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Universal Modular Full Flight-Testing System

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Abstract:

Driven by the need for a next generation flight test data acquisition and signal conditioning system, this presentation describes a new solution to fulfill that need. The on-board system design covers all aspects of signal measurement technology from high-precision analog signal processing (even in the high-voltage range for e-drive / battery measurements) to aircraft BUS acquisition and the embedding of existing proprietary user protocols.

The modular system is fully compliant with the latest IRIG 106 standards and include real time uplink ground control of the airborne system utilizing IRIG106 Chapter 7 capabilities. These include the complete signal conditioning system configuration, the IRIG106 Chapter 10/11 recorder control, the structure of the IRIG106 Chapter 7 telemetry downlink, the pilot and any local engineering display setups, the transmitter frequencies, modulation types and power levels. The total system timing is GPS based and utilizes the NTP and PTP network timing standards within the air vehicle under test.

This presentation should be of interest to anyone interested in air vehicle testing.

Key words: data acquisition system, embedding proprietary user protocols, aircraft BUS acquisition, IRIG 106, full duplex telemetry link.

Introduction

The definition of new standards, particularly IRIG 106 Chapter 7, 10 and 11, have opened the door to a new way of thinking about onboard flight test signal conditioning systems. These must not necessarily continue to be considered as systems that are setup in a predefined manner to match the requirements of a specific flight test scenario, but perhaps rather should be looked at as a flexible resource that can be, to a certain extent, changed in real time to match a series of flight tests which have different requirements.

Having realized this fact our thinking about what is an on-board flight test system, and how it is to be used, should also change.

This presentation introduces a new type of flight test system that takes advantage of this realization to offer new ways of working for flight tests engineers, ways that may reduce their workload and open new doors.

The Basics

To start with it is clear that in order to be efficient and successful in modern flight testing, you need solid precision measurement technology for the analog world, but with that said we must also deal with BUS based sensors and devices as more of these types become available and are put into use.

Many of these BUS based sensors and devices have proprietary bus protocols based on Ethernet, Serial, etc. and it is becoming clear that the fast, adaptive acquisition of such data sources is now just as important as that of analog sources.

Measuring Islands

These measure directly at the source and are remote data acquisition systems that help both to save cable effort (weight) and improve signal quality.

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New Instrumentation Challenges

Measurements on electric-powered aircrafts make it necessary to pay particular attention to the insulation resistance of the measuring amplifiers and sensors. Examples are, temperature measurement in the high-voltage environment and general differential voltage measurements on batteries that require high common-mode levels. Temperature measurements in this area can be covered either optically using FBG technology (fiber Bragg grating) or conventionally with RTDs or thermocouples and corresponding high-voltage measurement modules.

Figure 1 Example of optical FBG sensor system

Instrumentation Layout

To achieve a high level of flexibility the application of internationally recognized standards was key to the implementation of the system, these include:

- IRIG 106 various chapters (4,7,8,9,10,11)
- Ethernet 1000/100/100
- GPS position and timing synchronization
- NTP and PTP network timing
- ONVIF video capture and camera control

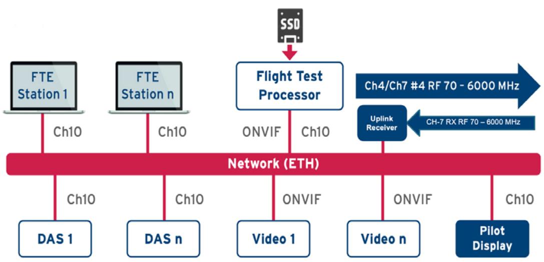

Figure 2 Ethernet based on-board system layout

As an overview, the onboard flight test system consists of the following main elements:

• Chapter 10/11 Ethernet DAS modules

• Chapter 10/11 Ethernet camera feeds

• Pilot display, Ethernet

• Engineering workstation displays, Ethernet

• Intelligent packet combiner/recorder

• Intelligent ethernet based Chapter 7 RF transmitter TIER0, TIER1 and TIER2 (L, S & C band)

• Intelligent ethernet based Chapter 7 RF receiver TIER0, TIER1 and TIER2 (L, S and C band)

• Modular airborne antennas with integrated amplification (L, S and C band)

• Ethernet backbone

Flight Test Processor

The heart of this flight test system is the Intelligent packet combiner/recorder which provides the functions of:

• IRIG106 Chapter 10/11 data packet combiner

• IRIG106 Chapter 10/11 recorder

• IRIG106 Chapter 10/11 packet selector/filter for telemetry link

• GPS synchronized NTP and PTP network Time Server

• Selected packet decoder and data server for pilot display and any airborne engineering workstations

• IRIG106 Chapter 7 telemetry encoder

• RF transmitter TIER0, TIER1 and TIER2 (L, S and C band) (suitable for use with modular airborne antennas with integrated amplification)

• Intelligent IRIG106 Chapter 7 RF receiver controller

• IRIG106 Chapter 7 uplink decoder

The system is distributed in structure in that all Chapter 10/11 data transfers are encapsulated, and therefore time stamped, within the data acquisition units themselves. To provide sufficiently accurate timing for this process the NTP and PTP ethernet time protocols were selected, with a system developed that provides timing to an accuracy of 0.000001 seconds in the data acquisition units.

A mechanism is included to provide accurate information regarding the relationship between the system time and the internal 10MHz counter originating from the combiner/recorder, which is required to conform to IRIG106 Chapter10/11 standard.

The setup of the entire airborne flight test system is managed from the DAS-setup software via the generation of IRIG106 Chapter 9 (TMATS) files, which are fed into the combiner/recorder over one of its available interfaces on that unit

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(Ethernet, RS232, USB, Chapter 7). The TMATS files are used to setup the entire system and also as the basis for a the TMATS header, which is the first packet in any Chapter 10/11 recording.

One of the new functions of the intelligent packet combiner/recorder is its ability, under customer control, to decode selected Chapter 10/11 data packets on the fly. Extract and calibrate the parameter data before distributing that recovered information to the Pilot Display and any connected airborne engineering display workstations.

As the combiner/recorder is also an IRIG106 Chapter 7 telemetry encoder, the incoming data is available to be sent over that Chapter 7 telemetry downlink, which may be any combination of the decoded parameter data and/or selected Chapter 10/11 encapsulated data packets.

The system design takes advantage of the Chapter 7 ability to provide a control uplink to the vehicle under test.

As the entire airborne system is configured via uploaded Chapter 9 (TMATS) files then sections, or a whole new, TMATS files may be sent over the uplink to the combiner/recorder even while the flight test is in progress.

These uplinks can control:

- The downlink Chapter 7 telemetry contents, data rates and structure.
- The downlink RF characteristics including data rate, transmission frequency, modulation type etc.
- The downlink transmission power.
- The content of the Pilot and any engineering displays.
- The control for the recorder start/stop/new file etc.
- The Chapter 10 data packet selection for decoding, recording, RF transmission etc.

In other words, the configuration of the airborne system may be changed at any time via a Chapter 7 uplink from the ground station, thus saving time and money on a flight test program by allowing multiple disparate tests to be carried out during a single flight.

One of the most important features of the total system design is the ability, through the use of internationally recognized standards throughout, to integrate customer supplied legacy equipment, with minimal effort, into the systems infrastructure.

Another important feature is the minimal internal cabling required within the air vehicle under test. Basically, just ethernet and 28V power is sufficient to bring the system together.

On the ground a standard telemetry antenna configuration (with optional uplink capability) is used along with unmodified telemetry data receivers.

The data thus recovered is decoded by the systems software and is then available for distribution to local or remote engineering stations.

The Chapter 7 uplink capability is provided by the same ground software and can take the TMATS files generated by the DAS-setup software and send them in a secure manner via the Chapter 7 uplink to the aircraft under test.

Conclusion

A new class of onboard flight test systems that uses internationally recognized standards to go beyond fixed configurations in airborne test systems offering new more efficient flight test capabilities.

This has applications to the issue of more efficient telemetry bandwidth usage, as well as for unforeseen data needs during a test flight.

The intelligent integration of previously separate functions along with control via the uplink, makes this a state-of-the-art solution, while still providing the ability to integrate customer existing equipment into the overall system.

The best news is that this is all immediately available.