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Ethernet puts Kinetic Rain in motion 14

1,216 synchronous servo axes control Kinetic Rain motion

The Kinetic Rain kinetic sculpture at the Changi Airport is a perfect combination of technology and art. The visual display depends on EtherCAT motion networking to individually synchronize the movement of 1,216 rain droplets, using a two millisecond numerical control task to move rain droplets at speeds up to 1.5 meters per second.

Droplets in the display move at a speed of 1.5 m/s with an acceleration rate of 1.4 m/s². Movement is dynamic, but at the same time flowing and absolutely free of jerk motions.

THE WORLD'S LARGEST KINETIC SCULPTURE may be the impressive Kinetic Rain display at the Changi Airport in Singapore. In an allusion to tropical rain, the installation consists of 1,216 brilliantly sparkling, copper-plated aluminum droplets which are suspended from the ceiling on thin steel wires and each one is moved by a small servo motor.

During a 15-minute show, the droplets are formed into different pictures connected with the subject of flying. MKT AG, experts in this type of kinetic installations, took care of the complete technical implementation of *Kinetic Rain*, including the application software development. The challenge of moving all 1,216 servo axes synchronously was solved using EtherCAT motion technology, the TwinCAT software development environment and compact servo drives configured in a bus terminal format.

Kinetic Sculpture

Air passengers and airport visitors who enter Terminal One at Changi Airport in Singapore are greeted by the kinetic sculpture as they make their way through the modernized check-in hall.

"The harmonious interaction of more than a thousand droplets also symbolizes the many people at the airport who ensure day after day that passengers and visitors to Changi Airport are positively surprised and have fond memories of it," said Yeo Kia Thye, Vice-Director of Airport Operations at the Changi Airport Group.

The installation consists of two contiguous fields of 608 droplets each, extending over a total area of more than 75 square meters and playing over a room height of over 7.3 meters. The artistic concept for this unusual space installation comes from the Berlin agency Art+Com. The technical implementation of the overall project and the programming was accomplished by MKT AG who received support from Beckhoff during the programming and implementation of the control system.

"In Kinetic Rain, we have realized the most sophisticated project of this type to date," said Axel Haschkamp, director of MKT AG: "More than 2,000 engineering hours flowed into this project." Particularly challenging was the job of transporting the fully pre-assembled installation weighing 30 tonnes to Singapore.

The demands on the control of Kinetic Rain are extraordinarily high, with the precise movement of 1,216 axes. In addition to that, the project demanded high availability, compact design of the components and a need to manage the replacement of components without adjusting addresses.

"One of the paramount specifications of our

customer, Changi Airport, was that the system must run 24 hours a day. Even if an individual axis were to fail, the show must go on," added Peter Haschkamp, a director at MKT.

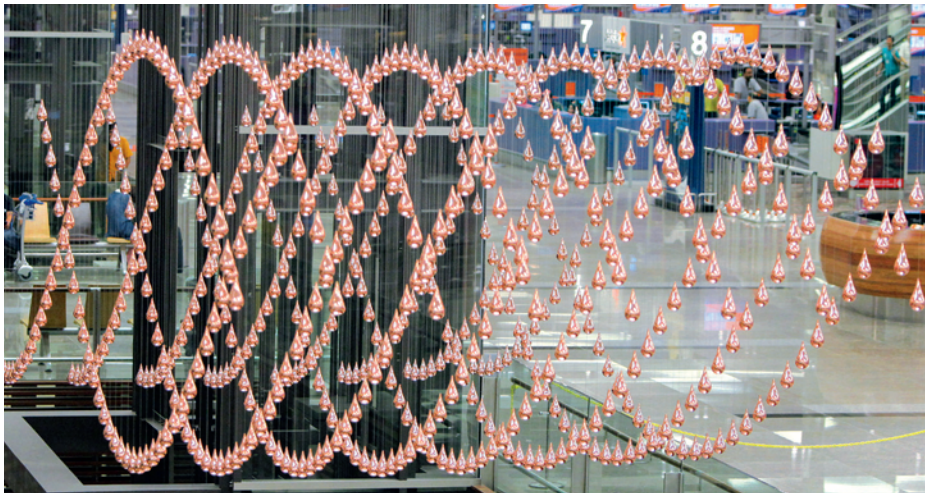
Control 1,216 synchronous axes

"The synchronous movement of 1,216 axes is one of the absolute highlights of this project," said Raphik Shahmirian, a member of the sales group at the Beckhoff office in Munich who coordinated the technical implementation of Kinetic Rain in close co-operation with MKT. Beyond that, high requirements had to be met where the dynamics, precision and speed of the motion sequences were concerned. The droplets move at a speed of 1.5 m/s with an acceleration rate of 1.4 m/s². The movement must be dynamic, but at the same time flowing and absolutely free of jerk motions.

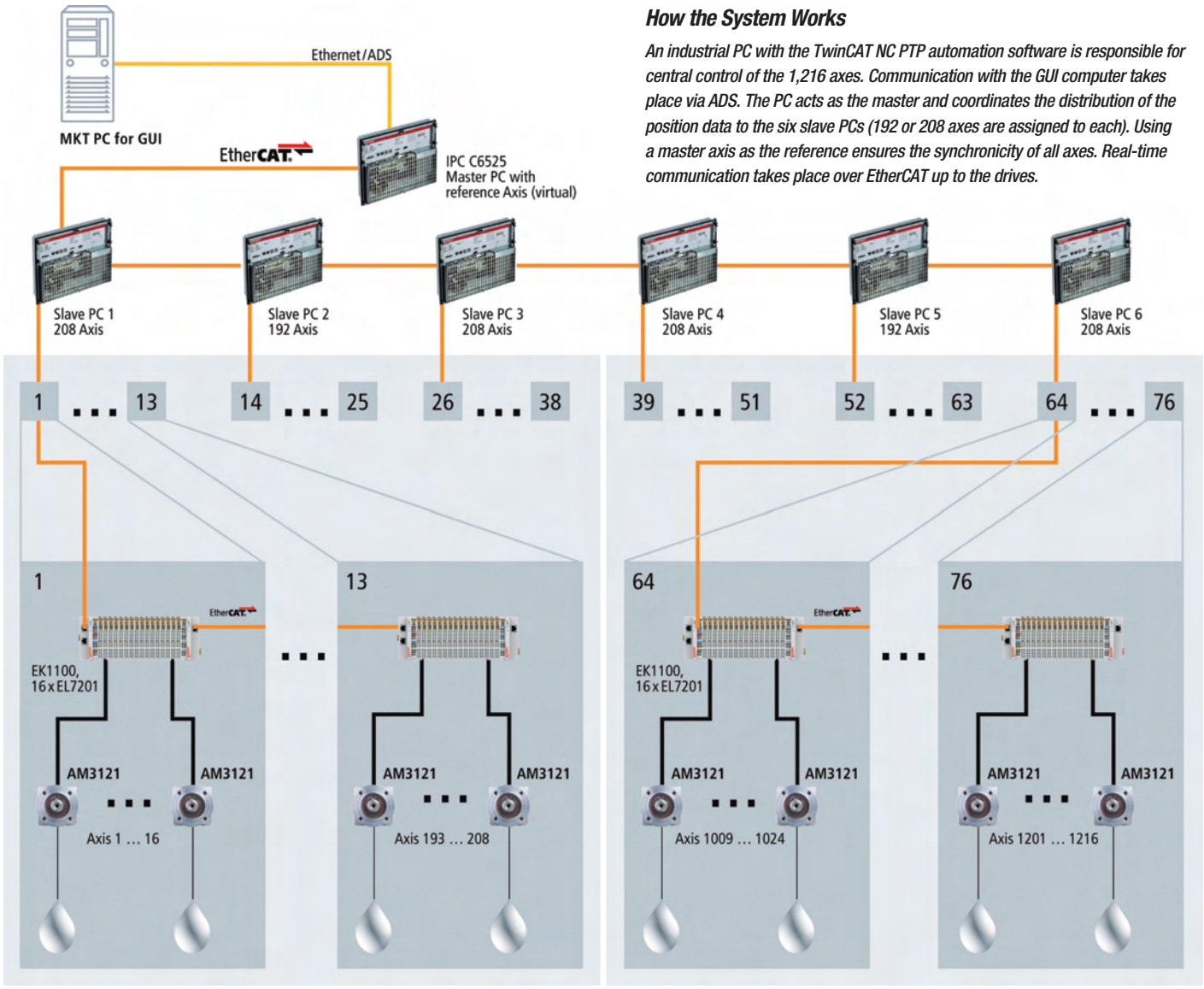
A central C6525 Industrial PC is responsible for the control which communicates using TwinCAT ADS with a special GUI computer supplied by MKT. In close coordination, the PC centrally controls the 1,216 axes via TwinCAT NC PTP and acts as the master controller in the system.

Using the TwinCAT cam table function, the master PC coordinates the distribution of the position data to the six slave PCs. Each of these units was assigned to control 192 or 208 axes, and ensure the synchronicity of all axes according to a master axis that serves as the reference. Communication takes place in real-time over an EtherCAT motion network up to the drives.

The GUI computer is used for system visualization, but it also controls the show in the form of a table containing the position data for each droplet at time intervals of 200 msec, corresponding to five pictures per second.



Servo terminals and compact servo motors (AM3121) provided a drive solution that fits perfectly into the tight installation space in the ceiling of the airport building.



How the System Works

An industrial PC with the TwinCAT NC PTP automation software is responsible for central control of the 1,216 axes. Communication with the GUI computer takes place via ADS. The PC acts as the master and coordinates the distribution of the position data to the six slave PCs (192 or 208 axes are assigned to each). Using a master axis as the reference ensures the synchronicity of all axes. Real-time communication takes place over EtherCAT up to the drives.

A flowing movement perceptible by the human eye without jerks is possible only through the interpolation accomplished in the TwinCAT NC PTP software module. This software calculates 100 intermediate positions for each droplet using a spline algorithm that is executed as a 2 msec NC task. The calculations for the local axes take place on each slave PC assigned to it.

The artistic intention to have the synchronous movements of the droplets run like a kind of 3-D film is possible only through the use of EtherCAT and TwinCAT NC PTP. While the master keeps all the axes synchronous to one another, the slave PCs calculate the positions of the axes assigned to them every 2 ms and communicate them over EtherCAT in real-time to the servo drives.

Compact servo drives

The movement of the individual axes is extremely precise and lies in the range of 1 mm for an overall length of 7.6 m. The maximum offset between two droplets is 0.25 mm. Each droplet is controlled via an EL7201 EtherCAT servomotor terminal and a servomotor (type AM3121).

"In the servo terminals which fit seamlessly into the EtherCAT terminal row, we found an extremely compact solution that fits the structural conditions perfectly, with limited installation space in the ceiling of the building," said Haschkamp. In addition, servo drive technology offers dynamic advantages and allows flowing transitions.

"Important for us was also the modularity of the control solution and the fact that an individual axis can be exchanged without addressing. That made partial commissioning possible, for example; i.e. we were able to work in parallel on software, hardware and the mechanism, allowing us to keep within the narrow timeframe that we had for this project," he emphasized.

With TwinCAT NC PTP, it is also possible to 'jog' the whole show which also allows users, for example, to fast forward and rewind the operation of the system like a film. That feature alone simplified the commissioning for MKT. If an individual passage of the sequence was not yet completely developed and 100 % satisfactory, the engineers from MKT could repeat it continuously.

"With other solutions this is not possible and you are forced to continually start the show from the beginning each time until you reach the desired position, which is very time consuming," said Haschkamp.

In contrast to comparable kinetic sculptures developed by MKT in the past using decentralized hardware controllers, Kinetic Rain is controlled via a central PC and software and transmitted over EtherCAT. The cam table function, which MKT accommodated locally in the drive amplifier in earlier control solutions, is now executed by the software. In this way, the position data can be managed centrally and distributed in real-time to the axes over the EtherCAT motion network.

View Kinetic Rein on Youtube.
http://www.youtube.com/watch?v=NXuQnDeIyY8

Application article by ***Beckhoff Automation****.*