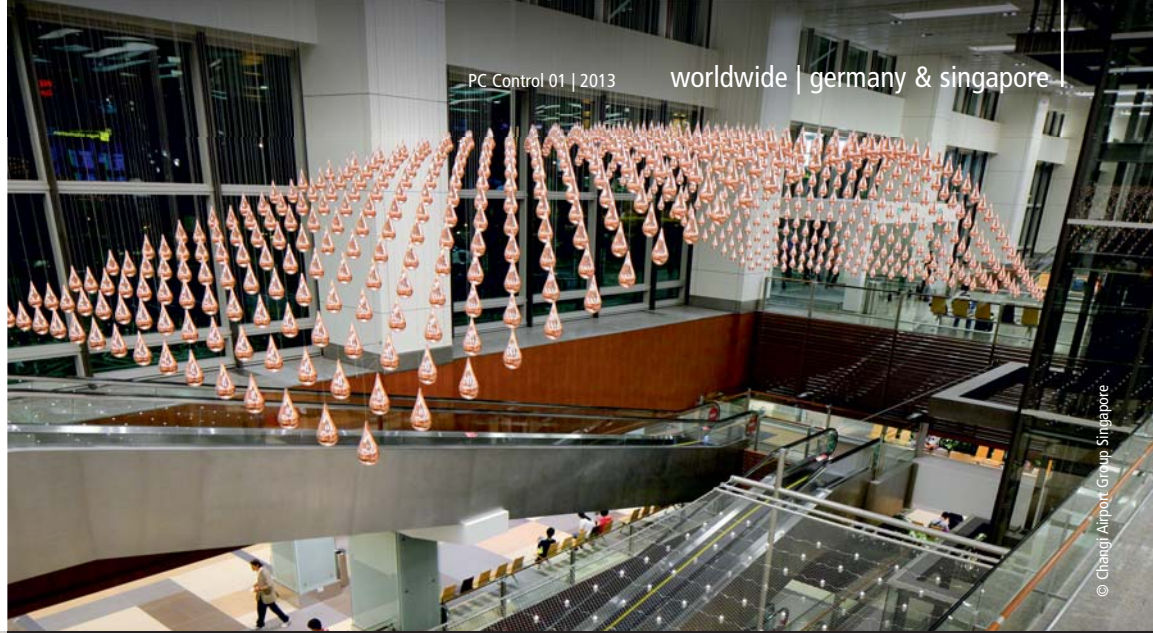


The installation, which consists of two contiguous fields of 608 droplets each, extends over a total area of more than 75 square meters and plays over a room height of over 7.3 meters.

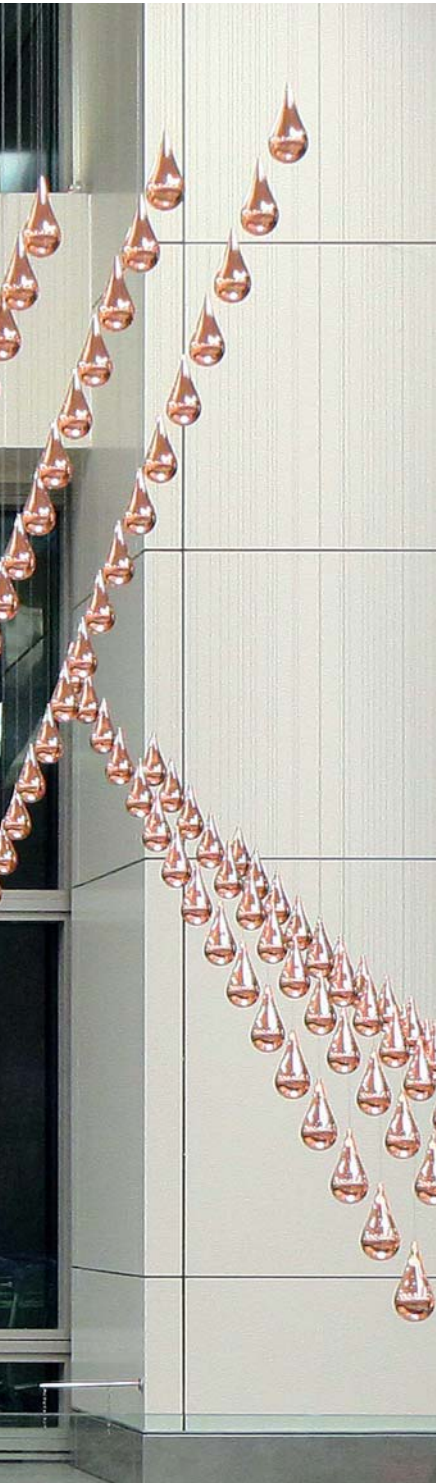


Changi Airport, Singapore: EtherCAT synchronizes the movement of 1,216 servo axes

“Kinetic Rain”

A perfect symbiosis of technology and art

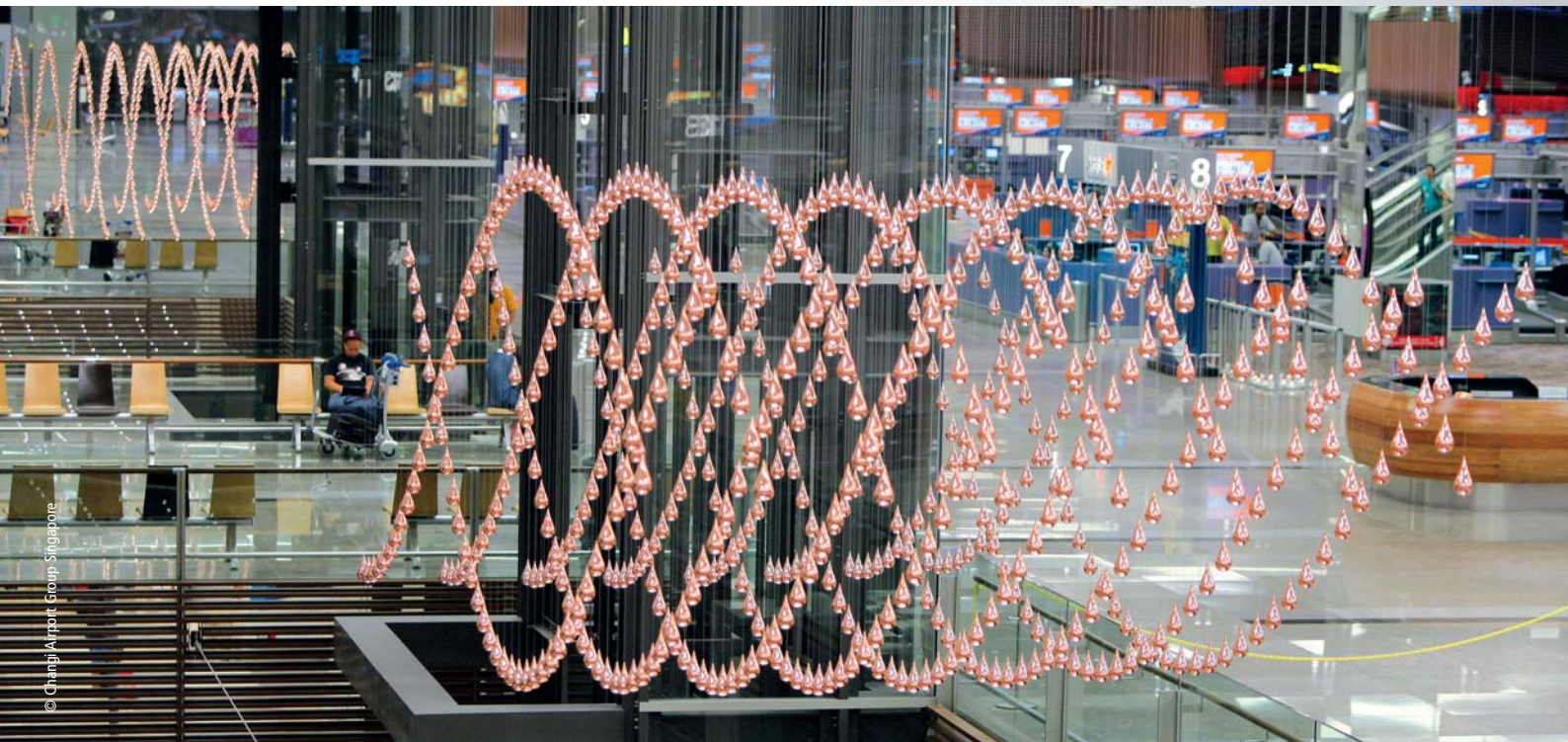
What is probably the world's largest kinetic sculpture was realized in “Kinetic Rain” at Changi Airport in Singapore. The artistic concept of the installation and the calculatory design of the choreography originate from the Berlin-based Art+Com AG. In allusion to the tropical rain, the installation consists of 1,216 brilliantly sparkling, copper-plated aluminium droplets. These are suspended from the ceiling on thin steel wires and each one is moved by a small servomotor. During a 15-minute show, the droplets are formed into different pictures connected with the subject of flying. MKT AG, experts in kinetic installations, took care of the complete technical implementation of “Kinetic Rain”, including the software. The challenge of moving 1,216 servo axes synchronously was solved on the basis of EtherCAT, TwinCAT and the compact Servo Drives in Bus Terminal format.



Changi Airport Group Pte Ltd.

The Changi Airport Group (CAG) Singapore was founded on 16 June 2009. As the administrative company of Changi Airport it is essentially responsible for the operation and management of the airport, its development as an air traffic hub, commercial activities and airport emergency services. The airport registered over 46 million passenger movements in 2011. As part of the modernization of the check-in hall, the CAG invested in a kinetic sculpture: with its allusion to the tropical rain, "Kinetic Rain" is an homage to the tropical city of Singapore.

During a 15-minute show, the 1,216 droplets are formed into sixteen different pictures connected with the subject of flying.

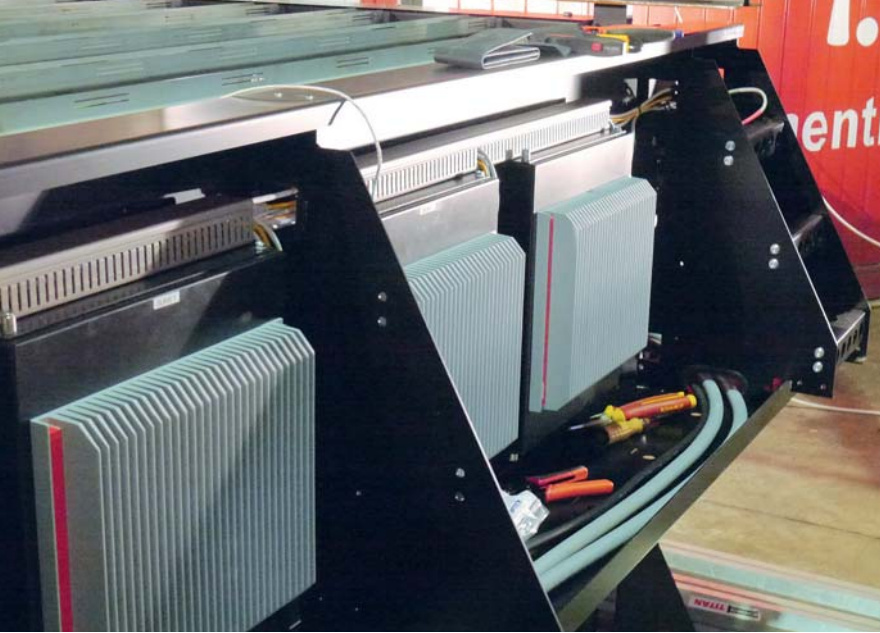


Air passengers and airport visitors who enter Terminal One at Changi Airport in Singapore are stopped in their tracks by a kinetic sculpture, "Kinetic Rain", as they make their way through the modernized check-in hall. "The harmonious interaction of more than a thousand droplets also symbolizes the many 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," says Yeo Kia Thye, Vice-Director of Airport Operations at the Changi Airport Group.

The installation, which consists of two contiguous fields of 608 droplets each, extends over a total area of more than 75 square meters and plays 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 from Olching, near Munich, Germany. The company, which specializes in kinetic in-

stallations, 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," says Axel Haschkamp, Director of MKT AG: "More than 2,000 engineer hours flowed into this project. Particularly challenging was not least the transport of 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 the replacement of components without addressing. "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," adds Peter Haschkamp, likewise director of MKT.



Due to its very flat design, the C6525 Industrial PC is ideally suited to installation in cramped spatial conditions. Thanks to an optional SSD storage medium and passive cooling technology, the C6525 does not contain any rotary components.

In the Beckhoff servo terminals, which fit seamlessly into the EtherCAT terminal row, and the AM3121 compact servo-motors, MKT found a compact drive solution that fits perfectly into the tight installation space in the ceiling of the airport terminal building.

How do you control 1,216 axes synchronously?

"The synchronous movement of 1,216 axes is one of the absolute highlights of this project," stresses Raphik Shahmirian from Sales at the Beckhoff office in Munich, who attended to 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 with a speed of 1.5 m/s and an acceleration of 1.4 m/s². The movement must be dynamic, but at the same time flowing and absolutely free of jerks. MKT found the solution to this task in the PC- and EtherCAT-based Beckhoff control platform with compact Servo Drive Technology.

A central C6525 Industrial PC is responsible for the control. It communicates by TwinCAT ADS with the special GUI computer from MKT. At the same time, the PC centrally controls the 1,216 axes via TwinCAT NC PTP and acts as the master. Via the TwinCAT cam table function the master PC coordinates the distribution of the position data to the six slave PCs, to each of which 192 or 208 axes are assigned, and ensures the synchronicity of all axes according to a master axis as reference (see diagram page 20). Communication takes place in real-time over EtherCAT up to the drives.

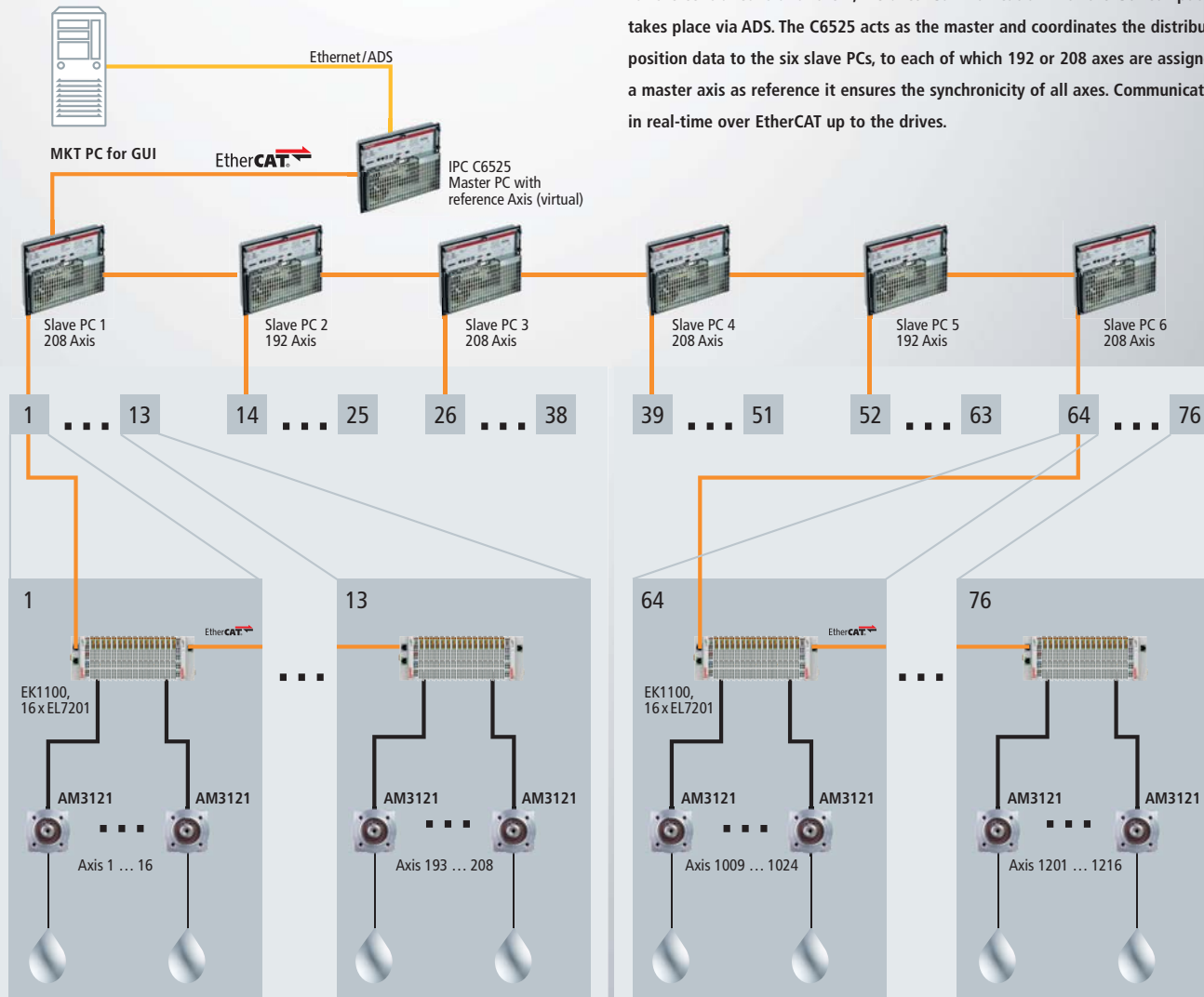
The GUI computer from MKT serves for visualization, but also contains the show in the form of a table containing the position data for each droplet at time intervals of 200 ms. This corresponds to five pictures per second. A flowing movement perceptible by the human eye without jerks is possible only through the interpolation in TwinCAT NC PTP. Here, 100 intermediate positions are calculated for each droplet using a spline algorithm in a 2 ms NC task. These calculations take place on each slave PC for the local axes 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 other, 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.





A Beckhoff C6525 Industrial PC with the TwinCAT NC PTP automation software is responsible for the central control of the 1,216 axes. Communication with the GUI computer from MKT takes place via ADS. The C6525 acts as the master and coordinates the distribution of the position data to the six slave PCs, to each of which 192 or 208 axes are assigned. According to a master axis as reference it ensures the synchronicity of all axes. Communication takes place in real-time over EtherCAT up to the drives.



Field 1 with 608 Axes

Field 2 with 608 Axes

A particular challenge was not least to install the completely pre-assembled installation weighing 30 tonnes into the existing building.

Compact servo drive in a 12 mm terminal

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 of the 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," stresses Peter Haschkamp. In addition, servo drive technology offers dynamic advantages and allows flowing transitions.

Modularity of the controller simplifies commissioning

"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," emphasizes Peter Haschkamp. With TwinCAT NC PTP it is additionally possible to "jog" the whole show, i.e. one can fast forward and rewind like a film. That very much simplified the commissioning for MKT. If an individual passage of the sequence was not yet 100 % satisfactory, the engineers from MKT could repeat it continuously. A big advantage, as Peter Haschkamp stresses: "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."

In contrast to comparable kinetic sculptures realized by MKT in the past over 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 EtherCAT.

Important for MKT in choosing Beckhoff as partner was also the global positioning of the company. This way, Beckhoff was able not only to accompany and support the project with experts from the company's headquarters in Verl, Germany. The end customer is also assured of on-site support and service by the Beckhoff subsidiary in Singapore.

MKT AG

Based in Olching, Germany, MKT AG has been conceiving, developing and realizing unique exhibits and kinetic installations for trade shows, events, museums and show-rooms for over 30 years. Its clients include not only artistic and cultural institutions, but also renowned industrial companies and service providers. MKT focuses on state-of-the-art technologies, interaction and stringent design.

Peter Haschkamp and Axel Haschkamp (right) of the management board of the MKT AG Fine Exhibition Engineering



ART+COM

ART+COM AG, based in Berlin, Germany, takes new paths in spatial design. In cooperation with media designers, media artists, IT developers, technologists, programmers, communication and product designers, scientists, engineers and project managers, the creative and technological possibilities of the computer medium are researched and put into practice in artistic installations. In the course of the renovation of Terminal 1 at Singapore Airport, ART+COM was commissioned by the Changi Airport Group Singapore to design an expansive installation. The goal was to develop an identity-defining and contemplative moment for the check-in hall that would contrast the hectic travel atmosphere.

Further Information:

www.changiairportgroup.com

www.mkt-ag.de

www.artcom.de