Switching names

Understanding the testing issues involved with the deployment of AFDX data communications is a complicated topic. PAMELA and VICTORIA aim to simplify the procedures

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1. AFDX/ARINC664 is being used for systems on the A380

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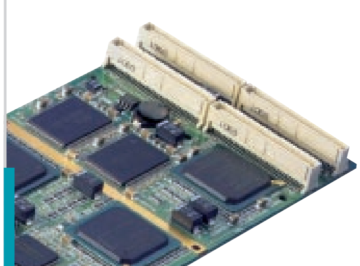

With the growing use of the AFDX (Avionics Full Duplex Switched Ethernet) data communications on the Airbus A380/A350 and A400M aircraft and the Boeing B787 Dreamliner, which will deploy ARINC664, understanding the testing issues is of paramount importance for manufacturers of the 'end systems' and 'switches' and to the prime aircraft manufacturers, who integrate the entire onboard systems.

AFDX/ARINC664 is being used as the backbone for all systems including flight controls, cockpit avionics, air- conditioning, power utilities, fuel systems, landing gear and others. The recent successful first flight of the Airbus Industries A380 in Toulouse on April 27, 2005 is a real testimony for the programme and a major milestone with the 'first-to-fly' with AFDX onboard based on the commercial 100Mbit/s switched Ethernet (wire) with deterministic behavior.

The selection of suitable test, simulation, monitoring and integration equipment, to perform adequate and reliable testing of the key elements end systems, switches and the network, is vital. In order to fully understand and define in detail the test issues of aircraft (namely the A3XX) which integrate an AFDX data network topology, two European Union funded technology programs were put in place. PAMELA (Prospective Analysis of Modular Electronic Integration in Airborne Systems) and VICTORIA (Validation platform for Integration of Standardized Components, Technologies and Tools in an Open, Modular and Improved Aircraft electronic system) projects defined specific work packages in each, which addressed the specification, prototyping and provisioning of AFDX test interfaces and analyzer tools which complied to the specified requirements defined by the consortium.

The PAMELA project started in January 2000 (a 25 month project) with Thales acting as the coordinator of 13 associated partner companies. One specific work package looked at the specification and prototyping of AFDX test interfaces and analyzer tools. Following on from this project the VICTORIA project started in January 2002 (a 42 month project) with again, Thales acting as the co-ordinator with, this time, 33 associated companies. The task here was to provision AFDX network test interfaces and analyzer tools ready-for-use by the VICTORIA members to use in their specific aircraft domains (i.e. energy domain).

Testing end systems

Since the 'end system' forms part of the aircraft data network, designed to operate based on a full-duplex switched Ethernet, each end system has two physical ports defined in AFDX/ARINC664 terms as one 'dual redundant port' or one AFDX Channel. The network, with which end systems communicate, can implement 100Mbit/s and 10Mbits/s. The physical layer complies with IEEE802.3 edition 1989 standard (chapter 25) which refers to the ANSI X3.263-1995 standard for 100Mbit/s full-duplex links (100Base-Tx).

Testing of the low level physical layers and the protocol layers is a requirement for end systems designs. Also the testing of each Virtual Link (VL) is required to ensure it conforms to the properties defined for each VL. As a reminder, a VL defines a uni-directional connection from one source end system to one or more end systems. Each one can support up to a maximum of 128 VLs.

Therefore, it is necessary to simulate and monitor the following properties; VL ID and the number of sub-VLs, Type (Rx/Tx), network selector, bandwidth allocation gap, maximum skew between both networks, maximum frame size, traffic shaping, integrity checking and redundancy management on a per VL basis.

Testing of end system layers including the MAC, IP (Internet Protocol) and UDP (User Datagram Protocol) is essential to ensure correct end system behavior and performance on the network. To do this it is necessary to have sufficient processor performance, memory resources, customized MAC (to access the MAC specific AFDX/ARINC664 requirements) and a high-resolution time code generator/decoder on the interface level of any AFDX/ARINC664 test and simulation resources.

To simulate an end system, it is necessary to generate frames and have the ability to fully program all fields of the AFDX/ARINC664 frame including the Virtual Link Identifier, MAC Source Address, IP structure, UDP structure, payload and sequence number. Important parameters for traffic generators include; Programmable timing and sequencing of the frames; physical error injection (CRC, gap, size and alignment); logical errors on layers two, three and four (e.g. AFDX compliance violations); timing error injection i.e. violation of Bandwidth Allocation Gap (BAG); autonomous dynamic data generation, and UDP port simulation with traffic shaping and sequence numbering.

For the monitoring of VLs being received by the end system, it is essential to have a capability to receive and to time-tag frames in a chronological mode to monitor, store, inspect and verify all frames being received on the dual redundant network. To handle these at full wire speeds, it is necessary to store them on the test card level. This data can be buffered and streamed to a larger storage device i.e. PC hard disk, in real time for monitoring or 'data logging' applications which may require several hours of recording. Frame headers are stored with the relevant timing and error detection information with the payload data being optionally discarded. It is also very useful to have a UDP/VL receive mode where each UDP port can have a separate buffer queue including time tag and error detection information for each UDP message.

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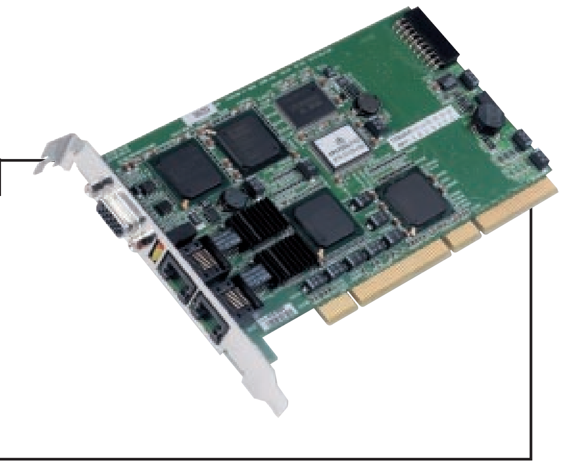

2. Two Port AFDX/ARINC664 test, simulator and monitor module for PCI

Traffic shaping verification enables detection of any violations of the BAG for a given VL. For testing end systems, in fact the entire network it is important to have at your disposal the following capabilities: VL oriented receive and filtering; filtering on second level generic frame parameters; time stamping down to one microsecond; inter-frame gap measurement (40ns steps); a range of comprehensive triggering, filtering and capturing; trace after trigger recordings; physical error detection (CRC, gap, size, and alignment), AFDX/ARINC664 specific error detection including traffic shaping verification, verification of the MAC, IP and UDP headers and VL-oriented integrity checking.

Testing switches

The Switch is at the heart of any aircraft data network which deploy AFDX or ARINC664 switched Ethernet topologies. The switch has multiple ports and connects end systems to end systems or switches to switches depending on the avionics architecture. The interface characteristics at the physical and network layers are of course fully compatible to that of the end systems. All end systems must communicate via the switch. Frames are received at the switch and go through a filtering and policing function which follow specific rules about the frame integrity, frame length,

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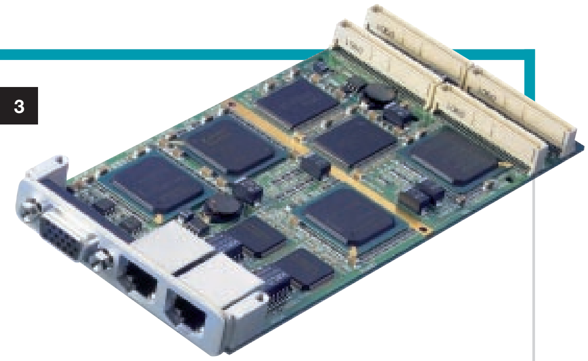

3. Two Port AFDX/ARINC664 test, simulator and monitor module for PMC

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4. AFDX/ARINC664 is being used as the backbone for all systems including cockpit avionics

traffic budget and end destinations. The switch also includes end system functionality as a means to communicate with the switch for configuration and maintenance reasons. Configuration tables and monitor functions log events such as the reception of a frame or a failed CRC check. Invalid frames are discarded and statistics about the internal status of the switch and its health and well being is monitored using the embedded Network Management Function (NMF).

It should be noted that the configuration tables (resident default and loadable configuration tables) are loaded by an ARINC615A loader in data load mode.

For the testing of switches the capabilities for traffic generation and monitoring as defined for the end systems is applicable. However, the test equipment will also need to generate high loads on differing VLs to fully check the throughput and performance and integrity of the Switch.

AFDX/ARINC664 test equipment and solutions

With more than 15 years' experience in the aerospace and defense industry, and having built a reputation for databus test products for MIL-STD-1553, STANAG3910/EFEX and ARINC429, AIM GmbH of Freiburg, Germany was selected to work as an associate partner with Airbus, France to develop and supply the AFDX test tools as defined by both the PAMELA and VICTORIA projects.

As a result of the early participation in these technology projects from the 'ground up' and the continued strategic decision to invest in the AFDX technology, AIM has created a complete family of advanced AFDX/ARINC664 test and simulation products and resources now being used in all stages of an aircraft project from development, production and integration, right through to in service aircraft support.

Taking full advantage of AIM's unique 'common core' hardware design as the basis for the first generation AFDX test tools. These incorporate all the necessary error injection/detection (low level physical layer and upper application layers), simulation and monitoring features defined by the consortium. The first card delivered to the VICTORIA project was a 6U, CompactPCI test and simulation module; know as the ACI-FDX-4 having four ports or two dual redundant AFDX Ports. AIM also invested heavily to further develop the next generation AFDX modules with even more powerful on-board resources with faster processors, more memory and enhanced functions and features demanded by the AFDX/ARINC664 community and users.

Today AIM's full function 'AFDX/ARINC664' and 'AFDX/ARINC664 Light' modules are available in PC-Card (PCMCIA, Type II), PMC, PCI/ PCI(X), CPCI, VME and VXI formats to support any and all AFDX/ARINC664 test applications. Driver software in the form of a high-level Application Programming Interface (API) is included with support for Windows, Linux, VxWorks, Integrity and LynxOS.

The AIM, fdXplorer™ Windows-based databus analyser software for AFDX/ARINC664 networks has become the industry standard AFDX network analyser. In April 2003, the fdXplorer was selected by Airbus Industries, Germany (on behalf of Airbus Partners in France and Germany) as the 'AFDX common standard databus analyser equipment' for the development of the A380 aircraft. This selection included the requirement to take the ICD (Interface Control Document) which includes all the network parameters for the A380 aircraft and load the database in the AIM ParaView Software.

AIM has built an ARINC615A data loader known commercially as EasyLOAD-615A™ allowing to perform data loading on End Systems or Switches. Furthermore, AIM introduced a small, portable AFDX/ ARINC664 network tap know as the fdXTap™ allowing monitoring of frames and traffic of a redundant AFDX Network between End Systems and Switches.

AIM's AFDX/ARINC664 modules and databus analysers have been utilized by the VICTORIA consortium and all the prime contractors and the majority of the sub-contractors on the A380 aircraft programme. More recently AIM products have been selected for use by both the primes and sub-contractors working on the A400M and Boeing B787 aircrafts programmes. Modifications for the Boeing Company implementing specific ARINC664 services and applications are being implemented.

With more than four years' experience with the design, development and manufacturing of AFDX/ARINC664 test tools, AIM has gained a formidable reputation providing unmatched capabilities, knowledge and experience for AFDX/ARINC664 test and simulation applications. ▮

Douglas Ullah is the director of sales and marketing from AIM GmbH of Freiburg, Germany and is based at the AIM UK office in the UK. *AFDX® is a Registered Trade Mark: AFDX is a registered trademark of Airbus Deutschland GmbH*