To this day, the central box on the first level of the auditorium is called the Kaiser-loge, or Emperor's Box, as it was reserved for the emperor and the court. The emperor was also able to retire to the tea salon behind it, which has been preserved in its original state. The sound control room is located behind the windows above the box.

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TwinCAT TCP/IP from Beckhoff sets no limits when it comes to network communication

At the Wiener Staatsoper, high-tech supports the creative work of the audio and video department

The renowned Vienna State Opera is considered one of the world's leading opera houses. Around 300 performances with more than 60 different operas and ballets are scheduled each season. This is an enormous challenge for all the employees who work here in shifts, and for the stage technology, which has to function smoothly. To give visitors the best possible listening experience, the sound system has been upgraded using state-of-the-art audio technology and the audio control system has been entirely refurbished. The system requirements for the sound technology were high: in addition to perfect acoustics, it needed to provide optimized diagnostics options plus energy metering and the ability to visualize the system, especially the amplifiers. The system was brought to life by Viennese company Salzgeber GmbH, a specialist in planning and implementing high-tech audio and video systems, working closely with Beckhoff Austria.

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On May 25, 1869, the Vienna State Opera was ceremoniously opened with a performance of Mozart's "Don Giovanni" in the presence of Emperor Franz Joseph and Empress Elisabeth (Sissi). Following serious damage sustained during the Second World War, the building was reopened on November 5, 1955 with a performance of Beethoven's opera "Fidelio".

"The sound system that had been in continuous use at the Vienna State Opera for over 20 years could no longer keep up with the sound standards set by modern systems. Our situation involves typical audio signals such as opera vocals, acoustic instruments, a choir, an organ, and incidental music," explains Athanasios Rovakis, who is in charge of sound and video at the Vienna State Opera.

The choice of speakers was primarily determined by artistic requirements, such as organically embedding vocal and instrumental soloists or the choir in a given original sound from the orchestra. The speakers also needed to produce a certain sense of direction and distance for these sounds, as well as a certain sound character in general. "Today's systems, with their modelable coverage, can be used and tuned very differently than they were just a few years ago. This is particularly important in situations involving a lot of room acoustics, as is the case in this theater," explains Rovakis. "Due to its unique architecture, the Vienna State Opera house has very lively acoustics and there are sometimes long distances and different types of directivity to deal with. The auditory impression in the stalls is different from the one in the gallery, for example.

Collectively, voices can be heard better further back in the "Stehparterre", a standing section of the hall, while the upper tiers receive a more balanced sound. The auditorium can accommodate almost 2,700 visitors, most of whom sit in the upper two tiers, so of course we have to take that into account when it comes to the sound system," explains Rovakis.

After several years of careful planning, the rebuild of the entire audio system was completed in November 2020. Tino Pfeifer, senior project engineer at Salzgeber GmbH – a specialist company with many years of experience in planning and implementing entertainment solutions – was involved from the very beginning. He planned and developed the monitored power supply, the amplifier monitoring, and the connection between the amplifiers and additional signals.

"I decided to go with an L-Acoustics speaker system – specifically, the ARCS W/F series sounded particularly good for the applications in this space. All the other integration steps then had to be based on the selected system, or be compatible with it," reports Athanasios Rovakis. The head sound engineer wanted a diagnostic

Group photo on the grand staircase of the Vienna State Opera, which has also been preserved in its original condition. (from left to right) Balazs Bezeczky, sales engineer at Beckhoff Automation Austria; David Salzgeber, managing director of Salzgeber GmbH; Tino Pfeifer, senior project engineer at Salzgeber GmbH; Athanasios Rovakis, head sound engineer at the Vienna State Opera; Michel Matuschke, manager for the entertainment industry at Beckhoff.

option based on collected and analyzed audio and power amplifier data. "This is a function that we had previously found to be very time-consuming to implement in an analog form, and which we definitely wanted to see brought up to date," explains Rovakis. "With the variety of audio channels we have to manage here, it's important that we can clearly see if a signal is actually getting to where it was intended for. We also have remote control abilities – for example, muting via physical hardware pushbuttons, which are also integrated into the automation of the audio mixing console." Other requirements were energy monitoring and fault diagnostics for the audio devices, as well as visualization of the audio system.

The next step was to find a solution that could combine these functions with the selected audio system. This is where Beckhoff came into play as a control equipment supplier. Since the audio devices from L-Acoustics can communicate with the control system via an SNMP (Simple Network Management Protocol V1.0) interface, Christian Henke from Beckhoff Austria worked closely with Salzgeber to develop a matching communication function block for TwinCAT 3.1. "Our TCP/IP server (TF6310) makes it possible to control an unlimited number of devices and functions. This is a unique selling point in the industry. And the

response times that we offer are even faster than was required," comments Michel Matuschke, market manager for the entertainment industry at Beckhoff.

Energy metering for the audio system

Since the 1950s, the Vienna State Opera's sound technology has been repeatedly added to and, in some cases, replaced. "This means that layer after layer was laid on top of each other, and that gave us a rather confusing system of cables and individual components to deal with in the sound control room," explains Athanasios Rovakis. "With the help of Tino Pfeifer from Salzgeber, we completely redesigned the sound control room in a highly modular way, which hopefully means that we won't have to make any more fundamental changes to it in the next 25 years," he explains.

The power distribution in the control room, the point from which all the audio and video equipment is controlled, now consists of only three types of cable for incoming circuits, outgoing circuits, and the network. "The ultra-compact C6015 Beckhoff Industrial PC with an EK1100 EtherCAT Coupler and matching Bus Terminals is used for power distribution; it handles the process of switching the power supply on and off, and performs diagnostics on the fuses," explains Tino Pfeifer.

Instead of hard-wired devices, Salzgeber designed a flexible system consisting of eighteen 19-inch rack elements. Using the individual racks, all loads and each socket can now be assigned to groups, switched, and have their energy status read in. This configuration was created with the aim of switching interrelated functional units together flexibly and independently of their location. The modular bus design even allows entire racks to be separated and moved out of the room for servicing. "With such a vast number of performances and rehearsals to deal with, each with different technical requirements, this really helps us keep track of everything," says Athanasios Rovakis. "We have duplicates of every critical component in case something breaks. We analyze the three phases of the mains supply, which are equipped with their own residual-current device or circuit breaker. We can dynamically switch devices via six remotely controlled and monitored ports, which are in the form of socket arrays."

All the racks are based on the same structure, which includes a BK9100 Ethernet Bus Coupler with two KL3403 3-phase power measurement terminals, six current transformers, two KM2614 four-way relay terminals with 16 A wired to break contacts, and a KL1809 for monitoring the ground fault circuit interrupter switches. "In total, more than 100 switching channels as well as a wide range of monitoring options are available," explains Tino Pfeifer. The

Left: To enable the amplifiers from L-Acoustics to communicate with the conwtrol system, Christian Henke from Beckhoff Austria worked closely with Salzgeber to develop a matching communication function block for TwinCAT 3.1.

Right: One of a total of eighteen decentralized 19-inch racks for energy metering. Elements can be operated via pushbuttons (on one of the two central keypads at the bottom of the picture) or on the screen. When a new device is installed in the rack, individual sockets or groups can be assigned via the HMI.

Head Sound Engineer Athanasios Rovakis in the sound control room. He and his team of seven colleagues are responsible for everything involving sound engineering (including sound and image media productions, the sound in the auditorium, and monitor engineering for the performers on stage). They are also in charge of the video and image projections on the stage and handle the Vienna State Opera's Live at Home streaming.

A pleasant indirect light is created via LED strips. Blue indicates that the amplifiers are muted. Red and dimmed ambient lighting in the fully automated control room is an "on-air" signal.

power measurement terminal accurately displays the status of each load. Envelope curve analysis is used to monitor the current consumption of each outgoing circuit, with this data then able to be stored as a reference. The racks can be operated via two central keypads as well as on the PC. "But we can also operate all the functions downstairs from the auditorium – all we need is a network connection," adds Rovakis.

Visualization displays the status of all power amplifiers
The visualization element was implemented on the basis of the TwinCAT HMI server (TF2000) and runs on a C6515 control cabinet Industrial PC. The HMI, used for displaying the status of all audio devices, is made up of approximately 1000 PLC variables on one HMI page, with the variables updated every 50 ms. It includes various windows responsible for power distribution, status monitoring, and audio signals. "The development of the visualization or field of view was one of the most important aspects as far as we were concerned, and one of the main reasons for choosing to work with Beckhoff," states Athanasios Rovakis. "Now we can use the monitor to track where things are happening. When you play an audio signal in a case where the speakers are far away, you receive a

diffuse noise whose origin you can't tell exactly when you're working at the mixer. This is where the 3D arrangement of speaker VU meters in the HMI comes in handy." The audio outputs can be muted individually or all together via physical buttons in the control room, via the audio consoles, and via the HMI. The current operating status of the amplifiers is also illuminated in the control room. A pleasant indirect light is created via LED strips. Blue indicates that speakers are muted. Red and dimmed ambient lighting in the fully automated control room is an "on-air" signal, which heightens the concentration of the operators.

"One major reason for choosing the Beckhoff control system was its openness and the long-term availability of the components. The Bus Terminals enable us to cover every function and we have even gained added value by implementing functions that we had not even considered before," states Athanasios Rovakis.

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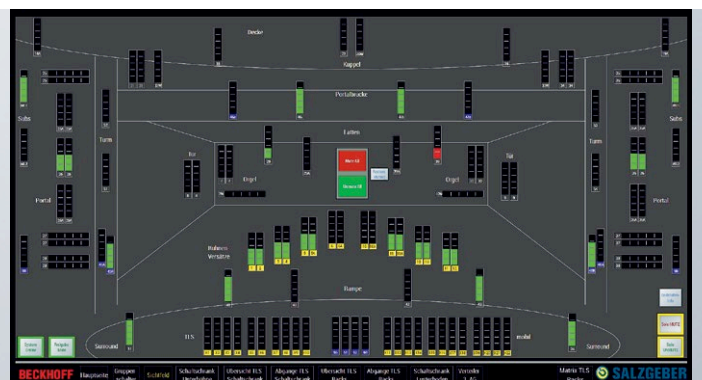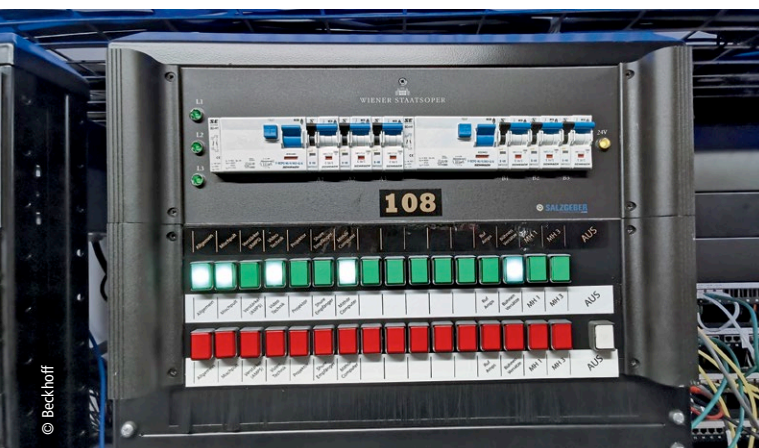
Visualization of the audio device statuses. The HMI is made up of approximately 1000 PLC variables on one page, updated every 50 ms.