CASE STUDY

DAQ System Helps General Atomics Develop Motor for Aerospace Application

General Atomics Electromagnetic Systems (GA-EMS) Group is a global leader in the research, design, and manufacture of first-of-a-kind electromagnetic and electric power generation systems. GA-EMS' history of research, development, and technology innovation has led to an expanding portfolio of specialized products and integrated system solutions supporting aviation, space systems and satellites, missile defense, power and energy, and processing and monitoring applications for critical defense, industrial, and commercial customers worldwide.

CHALLENGE

The General Atomics Engineering team was in need of a reliable and accurate way to collect electrical and mechanical data on a new aerospace motor. Because they must collect a considerable amount of data during the test, they needed a system that could acquire and store massive amounts of raw data for analysis. They were looking for a system that required little to no internal development and a more out-of-the-box system to get them up and running.

SOLUTION

The GA-EMS team used several HBK products including an eDrive system based on Genesis GEN4tB HighSpeed DAQ mainframe and torque sensor. This combination of products allowed users to quickly and accurately measure motor and inverter efficiency and help them understand how to improve their designs.They also used HBK's Perception software, supporting GEN4tB reliable storage and real-time display.

RESULT

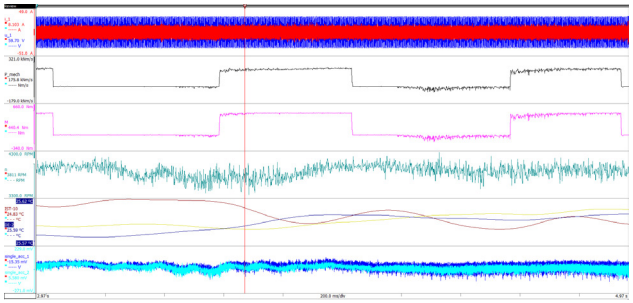
GA-EMS has been able to streamline the data-collection strategy and easily do post-processing to refine at a later date and give them exactly what they needed. They were able to focus on the prototype and refine data, allowing them to be efficient and focus efforts where necessary during the testing phases.

AEROSPACE MOTOR EXAMPLE

General Atomics Engineering teams follow a structured process when designing and evaluating a prototype. As an example, one project is a motor-development program for a three-phase brushless AC motor rated at hundreds of kilowatts for an aerospace application. The motor is very lightweight for its power rating and operates at very high inverter switching frequencies. The GA-EMS team is multidisciplinary and includes mechanical and electrical engineers as well as manufacturing engineers. The team engages outside suppliers for their expertise in areas extending down to details such as magnet wire and bearings.

GA-EMS lead electrical engineer, Matthew Zolot, described in general how the company approaches such projects. "We follow an R&D progression to develop clean-sheet prototype motors; we start with specification and requirements followed by an analytical proof of concept," he said. "The design is iterated until we've converged on an optimal concept solution. At that point, we go through an internal design review before moving on to prototype production followed by experimental proof of concept." The key verification parameters fall into three main categories: the thermal system, the electromagnetic system, and the structural or rotor-dynamic system.

According to GA-EMS, measurements on a new aerospace motor can present significant challenges. At these power, voltage, and current levels, one of the biggest challenges is measurement noise while the motor is operating. "We aim to minimize the noise coupling into the measurement signals or else we'll have to clean the signals up while we are acquiring them or afterward," Zolot said.



High sample rate data for electric, Torque, power, thermal, and acceration taken with eDrive and displayed in the software

The team collects considerable amounts of data during its test. During the first article prototype operation, the focus is on the vibration (accelerometer) data to monitor the prototype's build integrity during the initial tests. Simultaneously, GA-EMS collects data that will provide indications that the electromagnetic system is operating as expected, like back EMF and the phase currents. These early mechanical and electromagnetic tests are short duration.

As the GA-EMS team builds confidence in the prototype builds and the system's operation, the testing effort moves onto longer duration runs. The test setup shifts focus to evaluate the thermal capabilities. Meeting thermal targets under representative profiles comprises key performance metrics. This stage of validation allows for characterization of the overall efficiency and the cooling system performance.

Aerospace applications can present unique challenges related to thermal performance. "On this type of motor, we use both liquid and air for heat removal, which isn't necessarily something that you do in other fields that are not aviation-based," Zolot said. "It's different from land-based applications in that respect."

ACQUIRING AND ANALYZING DATA

GA-EMS motor drive group used several products from HBK (Hottinger Brüel & Kjær) in their work on the new aerospace motor, including an eDrive system based on the Genesis GEN4tB high-speed data-acquisition mainframe, which can transfer data to an external PC at rates of 400 MB/s using 10 Gbit Ethernet. The eDrive system can acquire and store up to 51 power channels and as many as six torque channels as well as temperature and vibration signals plus CAN messages. Because the system records all the acquired raw data, it enables users to rerun tests virtually.

eDrive can display data (as a scope would) and store massive amounts of raw data in real-time for extended periods (as a DAQ system would). eDrive not only lets users quickly measure efficiency and generate efficiency maps, but it also helps them understand how to improve efficiency. eDrive also allows for the correlation of different input channels, letting users determine, for example, that certain voltage or current anomalies are correlated with excessive vibration.

HBK eDrive - Gen4tB chassis with Perception software for analysis

The GEN4tB includes four slots for data-acquisition cards, allowing customers to choose from among HBK's lineup of power-analyzer cards, universal DAQ cards, high-speed DAQ cards, high-voltage DAQ cards, and piezo-electric (IEPE) input cards. The GA-EMS effort made use of two power cards and a universal card for temperature and vibration measurements as well as an HBK torque transducer that offers industry-leading accuracy and

bandwidth. The torque transducer offers a nominal measurement range of 100 Nm to 10 kNm and supports rotational speeds up to 22,000 rpm. It also features a minimal linearity deviation, including hysteresis, of 0.007% and superior temperature stability with a temperature coefficient of offset (TCO) of 0.005%/10K.

The GA-EMS team also uses HBK's Perception software, designed for fast and reliable processing of large amounts of data and ideal for high-speed data acquisition. Thanks to HBK's patented StatStream technology, Perception enables 10 GB of data to be visualized on a PC in 10 seconds. The software supports reliable storage and flexible real-time display. And it enables real-time or post-process computation and analysis. Users can access and zoom in on saved data even while measurements are running, with recording continuing in the background. Perception offers more than 150 analysis functions, ranging from statistics to FFT.

THE TESTING PROCESS

The GA-EMS aerospace motor testing is taking place in three stages: initially, in-house, and secondly, at an external test facility. Finally, customer site testing is ongoing. "We did some risk reduction testing with our internal systems and dyno, and then we went to a test house for additional operational characterization," Zolot said. Because the test house uses a different data-acquisition system, it was important that the HBK system could work with the same sensors that were compatible with the test-house system. Because the eDrive system is compatible with a wide variety of sensors, it's easier to use in environments that use a variety of different data acquisition platforms within the company or among various external testing partners.

The HBK products were of interest for two reasons. First, the mainframe supports different capabilities through a variety of options, making it adaptable for current and future projects. Second, the eDrive system was a drop-in solution for motor-drive testing and characterization. To minimize the effort required for getting up and running and measuring everything, GA-EMS was looking for a system that required less internal development to get to the point where they could start making measurements. HBK's eDrive system was out-of-the-box ready with those capabilities.

TRAINING AND SUPPORT

The training was also important to getting up and running. HBK's on-site training addressed the hardware, its setup, and the software. "This was our group's first HBK system, so we needed some initial training to get going, and we brought the trainer in relatively early because of that," Zolot said.

As GA-EMS got further into the setup and testing, they confronted additional challenges and needed additional support. "It worked out well because we had already established the contacts and relationships, so we just reached out and communicated with HBK as things came up." He said his team continues to receive ongoing support.

DATA COLLECTION

The HBK capabilities allowed GA-EMS to streamline the team's data-collection strategy. One approach would be to spend time upfront determining exactly what data is required and to collect only that data, but the GA-EMS team was able to take an alternative method. Because of time constraints, GA-EMS set the HBK system up to take a lot of high-bandwidth data while testing.

"The eDrive system was quite good at that by being able to oversample and record more data than we needed. The flexibility of the Genesis hardware and Perception suite allowed us to do post analysis and post-processing to refine all the data we collected to the point of getting exactly what we needed," Zolot said.

POST-PROCESSING POWER PROVED CRITICAL TO GENERAL ATOMICS

GA-EMS team emphasized the importance of being able to collect more data than the team needed, even though the approach can result in large data sets. Powerful post-processing capabilities within Perception helped to segment the effort. These capabilities allowed GA-EMS to focus on the prototype during the tests and then come in later and refine the data collected by applying different algorithms and decimating the data to make it more consumable. That helped GA-EMS be efficient and focused on the prototype while testing and then come back to the data-analysis effort later when there was more time to focus on in-depth analyses.

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