METHODS AND SYSTEMS FOR VIBRO-ACOUSTIC TESTING AND MONITORING OF AVIONICS ENGINES

A. Pozzi
Wintek

The Challenge

The vibroacoustic tests for the aerospace sector require a multi-channel system capable not only to carry out complex analysis but also to perform the real-time signal recording and monitoring. The challenge taken up by Avio Group, the leading player in the development and manufacturing of aerospace propulsion system, gave us the opportunity to develop a high performance system which is currently used in the test department.

The Solution:

The development of a multi-channel modular system with open and distributed architecture has been attained thanks to the PXI technology, to the DSA family boards and LabVIEW. This system offers 1 to 16 synchronized acquisition stations, each of them with 64 highly dynamic and bandwidth channels.

A Brief Description

The vibro-analysis of the avionic propulsion system requires multifunction measure systems which must guarantee in real time the acquisition, the recording and the monitoring of high number of signals, in addition to the possibility, given the size of the data to be managed, to analyze and report both manually and automatically.

On the one hand it is essential to have “cots” and easily integrated and essentially modular hardware architecture available, on the other the application software must also have these requirements.

The user, in this case, will have at his disposal a sole hardware product with different roles: as recorder for signals, as monitoring system for life-expectation tests, as a versatile common measure system, and as a easy-to-use programme for the management of complex test feedbacks. All the above with the assurance of granting an interface support with the common measure systems thanks to the use of export files and the temporary traces import, being classified according to the international standards. The development has been carried out in close contact with the user, thus reducing the time for production of measures but increasing the reliability.

Article

The vibroacoustic systems used for engines and aircraft components have been, until now, bases on traditional acquisition technologies relying on magnetic support multi-channels recorders or Dat.

Recently, the need to rely on highly dynamic and bandwidth width multi-channel systems, also offering real-time monitoring and automation of the analysis and reporting procedures, has highlighted the benchmarks set by the existing systems. In fact, with a traditional recording system it is very difficult, during the acquisition, to check, in real time, both the integrity of the signals and the potential exceeding of the thresholds relative to the functional test benchmarks. The good outcome of the test is in fact confirmed after the analysis which, normally managed by single channel, requires a huge amount of time. All this is exacerbate when destruction type tests are also required, for which it is necessary to check in real time the parameters.

Pc based technologies can undoubtedly carry out this task, but we are not talking about the development of systems with limited number of channels, and in order to reach such an ambitious target it is necessary to exploit as much as possible the architecture of the latest version of personal computers.

Considering that we usually require to acquire more than 100 dynamic channels with a net sample rate higher than 75 kS/s and a dynamic of at least 120 dB, it is necessary to rely on a distributed architecture. Based on some data computed on the throughput (about 30 MB/s of data on a hard disk) and to the power of calculation (FFT in real time for all the channels involved in the measure) and the information display (alarm indicators and scope/fft diagrams) we relied on a modular and extensible architecture based on a number of workstations (synchronized via LAN accordingly) each of which is able to treat up to 64 channels. Each personal computer, which must be of the latest generation, relies on a PXI system which is made of a 8 slot basket including a MXI-4 system with optic fibre link and 8 PXI-4472 dynamic acquisition boards guaranteeing the following performance: bandwidth up to 48 kHz, a dynamic higher than 120 dB, simultaneous sampling among the channels with a phase accuracy better than 0.1 degree for the whole band and last, but not least, the possibility of direct feeding of IEPE type transducers.

Thanks to this kind of front-end it is possible to acquire dynamic signals coming from accelerometers, microphones, strain gauges, pressure transducers, tachometers devices and other common transducers used in the vibro-acoustic environment.

The modularity of the solution enables to tailor the system according to the requirements starting from an instrument offering just a few channels up to a system made of 16 workstation for a total of 1000 active channels.

The core of the system is the application software which has been development in a LabVIEW environment confirming the well known reliability and performance features of the National Instruments products.

The application has three macro functions which are matching the usual requirements of the technician. The first NVA-REC gives the possibility to access to the acquisition, recording and monitoring functions, the NVA-Pro offers a module meant for the analysis and the drafting of reports and the third one NVA-Exp enables the user to import and export the signals in standard format.

The NVA-Rec module has been developed, as stated above, with the precise aim to use the system both as a digital signal recorder (offering full reliability and no interruption in the analog-digital conversion and in saving data on the hard-disk) and as a real time monitoring system for the analysis of he time-variable processes checking the overtaking of benchmarks and frequency masks, independent from each channel.
In addition to the normal features among which the possibility of configuring the acquisition, the setting up the channel, the visualisation characteristics (a entire board dedicated to alarms and one to the display of graphics), the additional features, which will be described here below, make this product bridging he gap between a traditional measurement system and a typical monitoring system.

In fact it is possible, during the acquisition, not only to visualize the instant, medium and peak spectrums and the rms levels, but also to rely on a number of alarms (on overall and spectrum masks) free from each channel which are functioning should the first level (warning) and the second one (alarm) be exceeded, replicating such action on I/O digital doors which could be interfaced to automatic system for test benches.

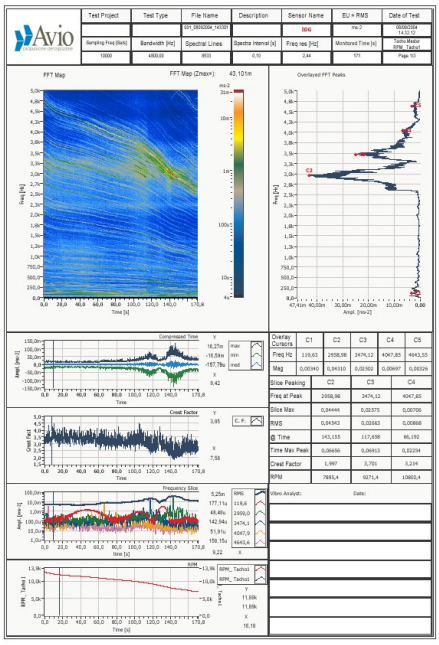
The possibility of recording long term events, acquisitions lasting a great amount of time at a high sample rate for a high number of channels, and therefore high storage requirements (more than a gigabyte/minute) is possible thanks to a particular data structure which is able to save, without interruptions, the amount of information, thus exceeding the dimension threshold of each single file which is approximately equal to 4 Gbyte, which is common in the 32 bit operative system.
In addition, it is important to highlight that each system can work as a stand-alone modality, or, should it be configured as “master”, give instructions to other “slave” type systems. In such a way we have distributed architecture measure systems offering a high number of channel.

Once the acquisition and the recording of signals is made, having examined in real time the consistency, it is possible to carry out a first analysis using another application module: the NFA-Exp module, thanks to which it is possible to immediately see the results of the recording which has just been carried out and which has another important feature i.e. to import or export the signals of part of them in the most customary formats, such as Uff58b and SDF.

The consistency with open standards was in fact the driving force of our project choices. For example, the initial format of the registration file contains a description “header” with a configuration trails in XML format it is possible to read it with a simple browser, therefore each file is self consistent and can be read independently form the system used.

The production and the analysis and report is sent to the NVA_pro module which has been developed to carry out temporary and typical spectrum analysis for vibro-acoustic situation arising from alternative excitations. Once the signal, or part of it, is detected it is possible to automatically or manually produce the measure results regarding the wide band analysis (rms, peak, envelope, crest factor), the order analysis (colormap and slices), the Campell analysis (colormap), the extraction of each spectrum (instantaneous or peak-hold) and the relative slices (both referred to time and to frequency according to the function of the tachometric referral). It is also possible to export the analysis results on tables or in text format, which are readable with standard electronic sheets, both in graphic prints and in jpeg format.

NVA-Pro can also produce multiple page print reports (frequency /timing analysis, analysis of order/frequency) of interactive type. In fact, once the calculation procedures are carried out in analytical sequence it is possible to access the pages of the report printing preview amending the contents and the features (scales, labels…)



To summarize, the open architecture enabled to develop a very flexible module system as to hardware. Its application software can carry out different types of analysis and using a single platform can perform both the monitoring and the testing of turbines, gears or other engine devices.

The user-friendly feature, arising from the application software, has been tailored made. Thanks to this we have been able to attain great advantages both as to reliability of the measures and as to quickness of execution which has been greatly, considering the standard production time for vibro-acoustic testing