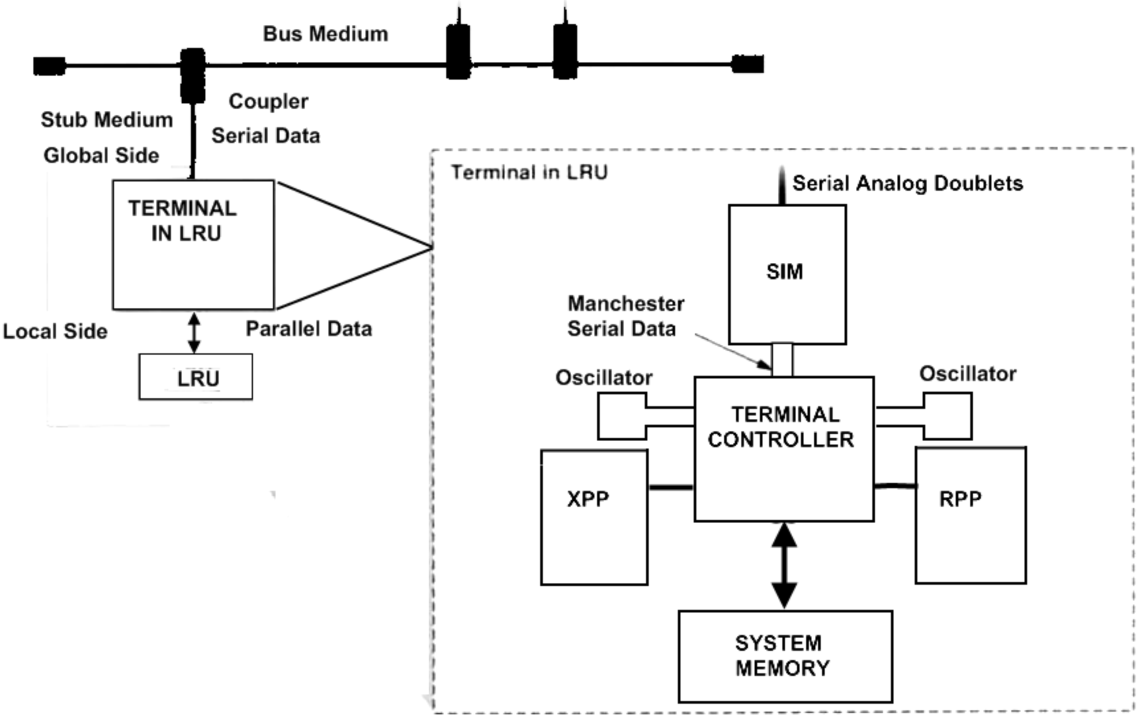

Fig. 2. Connectivity of the hardware components in the ARINC 629 Digital Communication System

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The gathering kind operation can be considered the key type step in performing the complex kind of mathematical type operations basically because of the required type multiple kind inputs which are geo kind dispersed. Gathering type scheme basically in order to aid in real time and also non real time can be of the geo dispersed type big kind data in application.

Terminal controller contains the bus protocol access logic that determines when the terminal will transmit. The TC listens to the bus and waits for a series of quiet periods before transmitting.

Only one terminal is allowed to transmit at a time, and once a terminal has transmitted, it must wait for all other terminals on the bus to transmit before it transmits again, timers are utilized to ensure that this orderly bus access occurs. For redundancy, the access protocol circuitry is duplicated and utilizes two independent clock sources to prevent a single failure from interfering with bus access for other terminals.

The TC lakes l6-bit parallel data words from system memory, converts them into serial bit stream messages, and transmits them via the SIM and CMConto the bus [4].

A message (Fig. 3) is made up of a series of word strings, each consisting of a l6-bit label word followed by up to 256l6-bit data words: the transmission rate is two megabits per second. The TC also receives everything it transmits and monitors the data for proper format and length. The labels are checked to ensure that they are allowed for transmission by this terminal.

The C utilizes two "personality tables”, most often stored in Programmable ReadOnlyMemory (PROM) or Electrically Erasable PROM.to impart a unique transmit and receive personality unto itself.

The Transmit Personality Table(XPT or XPP when stored in PROM)contains all the essential information needed to formulate a terminal's transmissions.

This information includes the set of all labels activated for transmission by that terminal, the number of data words to follow each label and the number of wordstrings in each message. It also contains the structured message information that determines the transmission order and transmission rate of each wordstring.

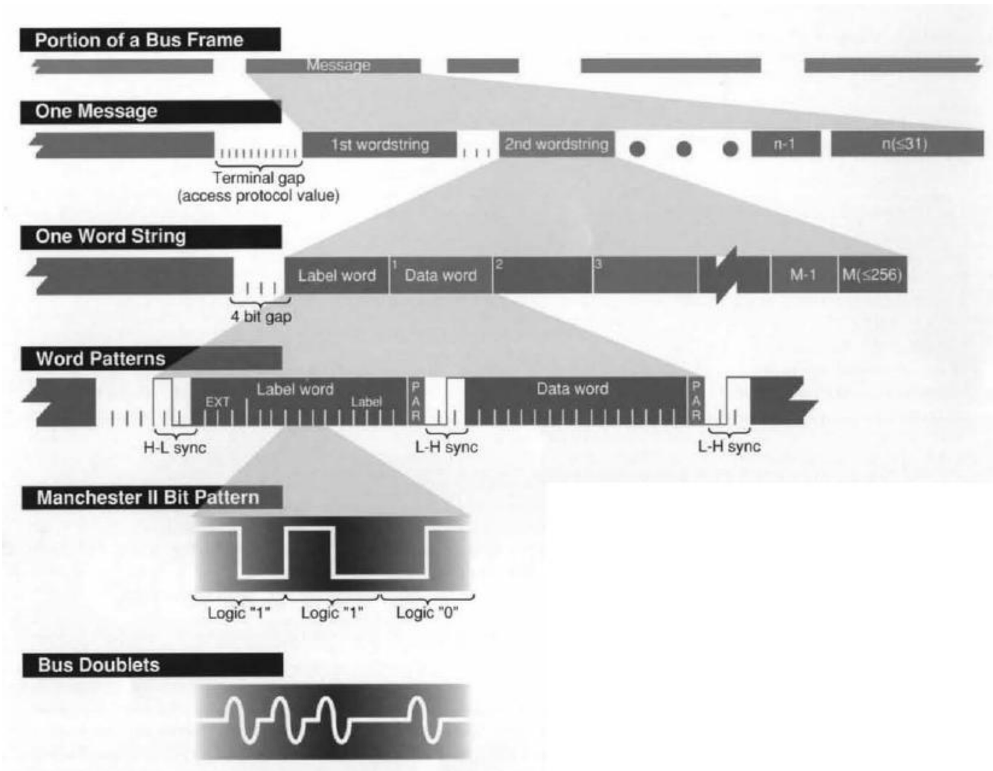

Fig. 3. ARINC 629 message, asone might view it with ever-increasing temporal resolution on an oscilloscope. Shown are both the digital and analog portions of the signal.

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The Receive Personality Table (RPT or RPP when stored in PROM) contains the set of all labels to be received by that terminal and the number of data words following each desired label to be stored in system memory. It also contains similar information on all labels and wordstringstransmitted by that terminal and utilizes this information in a monitoring capacity.

Labels and data present on the bus, but not desired by the receiver, will beignored by the Terminal Controller.

Both the XPT and the RPT contain the system memory addresses from which data to be transmitted is read and to which incoming data will be written. The receive addressing scheme can distinguish between identical labels from different channels of a system and store the data from each channel in unique memory locations. Or, the data can be programmed to selectively ignore one or more specific channels altogether.

The Serial InterfaceModule (SIM) converts digital Manchester II (a transmission standard)[5] encoded data from the TC into differential voltage mode doublets and conversely, converts voltage mode doublets back intodigital Manchester II serial data for digestion by the TC. The SIM also contains transmission waveform monitoring that checks every transmitted doubleton its return path to the TC for proper shape and amplitude. The SIM also controls the selection of CMC channels andCoupler BITE.

Current Mode Coupler takes the differential voltage mode doublets produced by the SIM and inductively couples them onto the data bus.

The doublets propagate along the data bus, where they are detected and read by all connected terminal CMCs. All doubletson the bus are coupled back onto the stub cable as a differential voltage mode signal. Although every terminal on the bus will receive all information, only data following labelspre-programmed into the receiving terminal's RPT will be transferred to system memory. The coupler contains two redundant transmit and receive channels to provide fault tolerance.

The Stub Cable Assembly consisting of four conductors, carries the differential voltage mode doublet from the SIM to the CMC and back. On the modern aircraft two types of stub cables are used. The first, located betweenthe LRU equipment rack and the stanchion (approximately three feet), consists of two twisted, shielded pairs.

The second, which runs between thestanchionand the couplers on the data bus, consists of a shielded quad-twist configuration. These quad-twist stub cables canbe up to 57 feet in length. In other applications, the stub cables can be increased inlength to support the design.

The Bus Cable Assembly is a twisted pair or wires, terminated at each end with the characteristic impedance of the bus cable, which is 130 Ohms. Nine of eleven buses on them are unshielded. However, the two longest buses are shielded to reduce radiated emissions. A bus cable can be upto 300 feel in length. For example, on the Boeing 777, thelongest bus is approximately 180 feel [5].

III. SYSTEM ARCHITECTURE

To describe an airplane's systems architecture, first of all, necessary functional capabilities must be realized. When the pilot pulls back on the control column, the elevator surfaces are expected to move. Similarly, the flight deck displays must present accurate information to the crew under normal and failure conditions, the air conditioning must warm and cool the cabin, the landing gear must extended retract, the radios must work, and the central maintenance computer must accurately record equipment faults and failures.

The entire list of functions from those critical to airplane safety to those that help keep the passengers comfortableandentertained is extensive.

Beyond functional considerations, the safety of the airplane and its occupants in all environments anticipated and unanticipated is of ultimate importance. Also, as airplane builders, owners andusers.we all count on the reliability ofthe airplane and its systems for competitive performance, comfort and peace of mind, expecting scheduled departures rather than unscheduled maintenance delays [6].

In order to meet all functional safety and reliability requirements, the following aircraft systems architecture resulted.

There are 11 ARINC 629 data buses consisting of three Flight Controls Buses, four System Buses, and four AIMS Inter-cabinet Buses.

The Flight Control Buses connect LRU' s containing flight control functions such as the Air Data Inertial Reference System, the primary night computers, and the autopilot.

The System Buses connect LRU's containing system functions such as avionics, propulsion. electrical, mechanical, hydraulic, and environmental controls.

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AIMS provides a gateway function allowing the transfer of data from one setoff buses to the other. The AIMS Inter-cabinet Buses are used solely for transfer of data between AIMS cabinets and the Control Display Units [7].
A clear benefit of this architecture is that all LRU's connected to the ARINC 629data buses communicate with the central maintenance function within AIMS. thereby allowing comprehensive maintenance reporting to a central location.

IV. ARINC 629 ONBOARD INSTALLATION

In the modern aircraft, ARINC 629 couplers and databus assemblies are mounted together inpanels. This allows for easier access during maintenance. The majority of coupler panels are covered; this also provides protection from physical damage to the couplers and bus cable assembly. Of the 11 data buses, nine have all couplers and the entire data bus assembly contained completely within a panel.
And in most cases. there is more than onedata bus per panel. The two longest buses (Left System Busand Right System Bus) run nearly theentire length of the pressurized fuselage.
These buses have the majority oftheir associated couplers contained within forward panels. The remaining few are mounted on small panels at the rear ofthe airplane. The output in the form of an information kind system herein should actually accomplish one or more of the respective following kind objectives. It is required to convey out the information primarily about the past type activities, current type status or the projections of those as to future. Signal paramount kind events, those of opportunities, premeditating problems or those of warnings can be known. It is followed by provoking that action.

V. CONCLUSION

Development of the ARLNC 629 Digital Communication System has been a significant effort by aircraft designers and the ARINC 629component and LRU suppliers.ARINC 629 successfully does its job as the primary means of digital communication between LRU's on the modern aircraft.
The success of the aircraft flight test program and the earlier system integration activities attest to the effectiveness of that effort. The ARINC 629 Digital Communication System is a high-integrity, highreliabilitymulti-user data bus that will serve the aircraft and its airline customers well into the future.

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