Passengers check the time on the monumental clock in the Besançon train station while they wait for the TGV high-speed train.

Monumental clock in TGV train station in Besançon

Synchronized motion control: so perfect, you can set your watch to it

Monumental clocks have a long tradition in Europe. Many churches and city hall towers featured them as early as the Middle Ages to tell citizens the time of day. Admired as architectural and technological masterpieces, their elaborate designs reflected a city's wealth and importance. Following this ancient tradition, French clock manufacturer, Utinam has built a modern oversized clock for the TGV high-speed train station in Besançon, France. Its axis management system, which accurately synchronizes the movement of the pendulum with its escape wheel, is controlled using automation technology from Beckhoff.

What makes this clock so impressive – in addition to its sheer size – is the fact that it has no housing, making its mechanical workings fully visible. "The installation of this monumental clock demonstrates the region's expertise in the areas mechanical engineering, railways, and traditional clock-making," explains Philippe Lebru, who for 20 years has designed clocks and watches for Utinam. "The full complexity of such a clock lies in the scope and size of the parts used." For example, the escape wheel, which links the gears to the pendulum and ensures regularity of the clock's movements, has a diameter of 1.44 meters while the hour wheel measures 2.85 meters. The entire clock is six meters tall and weighs six tons. "Highly sophisticated techniques were required to machine the large parts with a precision of up to 1/100 millimeters," says the clock-making specialist. He adds: "A clock is essentially a machine that must never stop. The parts must therefore be engineered to require virtually no maintenance. Let's take a look at the pendulum, for example. It is four meters long, weighs 80 kilograms and swings 1,000 times an hour, i.e. 24,000 times a day or 9,125,000 times a year."

PC-based controller synchronizes pendulum movement with sound and light effects

The clock uses a CX1020 Embedded PC running TwinCAT NC PTP automation software as its control platform. Two AX5000 Servo Drives and two AM3500 servomotors control two processes. One maintains the pendulum's steady movement, which would otherwise decrease because of friction. As the pendulum passes the lowest point, the controller synchronizes the motor with the pendulum's oscillation frequency and restores its momentum via a system of cams. The other process involves synchronizing the escape wheel's movement with the pendulum's position by having the motor simulate the escape movement. The movement profile is designed in CAD before the system exports the data to the PLC in TwinCAT software and generates a rotary cam.

The PLC controls the application based on information delivered by two encoders. One is located on the pendulum, while the other is on the escape wheel. The first encoder indicates the pendulum's position so that the PLC knows whether or not the pendulum must be relaunched. It also makes it possible to determine the escape wheel's position based on the simulated movement profile. The second encoder is used for servo control of the escape wheel which advances forward more than it moves backward via discontinuous movement. The two axes are therefore mechanically separate and driven by motors which are linked via software. They operate in a master-slave arrangement, because the position of one is dependent on the other.

Whenever the pendulum changes direction, it plays a recorded sound: "tick" in one direction and "tock" in the other. In addition to the sound effects, LED lights mounted around the clock are synchronized with the movement of the pendulum. To do this, the Embedded PC has an audio output and a DALI interface. The real-time communication among PLC, drives, and motors is based on the EtherCAT industrial Ethernet system.

The application software was developed in the TwinCAT programming environment. "The solution is very user-friendly and made project development much easier. Combining the various elements is simple, as is the management of the axes," says Olivier Lehmann, the automation specialist from Utinam who supported the project.

The eye-catching clock which Utinam designed for the TGV station in Besançon has no housing, making its mechanisms fully visible. With its considerable height of six meters, it stretches over two floors. The escape wheel, which links the mechanisms to the pendulum, has a diameter of 1.44 meters while the hour wheel measures 2.85 meters.

Further information:

www.utinam.fr

www.beckhoff.fr