

High Innovative Telemetry Solutions for Demanding Applications in the Aerospace Industry

Dr.-Ing. Stephanie Manner¹, Dr.-Ing. Ernst Manner², Dr. Julia Manner³

^{1,2,3} MANNER Sensortelemetrie GmbH, Eschenwasen 20-24, 78549 Spaichingen, GERMANY
manner@sensortelemetrie.de

Abstract:

The aerospace industry is a field of its own. Always driven by innovations, safety and efficiency, this sector plays a vital role in shaping global transportation, communication and defense capabilities. Innovations and developments in this industry have far-reaching impacts on various sectors and contribute to the progress of technology as a whole.

Providing measurement solutions with contact free energy and real-time data transmission for aerospace applications is a supreme discipline and has ever been a core competency of our telemetry solutions.

Not only the high demands on environmental conditions such as temperature, humidity and shock/vibrations but also a highly precise and robust signal measurement and signal transmission in a system without foreseen space for measurement tasks is a challenge by itself.

In this paper we will discuss different solutions for measurement tasks in the aerospace industry with a focus on helicopter applications.

Key words: near field telemetry, sensor telemetry, helicopter applications, time synchronous data acquisition, PTP V2, IRIG B, IENA.

Space Constraints for Measurement Systems

Developing complex systems as aircrafts or helicopters means not only a lot of moving parts but also quite some loops during the engineering phase and test campaigns. Each loop will help getting closer to reaching the goal but often there arise problems the engineers did not think about. All the parts are carefully engineered and designed, the stress on the parts is simulated in FE models and if in doubt a measurement campaign for the part is done on test benches. Anyhow, once the subsystems are assembled to systems of the aircraft or rotorcraft, totally new behaviors might be identified during a ground test.

To understand the new behavior of the systems and to overcome the challenge a physical measurement is aimed for. Since the major part of engineering is already done there is no space foreseen for measurement systems or sensors. Additionally, the parts should not be manipulated in any way but measurement signals are needed. Adding e.g. weight to a shaft might change the behavior, stiffening or weakening shafts will also result in a different behavior. Here it is very important to choose very light weight measurement solutions. A high

grade of customization is necessary to push the borders of the feasible. Modular and adaptable components and a variety of package sizes are important to be able to solve such demanding tasks. This is called retrofit, meaning enabling measurement systems in locations where this seems impossible.

Environmental challenges

Since the constraints of available installation space are known and identified and can be addressed by the means in the passage before, the environmental conditions such a measurement system has to stand are to be defined.

The exact environmental conditions an aircraft system has to withstand can be studied in the standards like DO160 or CS-23, CS-27 or CS-29. The most challenging conditions are a significant range of temperature. Reaching from -50°C to up to 160°C or even 200°C the challenge for those systems is big. Components not only have to survive these temperatures, they also have to perform with nor or only minor degradation of the measurement accuracy and lifecycle of the system. The most challenging for electronic components as telemetry systems are temperature cycles. Going through the

freezing point and the dew point each time as well as cold starts are demanding.

Humidity and especially salt water tend to creep under the potting and sealing of the sensor installations.

Oil, especially gearbox oil is very aggressive. There are telemetry systems necessary to be installed in oil or oil mist. This is an additional challenge. Together with temperature cycles and vibrations as well as accelerations and high rpm this is nibbling on the potting and sealing and the oil tends to creep under the potting even more than salt water.

The circuit boards are the heart of the telemetry system. Electronic components are very vulnerable and cannot stand any force to them. These electronic circuit boards are highly complex with a lot of layers and the smallest electronic components on the market. Driven to the edge to perform in temperatures that are not even possible according to their electronic components data sheets but somehow realized with the fines engineering teams of the telemetry manufacturers. This means that the packing of the electronics needs to be done with a lot of knowledge. The resins need to be chosen wisely and several layers of different sealings and enforcement techniques need to be done to lead to success. There is a lot of sensitive and intellectual knowledge coming to this.

At the end the customer needs to choose the best fitting technology and industrial partner and telemetry manufacturer for a system to be operated in such demanding environments.

Electromagnetic Interferences (EMI) Awareness and Proofness

Part of such standards as DO160 or CS-23, CS-27 or CS-29 is EMI. EMI is not just the immunity against external fields and disturbances but also the EMI emissions of the telemetry system that could possibly disturb other systems of the aircraft or rotorcraft, especially the NAV/COM frequency band. Two decades ago the main focus has been to gather all the data during the flight campaigns or ground tests. A disturbed frequency was seen a minor issue.

This point of view changed drastically. A major trigger has been the NAV/COM systems that read signals as small as -90dBm using enormous amplification on the signals. On the contrary with the higher data rates and bigger bandwidths needed, EMI becomes even more prominent in telemetry systems. Therefore, the suppliers had to address this and eliminate the root causes. Highly innovate filtering techniques

perform fine tuning and optimize the EMI behavior of measurement systems.

At the end, the EMI behavior of a system is vastly influenced by the sensor application and especially the wiring and shielding of sensor wires. This is not always part of the installment done by the telemetry manufacturer. Anyhow, the manufacturers that provide installation on customer parts have gained a lot of knowledge and are willing to help their customers out with support to lead them to success.

State of the art systems and their components proofed their EMI behavior in certified labs.

Flexibility in a Custom Specific Telemetry System

This sounds like a contradiction but it is possible with the new generation of multi-channel telemetry systems.

The more flexibility a telemetry measurement system has, the shorter is the period of time necessary for customization. This is often a game changer in fast development cycles.

Some of the new generation of multi-channel telemetry systems on the market are software configurable. This means, that a majority of sensor interfaces are foreseen as hardware and can be activated as necessary. E.g. strain gauges (1/4- bridge, 1/2- bridge, full bridge, RTD, PT100, high voltage sensors, ICP and more). This is even possible after the system has been delivered and installed.

The number of channels can be upgraded by adding another module and this is possible up to 256 channels by multiples of 4 channel systems.

A huge advantage is the remotely configurable filter frequency using digital filtering onboard the amplifier electronics. Digital filtering on top allows very sharp edges of the filter function.

This often is a crucial advantage once the realization during a measurement campaign is made that e.g. the cutoff frequency needs to be changed. Of course, the necessary bandwidth has to be granted.

Monitoring of the System and Sensor Health Status

The new multi-channel telemetry systems are equipped with a monitoring function. The software allows the user to set alerts for critical system parameters and few the telemetry health data on a dedicated page of the software.

This can be measurement values, supply voltages, onboard temperature of the amplifier as well as forward and reflected power in

inductive systems. A logging function for an alert will allow the user to replay the system data recorded during the alert and help to understand certain issues.

On top, there is the possibility to recognize sensor losses such as disconnected wires or shorts.

Single channels can be shut down to avoid further harm or energy loss to the system and guarantee a successful measurement even when one sensor has failed.

E.g. turbine telemetry systems especially for aeronautical engines need this to be addressed. Those systems are highly integrated and a disassembly of the system to do certain problem solving is impossible.

To be able to check the overall telemetry system health can be a game changer and avoid issues during a test campaign.

Accurate Data without Loss

Data loss during a flight campaign are very aggravating. Even during ground test this is a scenario nobody wants to encounter. The majority of our telemetry systems are engineered as inductive systems. This is due to their robustness for signal transmission and the omission of maintenance of the system. The inductive transmission path is very robust and secure against disturbance or signal loss.

Besides inductive telemetry solution, we provide also radio telemetry systems that either can be used with batteries to supply the rotating part of the system or an inductive supply can be used with radio signal transmission for the data.

Each sample has a checksum, so corrupt signals get not passed through.

High Data Rates

Especially for flight test instrumentation (FTI) a lot of different measurement channels are needed. Looking at turbine telemetry system the number of channels and necessary bandwidth explodes. Our new technology can handle up to 256 channels with a total system data rate of up to 320Mbit/s.

Time Synchronous Sensor Data

The aim for a fully synchronized measurement is clear. On a complex system as a rotorcraft or aircraft it is very important to bring the different samples back to one master clock. Then being able to compare the sensor data especially in case of conspicuous data.

There are a lot of protocols available on the market. Thus, making this whole task even more demanding.

The most common protocol in the aeronautics is the PTP V2 IENA protocol but the older protocol like IRIG B is also demanded by some customers.

PTP v2 or IRIG-B

Both standards provide precise time synchronization. Even though PTP v2 is more common these days, our telemetry systems can handle both standards.

IRIG-B being a time code format that is able to provide time information up to an accuracy of milliseconds (when used in conjunction with PTP) and synchronized to a reference clock. The precise time information can also be integrated in the IENA format.

PTP v2 is designed to provide precise time information over local area networks using a master slave hierarchy. PTP v2 has a sub-microsecond accuracy.

The precision time protocol (PTP) allows to have one master clock e.g. GPS grand master and to synchronize every sample with this master clock.

By performing this every sample is defined in time with very high accuracy.

The time accuracy is about 10 ns and also depending on the sample rate.

IENA Format

The IENA format is used for encapsulating data in a standardized manner to allow data exchange over Ethernet networks. It is often used in the defense and aerospace industry where real time telemetry data is critical. It is a network-centric approach and allows efficient distribution of data across complex networks.

Combining PTPT v2 or IRIG-B with the IENA Format

Both approaches are promising even though the most common solution is using PTP v2 with the IENA format making the telemetry data easily accessible via Ethernet and having a precise timestamp.

Conclusion

Depending on the measurement task of a telemetry system the choice which technology is the best fit should be made after consulting your telemetry manufacturer of trust. There are many different realizations on the market each having its own advantages and disadvantages.

Major criteria are the available space and the number of channels needed together with the bandwidth and environmental conditions the system will be operated in.

Especially for telemetry systems used in flight there should be a focus on reliability, EMI proofness and time synchronous data acquisition together with time stamping.

For a measurement task that might get more complex after having obtained the first measurement data, highly flexible solutions are to be preferred. Using the new innovations on the market and being able to readjust the system down to the sensor interface and filter frequencies comes with a huge advantage not only for the flexibility of the measurement task but also for the lead time of customized telemetry systems.

Different systems can be operated on one bus by daisy chaining the evaluation units. One grandmaster for time stamping and resulting in time synchronous data. Analyzing all data and compare sensor data is possible not being limited to the telemetry sensor data but all sensors participating in the time stamping and using the same protocol. The majority of the systems nowadays use PTP v2 IENA but IRIG-B combined with IENA is available.

The sacrifices that have been made a few years ago are now able to overcome with the innovations and new technologies on the market. A reinvest in telemetry equipment might have enormous benefits.