Precise, simultaneous data acquisition on rotating components

Dx telemetry: from single channels to complex multi-component systems

Application: Dx telemetry used to test the complex drive train in this Mercedes-Benz Sprinter 6x6.

The measurement tasks in today's vehicle testing have been focusing more and more on assemblies consisting of multiple rotating components. The trend towards a holistic approach in vehicle component testing poses new challenges, especially with telemetric signal transmission.

A brief review of history

In the past, it was not simpler, but less complex: in durability testing, experiments were conducted to determine the stresses to which a single component was exposed to during operation. If it was a rotating component such as a shaft, axle or wheel, the sensor lead was replaced by a telemetry system. A single channel analog telemetry system was used, which detected the required measurement value directly at the component and sent it to the assigned receiver wirelessly.

From today’s perspective of vehicle development, these types of measurement systems are becoming more and more inadequate. If, for example, the efficiency of a complex drive train with several driven axles is to be dynamically recorded, measurement data must be simultaneously acquired from several different components. In the case of a classic, analog telemetry solution, this requires the use of several independent, parallel-operated systems with different transmission frequencies. Then, the subsequent integration of these measurement signals coming from the individual telemetries must be executed by an additional system.

The consequences are well-known: a real simultaneous sampling, and thus, a precise temporal allocation of events cannot be guaranteed. Changes in the configuration are cumbersome and error-prone because each system needs to be reset individually.

If the installation situation at the measurement points requires different systems with different specifications, the comparability of the measurement data is even less.

In the case of most analog telemetries still used today, the measurement signal is modulated onto a high-frequency carrier signal. On the way from the transmitter to the receiver, this signal is highly susceptible to electrical noise in the environment: electric motors and electrical actuators can change the measurement signal so that it supplies corrupted data at the receiver. If these are not recognized by the test engineer as errors and manually eliminated, these corrupt data can then be found in evaluations and simulations – and in the worst case, they will lead to a faulty design of components.

The new solution: serial transmission of measurement signals

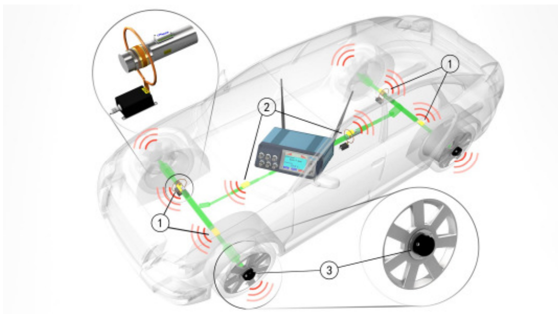

Fig. 1: Dx telemetry system with four synchronized transmitter modules.

With the Dx telemetry, CAEMAX has created a system for simultaneous data acquisition from several rotating components. Up to four transmitter modules can be operated synchronously with only one receiver unit. Although these four modules can be located on different rotating components, they are centrally controlled and synchronized (Fig. 1). The linked modules are able to simultaneously and precisely acquire the measurement signals. The zero calibration and the sampling rate are set centrally. This ensures the same parameters at all measurement points. The receiver unit (Fig. 2) synchronizes and controls the individual transmitters and generates their respective measurement data into a single data stream. There is no need for additional measurement hardware for the integration of the data.

Fig. 2: The receiver unit (RCI) of the Dx telemetry system.

The serial transmission of the measurement signals ensures that multiple modules are sending data without interference over the same carrier frequency. When more than one system is being used in the area, additional transmission frequencies are available that allow, for example, parallel testing of several vehicles without any problems.

Having a robust telemetry link is a prerequisite for reliable measurement data in environments that have high EMC loads from electric motors or other electrical actuators. Therefore, the Dx digitizes the analog measurement signals as early as possible directly in the transmitter unit. Instead of modulating an analog measurement value to the carrier signal, a digital data stream is transmitted, which can be decoded by the receiver with a high resistance to interference. In addition to the actual measurement signals, redundancies are also transmitted for error detection. An erroneously received measurement signal is recognized and discarded as such. This ensures that the receiver unit outputs only correctly transmitted measurement data.

Two antennas on the control unit operating in parallel in diversity mode further increase noise immunity: in the case of poor signal quality at one of the two receiver antennas, the measurement values are received and evaluated seamlessly via the other antenna. Instead of a large number of special modules, CAEMAX relies on the transparent concept of one fits all: the same, universal transmitter unit can be used for different types of sensors (strain gauges, thermocouples, acceleration sensors) and channel numbers. The individual configuration is carried out via the firmware of the Dx receiver unit. This concept makes it possible to obtain comfortable upgrades to Dx functionality via firmware updates. The Dx system is flexible: whether inductive transmission or DC supply, the operator can decide for each measurement task. In addition, the temperature at the measurement point and the supply voltage can also be acquired and transmitted. All signals are displayed online in physical quantities on the OLED display.

Background: Application example with Oberaigner

The Dx telemetry proved its strengths when testing complex drivelines by Oberaigner. The company develops and manufactures automotive system components. Oberaigner has been developing and supplying essential components for all-wheel drive versions of transporters for companies such as Daimler, Renault and Opel for more than 20 years. The product portfolio includes complete drive axles, gearboxes and differential locks as well as complete vehicles. Oberaigner invests heavily in the research and development of new drive technologies. In order to evaluate new developments such as a new front axle, extensive tests and trials are required. Load models calculated in the simulation are then compared with the actual results from comprehensive driving tests.

Torque measurements on drive shafts

One of the core tasks during vehicle testing is to examine the torques at the drive shafts. When converting a truck with rear-wheel drive to all-wheel drive, a transfer case is coupled to the transmission. The transfer case allows for a gear reduction to be selected or a differential lock. From the transfer case, both the rear axles and the front axle are driven via drive shafts. In the case of the Oberaigner 6x6, the first rear axle features a pass-through differential which allows the power to be divided and transferred to the second rear axle via a short Cardan shaft. The distribution of the torque on these driven axles during various driving maneuvers can be measured precisely with the Dx telemetry. A Dx transmitter unit for measuring torque is placed on the three drive shafts. These are controlled by a Dx receiver unit allowing the measurement data from all three transmitters to converge here centrally.

Fig. 3: Dx transmitter module (SCT) with integrated battery in a half-shell housing for mounting on drive shafts.

Allowing quick installations, the Dx transmitter units are integrated into a housing in which the secondary coil is already installed for the inductive power supply. After the strain gauges have been applied for measuring torque, the system is ready for use. For rigorous applications on the test track, the housing protects the sensitive strain gauges against chipping and water and can be used repetitively. Due to the installation location behind the transfer case, an inductive supply to the transmitter unit was not possible. Therefore, a battery was integrated into the housing. Here too, the same standard transmitter electronics were used since the modules support both DC and AC supply.

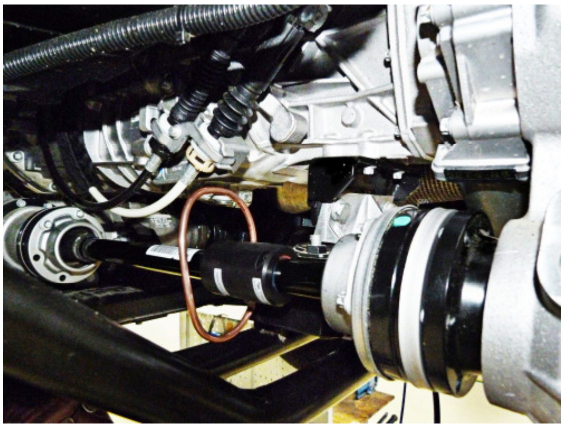

Fig. 4: Dx transmitter module with inductive power supply on a drive shaft from Oberaigner.

In order to fully evaluate the characteristics of all-wheel drive vehicles, the following additional measurement variables must be acquired: temperature, acceleration, force and control unit information via CAN bus and GPS. To make use of this data for subsequent analyses and calculations, all measuring signals must be synchronously acquired. Oberaigner used the imc CRONOS*flex* modular measurement system which can directly integrate the Dx telemetry and, thanks to its modular design, can synchronously detect a wide range of sensors and signals. The possibility of online calculation in the measurement system proved particularly helpful during trials. During active test drives, the test engineer can already calculate target values from the raw signals, such as the torque, as well as carry out an online classification.

The results obtained from the field trials flow back into the simulation to compare the calculated and actual values with one another. In addition, the recorded measurement data serve as vehicle testing profiles for test bench operations in order to be able to carry out long-term testing with real data.

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