

New Architecture : Universal Modular Acquisition System

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Abstract : Based on more than forty years of experience, acquired on several space, Defence and avionics programs as prestigious as ESA ARIANE launchers or A380 aircraft, IN-SNEC company presents its new Data Acquisition System: UMA2000.

Taking advantages of its predecessors, these Universal Modular Acquisition System main features are:

- New and Modular architecture,
- High speed internal communication busses,
- High density and versatility of interfaces with large combination of acquisition boards,
- High data throughput with ETHERNET interface,
- Low cost.

This article presents the new architecture and the key features of this system.

Key words : Modular architecture, Ethernet interface, High data throughput, High channel density.

1. Introduction

With the opportunity of the renewal of Airbus test equipment started in the end of the 90's, In-Snec has developed a new generation of Data Acquisition System (DAS).

One of these systems (TMA2000) currently equips and flies on the A380 performing acquisition of several thousands of low and high bandwidth sensors for the qualification of the aircraft.

In addition, In-Snec produces telemetry equipment for missiles (CMA) and the ESA ARIANE launchers.

Benefiting from this knowledge and taking into account the market trends, in a constant improvement process of its products, In-Snec proposes a new architecture for its new DAS (UMA2000) based on high speed communications and more overtured to futures needs (broadband acquisitions > 20 kHz, video compression).

2. Architectures

2.1 Traditional DAS Architectures and limitations

The traditional DAS of the market (figure 1), designed to output a PCM flow have evolved to multi-chassis and multiprocessors architecture linked in a daisy chain. The

acquisition boards communicate with a local processor board through a parallel bus. Recursively, each processor board collects the data from its chassis and merge them with the data coming from the previous chassis. Data format is mainly PCM oriented.

The last chassis finally produces a PCM output (IRIG106) applying the adequate filtering or modulation in order to be able to send the signal to a transmitter.

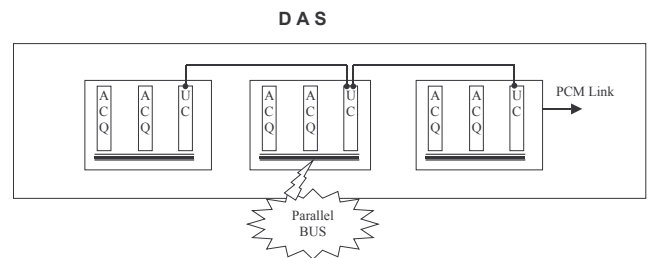


figure 1 : Traditional DAS.

The major limitation factors of these systems for new needs as broadband acquisitions (> 20 kHz), video acquisitions, local recording, are communications.

This limitation is external as well as internal (figure 2).

- External because of output flow limitation (PCM data flow << 20 Mbits/s)
- Internal when architecture does not allow modules with other purpose than acquisition, without large redesign of the system (parallel bus oriented for acquisition, one way communication).

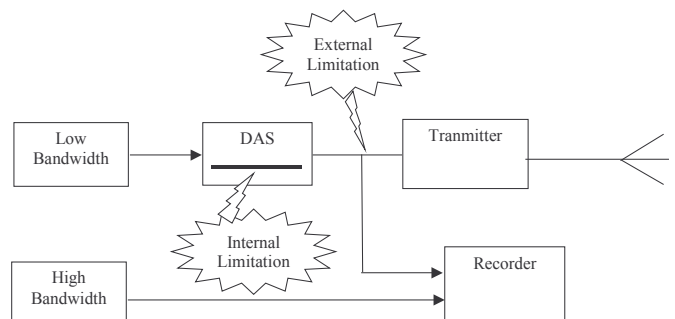


figure 2 : Traditional DAS architecture.

2.2 DAS with ETHERNET

To overcome the PCM data rate limitation for DAS such as TMA 2000 used on A380 (figure 3), since aboard the aircraft a significant data flow of acquisitions is recorded, a first evolution was to add an ETHERNET interface on existing architectures.

This ETHERNET interface offers better output data flow, even if internal limitations still occur, and provides several advantages. It allows a greater flexibility in the use of the system, its control and configuration are accessible through this interface with standard devices. Acquisition systems are connected to a network and linked easily to other devices, such as displays, recorders, computers, transmitters..., data are routed with COTS switches through this network.

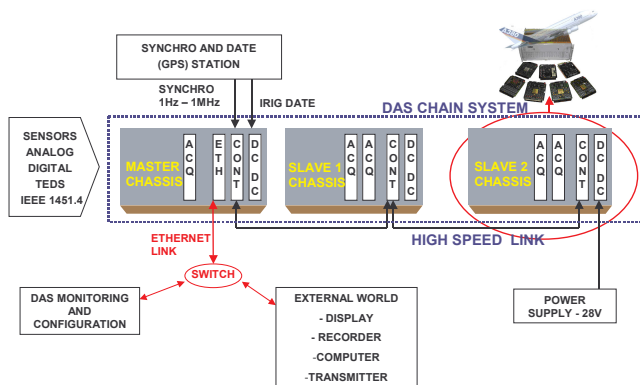


figure 3 : TMA 2000.

2.3 New architecture

To define a new architecture, two main goals were pursued:

- First, simplification of the system leading to **costs reduction**, reliability improvement by reducing software and data processing device layers between acquisition and system output.
- Second, give special attention to communication links between acquisition and data processing :
 - In building a versatile communications protocol not only designed for data acquisitions
 - In considering acquisition modules to be peripherals

Derived from USB architectures, the idea is to propose a HUB architecture (figure 4) managed by a single "intelligent" board called MASTER.

- The HUB is connected to a master board and several peripherals.

- The peripherals are in most cases acquisition boards but the HUB can manage any type of modules. Its communication protocol is versatile and bi-directional.

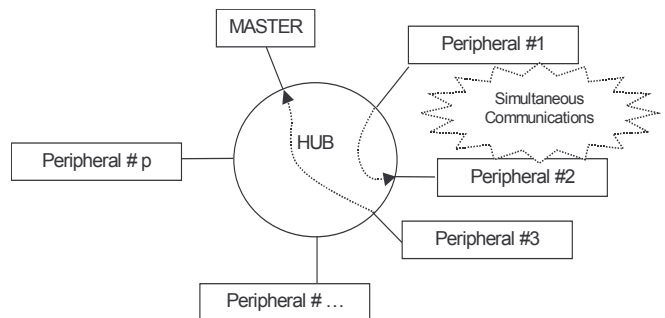


figure 4 : HUB architecture

- The HUB is a routing hardware device which can manage simultaneous communications between its ports and thus between different peripherals,
- Communications are all sequenced by the master.

2.3.1 Chassis physical organisation

To match with a chain organisation of several chassis, several HUBs are chained (figure 5).

In each chassis the same HUB is integrated.

- The master board is connected on the HUB #0.
- This unique master board sequences communications on the entire chain.
- Within the chassis, two standard ports are used for downstream and upstream communications in the chain, other ports are dedicated to peripherals.
- The Master communicates with all the peripherals in a maximum given time related to the depth of the chain.

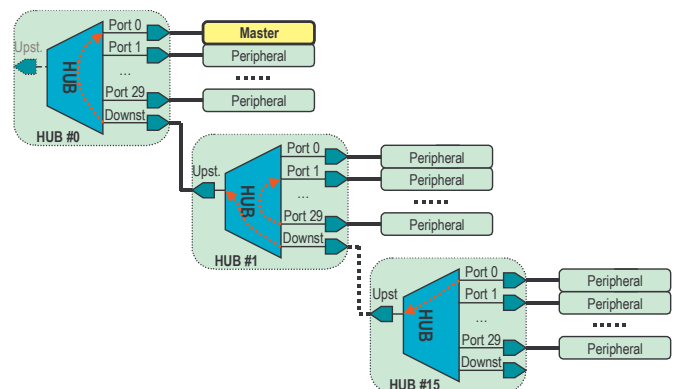


figure 5 : HUB organisation in a chain

- Up to 16 chassis can be placed in the same daisy chain (largely beyond the usual needs).

- The links drawn in dotted lines on the HUB in the figure are an example of the links that can be established at a given time. Thus direct links between peripherals can be initiated, under control of the master.

2.3.2 Synchronisation function

An important DAS requirement is the accurate synchronisation and dating of acquisitions within the chain with external clock and date references.

Without external references, the chain will perform freewheel dating.

With external references, any acquisition module in the chain will perform data acquisition at the same time within a jitter of less than a few hundredth of nanoseconds.

In addition to communication links, this function requires clock distribution between HUB and peripherals.

2.3.3 Communication function

For the communication function, serial links are the best choice to reduce wiring between chassis, HUB and peripherals.

For a better efficiency, the bi-directional link is performed on two separated up and down links. A lot of standard serial link transmitter/receiver can be found on the market to perform a high speed data link.

Technologies improvement in this field of application can be applied without calling the architecture of the system nor the transmission protocols into question.

2.3.4 Communication bus

Taking into account the requirements of the both previous paragraphs synchronisation and serial communication lead to the following definition of the proposed In-Snec Serial Bus (ISB):

The ISB is composed of:

- two twisted pairs for both up and down serial links with a data rate higher than 400 Mbits/s
- two twisted pairs for fast and slow clocks (necessary for fine synchronisation and dating).

This bus links (figure 6):

- Master and HUB
- HUB and peripherals

- Two HUB

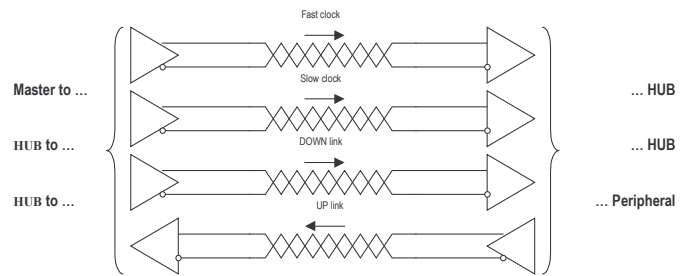


figure 6 : ISB Bus

2.4 Communication protocol

2.4.1 Synchronisation and dating

The master board generates the clocks for synchronisation. The peripherals synchronise their internal clock on these signals for acquisition. Through the serial link the master transmits the date in order to allow the peripherals to perform accurate dating of acquisitions.

2.4.2 Communication

The communication protocol answers to the following requirements to :

- minimise latency time of acquisitions, (in these system, the goal is less than 10ms)
- gather synchronous data whose flow is known at stage time of system configuration
- collect asynchronous data whose flow is related to external events (data ON/OFF, ARINC, RS, CAN...).

Taking benefits of system synchronisation, the communications are time shared in time slots.

The time slot is long enough so that the protocol exchanges represent a short wasted time and short enough to be compatible with system latency.

For each time slot, the master allocates communication time to each peripheral. This allocation is carried out according to the configuration for the synchronous data and on request of the peripherals for the asynchronous data. During the time slot, all peripherals one by one may upload some data to the master.

This dialogue with peripherals allows the master **to adjust dynamically the bandwidth allocation** and thus to grant band-width to asynchronous acquisitions when it is required.

As it is shown on figures 4 and 5, the master can also initiate direct communications between peripherals to allow direct recording of a video data flow for example.

2.5 Input / Output communication link

The ETHERNET interface on such existing systems has shown its advantages.

For future needs, In-Snec proposes several standards of ETHERNET interfaces and in addition, maintains the PCM compatibility with existing equipments.

3. UMA Presentation

Succeeding to the TMA 2000 design, flying on A380, the Universal Modular Acquisition system (UMA2000) developed by In-Snec belongs to the same embedded DAS product.



For this system, the ideas of new architecture described in this article were largely applied. Each chassis includes a HUB and peripherals. Chassis are available in two sizes, 8 or 13 slots.

The chassis can be chained (figure 7). One master board placed in the master chassis controls all the HUB and peripherals of the entire chain.

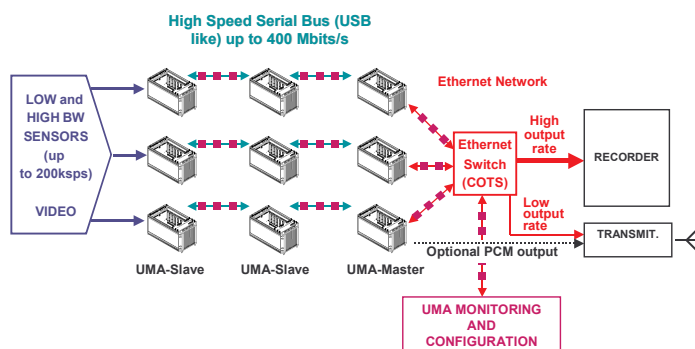


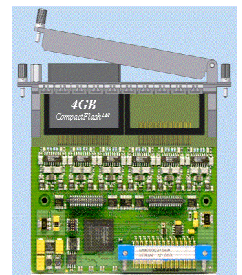
figure 7 : UMA 2000 acquisition chain

Operating in harsh environment (industrial or military), a large combination of acquisition boards is provided in this product.

For analog acquisitions, additional mezzanine boards offer a large set of signal conditioning. A high density of acquisition is provided. For example, a 8 slots chassis allows up to 280 analog channels, 28 “1553” bus inputs or 112 ARINC data bus inputs. A chain of 16 chassis of 13 slots would allow more than 8000 analog channels.

The advantages of this product are its capability of broadband acquisition (> 20KHz/s) and its overtone to other kinds of peripherals than those dedicated to acquisition:

- video compression,
- recording on discs flash,
- data transmission,
- signal generation...



3.1 External interfaces

The UMA2000 product provides a high data throughput based on several simultaneous outputs 1GT ETHERNET link and 2 each 100T ETHERNET links. In addition the UMA2000 provides two PCM data streams supporting various formats IRIG106, DANIEL and CE83.

When PCM output is selected and sequences output data flow, it is possible to select all or part of information on the ETHERNET link in TCP/IP or UDP standard. This output supports the use of display tool as MAGALI™.

Without PCM, the device supports ETHERNET IRIG 106 chapter 10 format making it possible to directly connect a recorder with a maximum data rate.

The ETHERNET link can be used to connect several chain. One dedicated master chain can perform data merging from the other daisy chains and output a unique PCM link.

The operating system (OS) of the master board chart is based on a kernel LINUX embedded 2.6. To the basic software of the product, "plug-ins" can be added to match proprietary interface requirements.

3.2 Monitor & Configuration tool

The Monitor & Configuration (M&C) tool, necessary to manage and configure the DAS, consists in a standard PC including an ETHERNET port with a set of software installed from a CDROM.

In-Snec has done his best to make it easy to use and improve the GUI of the configuration software:

- Screens with configuration options at each stage of operation,
- Management of the hardware and software configuration of the DAS,
- Definition and constitution of PCM and/or ETHERNET output flow,
- Downloading of the configuration, the software and the firmware in the DAS through ETHERNET link
- Monitoring in real time by an ETHERNET link of the status of the system

For whole configuration, the operator can use the improved GUI, however, the entire description of the configuration can also be carried out through a set of XML files. This leaves the possibility to the user of generating the configuration files from his own data base. All the operations from configuration to downloading can be automated in a script.

The advantages of the Configuration Tool are :

- When connected to a chain, automatic uploading of hardware configuration (plug and play function)
- Multiple chain configuration
- Secure update of software
- Analysis of ETHERNET flows with a Quicklook tool available on PDA,
- Quicklook configuration with XML files (available also with full MAGALI™ tool)
- Analysis of ETHERNET flows with an In-Snec tool able to take into account several chains by macro-configuration.

4. Conclusion

Data Acquisition System have followed digital technologies evolution without revolution in their architecture. With new needs as broadband acquisition, the data throughput of PCM based systems becomes insufficient.

Taking advantage of new technologies like ETHERNET and fast digital transmission, some new DAS architecture can be imagined to answer to these new needs.

After a review of a new architecture for its embedded DAS product line, this article presents In-Snec' new product : UMA2000. With benefits of this new architecture, this DAS provides capability of broadband acquisition and video acquisition which could not be supported in older designs.

5. Glossary

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| <i>CMA</i> : | Coding Missile Acquisition (In-Snec DAS product) |
| <i>CT</i> : | Configuration Tool |
| <i>DAS</i> : | Data Acquisition System |
| <i>ESA</i> : | European Space Agency |
| <i>GUI</i> : | Graphical User Interface |
| <i>M&C</i> : | Monitoring and Control |
| <i>PDA</i> : | Pocket Digital Assistant |
| <i>PCM</i> : | Pulse Coded Modulation |
| <i>TCP/IP</i> : | Transmission Control Protocol / Internet Protocol |
| <i>UDP</i> : | User Datagram Protocol |
| <i>XML</i> : | Extensible Markup Language |
| <i>ISB</i> : | In-Snec Serial Bus |
| <i>TMA2000</i> : | TeleMetry Aircraft (In-Snec DAS product) |
| <i>UMA2000</i> : | Universal Modular Acquisition (In-Snec DAS product) |
| <i>MAGALI™</i> : | Distributed by Eurilogic (Multi-signal acquisition display and tools system) |