

SENSING THE MOTION

The use of high-end MEMS motion sensor technology is becoming more widespread in industrial and instrumentation applications



BY JEAN-MI STAUFFER

MEMS motion sensors have prompted major revolution in the automotive, IT, and consumer markets. Indeed, MEMS accelerometers are used on a daily basis in our cars, computers, and cell phones.

And now MEMS motion sensors are also invading high-end applications in the military aerospace and advanced industrial and instrumentation markets. MEMS motion sensors, and more specifically MEMS accelerometers, are starting to replace established, expensive, and fragile high-end electromechanical devices, offering same or even better performances at lower cost, lower power consumption, smaller size, and much better environmental survivability. Today some of these sensors are already fully qualified in civilian and defense programs. They offer advantageous opportunities, for example as back-up systems on the most recent Airbus and Boeing airplanes or as new and innovative solutions for harsh environment applications such as borehole drilling or gun-launched smart munitions.

High-end accelerometers

The industrial and instrumentation markets benefit largely from existing fully qualified MEMS accelerometer products from Colibrys.

Driven by military aerospace requirements, the validation and demonstration of product performances is systematically done across the full range of environmental conditions, including wide temperature ranges, vibrations, and shocks, which is mandatory to demonstrate long-term validity of the critical parameters.

All the major specifications are achieved through the design of the products themselves and through a very precise and well-controlled manufacturing process performed under close statistical control, avoiding lengthy and expensive screening.

This approach enables Colibrys to offer repetitively and constantly high-end accelerometer products to the industrial and instrumentation markets as well.



CENTER: MEMS capacitive accelerometers are certified for the latest civilian airliners

TOP RIGHT: MEMS accelerometers are certified for the latest generation of high-speed trains

The company does not have to produce high quantities of accelerometers to select only the best one for military/aerospace applications and classify the remaining products as lower-end product performances for the industry.

Industrial & instrumentation requirements

The approach of these markets is very different to the military/aerospace

market and the diversity of products required is somehow larger. The basic technology platforms available to Colibrys, as well as the targeting of the right product for the right application, are fully compatible with the high-end requirements of the industry and instrumentation.

By combining existing technology platforms based on capacitive MEMS silicon sensors, open loop or closed



Typical MEMS applications in the railway market

- Bogie monitoring and diagnostics system for security and comfort;
- High-speed train tilt control system for improved passenger comfort;
- Position monitoring of magnetic levitation train;
- Control system;
- Health and Usage Monitoring System (HUMS);
- Shock monitoring during transportation;
- Precise train positioning;
- Railway track monitoring system for safety and maintenance.

loop electronics, and high-grade assembly in hermetic ceramic packaging with dedicated platforms specifically developed for the industry (i.e. wide bandwidth product for vibration measurement), Colibrys offers a full range of inertial, tilt, vibration, and seismic sensors with performances and advantages developed to meet the specific sensing objectives detailed below.

Inertial sensing

Very precise measurement of acceleration and rotation is key to determine accurately and without external reference the position, the orientation, and the velocity of a moving object. This principle is used

extensively in inertial measurement units (IMU) and attitude heading reference systems (AHRS) for high-precision guidance and navigation in the air, on the surface of the earth or under water, and is generally implemented as a complement (short-term data), a replacement, or a backup of GPS in the event of jamming or loss of signal. Extensively used in military/aerospace, the products (Colibrys MS8000, MS9000, HS8000 product families) are also used in interesting civilian applications, such as guidance of blind people and the locating of firemen in buildings.

Tilt sensing

Accelerometers are extensively used as tilt sensors or inclinometers to determine a slope, an elevation or a depression of a reference plane in terms of gravity. The applications differentiate themselves through the required resolution and the absolute accuracy or combined total error, taking into consideration the linearity, the hysteresis and the stability under environmental conditions (vibrations, shocks, temperature). Tilt or pitch and roll indicators (Colibrys MS8002,

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ABOVE: MEMS manufacturing using advanced equipments under clean room conditions

ABOVE RIGHT: Open view of Colibrys MEMS capacitive accelerometer (MS9000)

MS9001 or MS9002 products) are used for high-precision platform stabilization in various markets such as military/aerospace, industrial and instrumentation or energy.

Vibration sensing

Precise and stable vibration measurements (Colibrys VS9000 product families) are required in many applications, ranging from civilian and military aircraft or helicopters to land vehicles, large structures (bridges, buildings, dams), and industrial equipment. The aim of these wide dynamic measurements is to assess a modal shape and its stability, or to monitor and measure a given vibration level to be able to reduce its impact and improve comfort, increase durability, or anticipate preventive maintenance in the fields of research, development, production, or test.

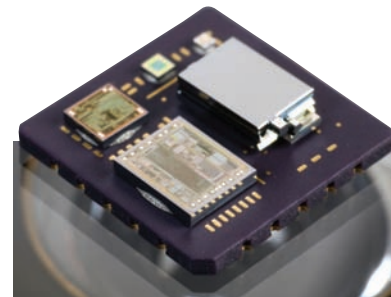
Seismic sensing

Sophisticated MEMS capacitive sensors (Colibrys SiFlex product families) combined with advanced electronics are replacing traditional geophones or seismometers for different types of seismic measurements. Numbers of applications outside the traditional strong motion earthquake monitoring are using these seismic motion sensors for their extreme low noise, high resolution, and large dynamic range. These applications are characterized by

low-amplitude signals produced by natural (earthquake, volcano, subsidence or even wind) or human-induced (explosions, shock, constructions) movements.

In the building industry, seismic accelerometers in the form of structural health monitoring (SHM) systems are increasingly being installed throughout the world. This is especially so in areas vulnerable to high-level seismic activity for seismic pre-mapping and intensity measurements, but is also the case within large structures such as buildings, dams, bridges, nuclear plants, etc, that are subject to subsurface landslip or externally induced stress and vibrations to determine the structural integrity.

Strong motion seismic sensor technology is evolving in response to these emerging demands, and traditional electromechanical solutions, such as forced balanced accelerometers (FBA), are increasingly being displaced by more cost-effective and robust MEMS-based solutions. The growth of SHM systems in many regions of the world is driven by both the preventive measurement and the prediction of unquantifiable and subjective ageing of many large structures such as dams, bridges, high-rise buildings, etc, and the increasing pressure on many governments to provide effective civil protection, control, and intervention solutions through comparative analysis



of structures before, during, and after major earthquakes, as seen in recent years in Indonesia, Italy, Haiti, Chile, New Zealand, Spain, and Japan.

It has been reported that earthquakes are responsible for almost 60% of all deaths caused by natural disasters, which heightens government and public awareness of the devastating consequences of such events.

High-speed train market

The fast-growing railway market of high-speed lines in most countries and the deployment of new-generation high-speed trains, which will be increasingly equipped with onboard safety control equipment, require reliable and high-spec accelerometers. The desire to increase the sophisticated technologies used to guide and control the trains while reducing maintenance costs, facilitating repair planning, and improving passenger and driver safety and comfort means that a variety of sensors needs to be incorporated into modern trains. (See box, on previous page for a list of typical applications of MEMS in the railway market).

The company

Colibrys is a supplier of standard and semi-custom high-end MEMS-based motion sensors in the energy, military aerospace, industrial, and instrumentation markets. Its products are designed for use especially in harsh environments and/or safety-critical applications. Its accelerometers, developed for a broad spectrum of functions, include extremely low-noise and shock-resistant seismic sensors, high-stability and high-shock inertial accelerometers, low power tilt accelerometers, and DC coupled capacitive vibration and shock sensors. ■

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