The highest safety inspection level in the world

imc systems acquire & analyze data from over 10,000 channels on China’s high-speed railway

Fig. 1: CRH2A-4028 at Pearl River West Bridge

For the last 10 years in the fields of scientific research and manufacturing in China, one of the important hot spots of the national economy and the people's livelihood is their high-speed railway – a large-scale test project whose mobile laboratory is referred to as “Doctor Yellow”. This comprehensive high-speed test train represents the highest level of research and testing in the construction of high-speed railway vehicles and infrastructure. The National Key Laboratory, National Engineering Laboratory and National Engineering Center have widely used imc data acquisition systems to carry out a variety of testing, including prototype testing, long-term railway safety monitoring, as well as for scientific research support.

Safety operations on high-speed railways

With an area of 9.6 million km^2, China's territory is vast and the natural and geological conditions are complex and diverse. The high-speed railway travels a length of around 30,000 km and traverses through mountains, plains and over rivers and gorges. In northern China, the lowest temperatures can reach as low as -40°C, while in the south they can reach as high as +45°C – a challenge for infrastructure and rolling stock. The routes are traveled at speeds of over 200 km/h and can even reach top speeds of up to 350. At present, there are more than 4,500 EMUs (Electrical Multiple Units) running on the high-speed railway every day in China.

Safe and reliable operation of these high-speed locomotives is of the upmost concern.

"Doctor Yellow" for extreme physical examinations with joint debugging

Before each rail line goes into operation, extremely rigorous and comprehensive safety inspections will be carried out. The technical term for this is called "joint debugging", meaning a holistic approach of testing.

The comprehensive high-speed test train, "Doctor Yellow", is a rolling laboratory that reaches speeds in excess of 250 km/h and is outfitted with a multitude of computers, processors and test equipment. Various high-precision sensors and measurement devices are installed on the vehicle, which can perform a wide-ranging physical examination on the high-speed rail: Does the thousand kilometer long track have any defects? How comfortable are people traveling onboard? Is the power supply and communication system nominal?

Wheel load reduction rate, for example, is one of the most important indicators for measuring the safety of train operation. It describes the degree of fluctuation in the vertical direction of the wheel due to poor contact on the track during the running of the train. If the index is out of range, damage to the tracks can occur, or even more serious accidents such as train derailments.

The measurement signals and tests include:

1. Dynamics detection system – wheel and rail force, acceleration, etc.
2. Comfort evaluation – vibration, acceleration
3. Traction tests – network voltage and current, motor current, etc.
4. Acoustical testing – microphone
5. Pantograph test
6. Bogies, body chassis dynamic stress test

Real-time monitoring and data analysis with the imc C-SERIES

All the data and information from the external sensors are acquired through compact and network-capable imc CRONOS*flex*-400 and/or imc CRONOS SL and imc C-SERIES measurement devices to be monitored and analyzed in real time.

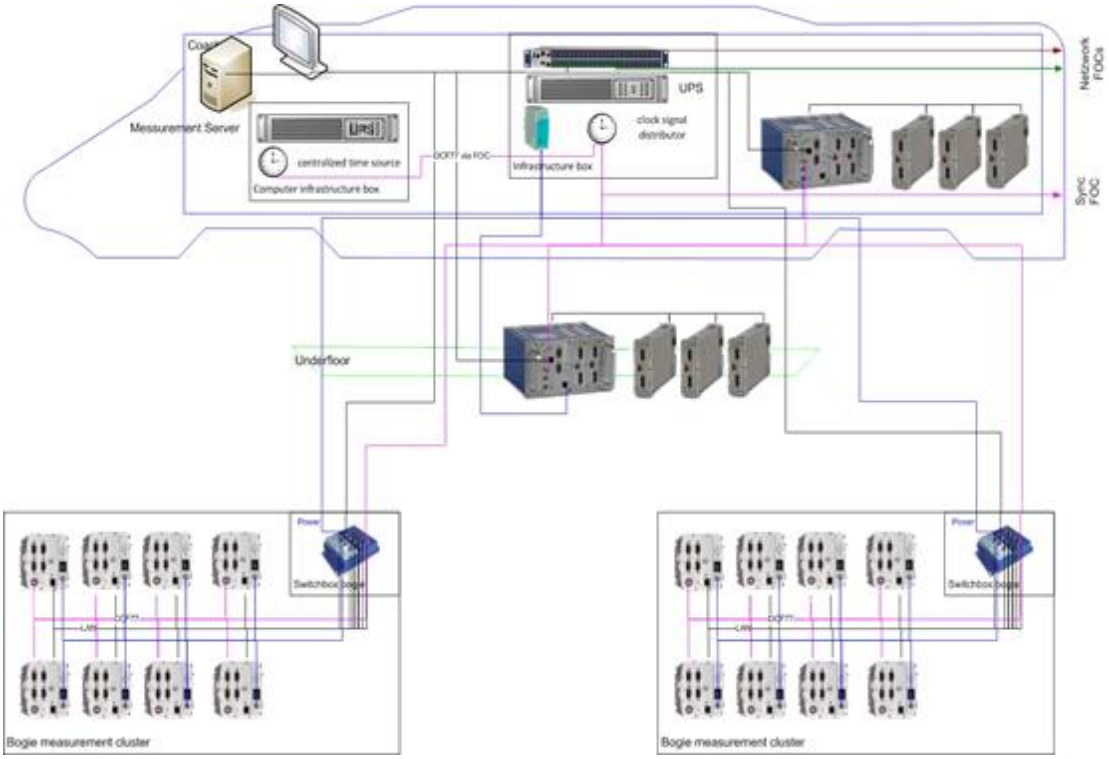

Fig. 2: Schematic of distributed test & measurement in the “Doctor Yellow” train @imcAccess China

The imc CRONOS*flex* is a modular system that covers the entire frequency range of physical test and measurement requirements by providing up to 2 MSamples/s with channel rates up to 100 kSamples/s. Measurement modules are available for every common type of signal and sensor.

Fig 3.: imc CRONOS*flex* measurement device ©imc

The imc CRONOS-SL is a highly compact, extremely robust measurement system for applications in tough environments. Conforming to MIL STD810F, one of the highest standards for temperature, environmental contaminants, and shock resistance, the imc CRONOS-SL is ideal for measurement tasks involving long duration testing and monitoring.
The imc CRONOS measurement devices are used to measure destructive transient overvoltage and ESD discharge processes. With imc CRONOS SL's ENC-4 signal conditioners, speed and distance are monitored.

Fig. 4: imc CRONOS-SL measurement device ©imc

The imc C-SERIES are smart network-capable, fanless compact measurement devices for universal measuring of physical quantities. These devices can operate either in computer-aided or autonomous mode and are lightweight, compact, and robust. They are therefore especially well adapted to applications in R&D or in the testing of mechanical and electromechanical components of machines, on board vehicles or in monitoring tasks in installations.

Onboard the "Doctor Yellow" train, the imc C-SERIES devices meet the demands for handling high channel counts over long distances. In particular, the real-time synchronous data transmission, storage and analysis processing functions are essential in this application.

The imc C-SERIES is rugged and durable and is capable of wireless data transmission, simultaneous measurement signal triggering and data synchronization, even in harsh environments. Thus, it works reliably in the field under high and low temperatures and can withstand high humidity, strong vibrations and shock.

Fig. 5: imc C-SERIES ©imc

Dynamic testing of bridges, tunnels & subgrades in harsh conditions

Because the testing sites are often in the mountains, there is a higher challenge for data acquisition:

1. Front-end storage of measurement signals and networked data transmission.
2. Real-time data processing, threshold limits and warnings.
3. Synchronized layering of GPS and measurement data at any point.
4. Intelligent, unattended automatic data acquisition.
5. Remote, real-time data transmission.
6. Sorting of measurement data, intelligent automatic processing.
7. High-intensity continuous online test for nearly 300 days in 1 year.

Fig. 6: High-speed railway bridge and tunnel – measurements under harsh conditions.

When the high-speed test train passes over a railway bridge, like the Jixi Village Bridge along the Anhu–Jiangxi line, with a speed of 220km/h, precise data are acquired through dozens of sensors located both internally and externally on the bridge structure. With sophisticated **imc C-SERIES** measurement devices, even very subtle changes can be captured.

At the ***National Key Laboratory of High-speed Railway Technology*** located in Beijing, bridge structures also undergo extensive testing under controlled environments. Here, the **imc C-SERIES** device is also implemented. Tens of thousands of durability tests are carried out to ensure the reliability of these infrastructures.

Simple experiment preparation – effective data display with imc software

With imc STUDIO, you are ready to start your measurement in a few minutes. A clearly organized channel configuration list, extensive sorting and filtering functions, numerous assistants, built-in sensor management and support of TEDS are just some of the useful functions for achieving quick, intuitive system configuration.

With the powerful analysis, visualization and documentation tool, imc FAMOS, a vast number of analysis functions and powerful automation options will provide quick and productive results – from data importing and analyzing to print-ready reports.

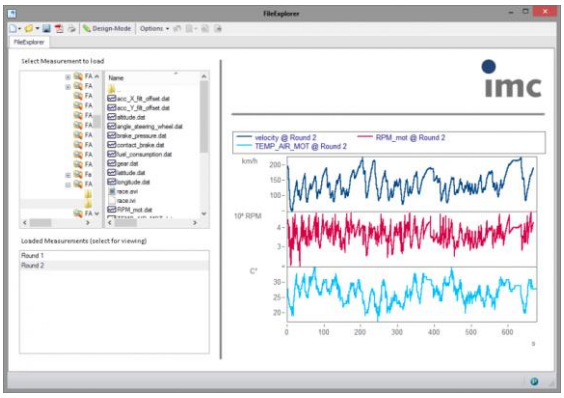

Fig. 8: imc FAMOS software @imc Test & Measurement

Post-processing

Thanks to imc COM (customized software development tool), the Chinese railway researchers can easily arrange their test system interface. The data display windows of the imc software can be easily embedded, and the extensive imc function library can be used to set up post-processing analysis. From sensor to test report it is easy to complete tasks.

Conclusion

In the past 15 years, great progress has been made in the construction of Chinese railways, especially high-speed rail. It has not only shortened the distances between cities, but also profoundly changed the way people live and work.

The advanced, feature-rich data acquisition equipment from imc Test & Measurement can meet the needs of China's high-speed rail test mission. In the future, imc will continue to support the Chinese railway industry to expand the development and construction of one of their largest infrastructures.

List of Figures

CRH2A-4028 at Pearl River West Bridge, by N509FZ - Eigenes Werk, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=73004989; High-speed railway bridge and tunnel, by MNXANL - Own work CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=55266759.

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Our customers from the fields of automotive engineering, mechanical engineering, railway, aerospace and energy use imc measurement devices, software solutions and test stands to validate prototypes, optimize products, monitor processes and gain insights from measurement data. As a solution provider, imc offers their customers an attractive and comprehensive range of services. These include project consulting, contracted measurements, data evaluation, specialist deployment, customer-specific software development and system integration. imc consistently pursues its claim of providing services for “productive testing”.
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