High performances MEMS accelerometers are used in railway applications

Philippe Krebs, Colibrys

Colibrys is a world-leading supplier of standard and semi-custom high-end MEMS based motion sensors into the Energy, Mill/Aerospace and Industrial & Instrumentation markets for use especially in harsh-environment and/or safety critical applications. Colibrys 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.

The company was founded in 2001 and is based in Neuchâtel, Switzerland.

High-speed rail market
The fast growing railway market of high speed-lines in most countries and the deployment of new generation of high-speed trains which will be more and more equipped with onboard safety control equipment are requiring reliable and high specification accelerometers.

New train systems are integrating more and more high tech technologies to guide and control the vehicles but are also looking to reduce maintenance costs and facilitate repair planning whilst at the same time improving passenger and driver safety and comfort. Therefore, a large variety of sensors are required and incorporated into modern trains.

Typical applications in railway market
MEMS accelerometers find a variety of applications in the areas of railway technologies. Typical examples are:

- 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.

Various technologies such as capacitive, piezoelectric or piezoresistive compete to provide the best solution. However these different sensing technologies do not offer the same level of performances and the best specifications in term of long term stability, temperature stability and precision are clearly offered by the capacitive products.

Colibrys offers different types of high-end MEMS accelerometers dedicated to the railway applications:
- VS9000 Colibrys product is designed for vibration sensing which requires wide bandwidth, extended g range, small size and dedicated signal conditioning. Typically this product family covers the full range from ±2g to ±200g and offers a constant frequency response (<5% variation) from DC up to 1 kHz.
- MS9000 product family is designed for inertial sensing which requires long term stability.
- SiFlex™ are world best in class seismic sensors widely used to assess vibration in structures such as bridges or rail tracks.

Technology
The three key ingredients needed to make a high performance accelerometer are a highly stable MEMS sensor element, a good assembly and packaging.
technology and high quality electronics. The advantage of this technology over other traditional solutions comes mainly from the lower manufacturing cost of MEMS devices induced by the possibility to proceed in batches.

Performance such as stability relies on the excellent quality of the raw material (silicon wafers) and capability of the design to meet the performance with manageable manufacturing tolerances and manufacturing processes, avoiding lengthy and expensive burn-in and selection procedures.

MEMS sensor element
The basic structure of the acceleration detector is constituted of a proof mass with a surface of few mm² and a thickness of few hundreds microns, attached by a silicon spring to a frame and separated from the detection plates on each side by a narrow gap of few microns. This sensor element is realized by a so called bulk micromachining MEMS process inspired from the standard microelectronic technologies.

The three layers are manufactured independently and are then hermetically bonded under vacuum and at very high temperature to form a wafer stack of hundreds finished sensors.

Such components are extremely stable over time, temperature and environmental conditions. It has been demonstrated that after 10 years of storage, temperature up to 200°C and shock larger than 20,000g, the silicon proof mass returns to its initial position within 0.03nm, which represents 1/30 of the radius of a silicon atom.

Assembly and packaging
The sensor assembly is extremely critical for high precision under harsh environments. Colibrys has chosen a multi chip module (MCM) approach combining the MEMS device and electronics in a hermetically sealed ceramic package, qualified against MIL standards and insuring long term stability and reliability. The MEMS die is attached with a propriety low stress process assuring that the intrinsically good performance of the MEMS is not degraded by the assembly process.

Electronics
The electronics associated with the MEMS sensor is crucial to get high performance. There are two ways to operate a Capacitive MEMS sensor. For the open loop approach, the mechanical plate deflection is measured through the associated capacitance change.

This concept gives excellent results and is small and low power. However it has limitations in terms of the ultimate noise and linearity. Typically open loop sensors are good where 16 to 20 bit resolution is needed. For closed loop (or servo) accelerometers, the proof mass is maintained in a fixed position and the inertia is compensated by electrostatic forces. With this concept the ultimate limits of MEMS sensors can be pushed further in terms of stability, noise, linearity. Closed loop sensors are covering the resolution range of 20 to 24 bits and beyond in the future.

Conclusion
MEMS accelerometers penetrate more and more railway applications. The driving forces for this revolution are the need for devices offering the same or even better performance, at lower cost, lower power and smaller size and significantly more robust and stable. The success of high end MEMS accelerometers is completed by their unique capability to serve harsh environment and safety critical applications, characterized by extreme temperature, vibrations or shock conditions in the Mil/ Aerospace, Industrial, Instrumentation and Energy markets.

Contact Information
Colibrys (Switzerland) Ltd
Maladière 83
2000 Neuchâtel
Switzerland
T: +41 32 720 5811
F: +41 32 720 5784
High Performances MEMS Accelerometers for Railway Applications

The unique opportunity offered by MEMS accelerometers to perform reliable measurements under harsh conditions in term of temperature, vibration and shocks encountered in railway applications.

To get more information on our full range of accelerometers contact our experts at sales@colibrys.com.