Figure 1: The monitoring system for the Pfänder tunnel is a highly complex application integrating a total of 141 tunnel control units and using 45,000 external system data items.

Re-opened Pfänder tunnel features cutting edge supervisory control system based on PROFIBUS DP

Double-Tube Tunnel Opens to Traffic

The construction of a second tube for the Pfänder motorway tunnel in Austria involved a modernization of the supervisory control system for the entire tunnel and the integration with the tunnel control center. This upgrade to state-of-the-art technology was performed by evon GmbH. The requirements included the integration of all field devices into the communication system and the implementation of a redundancy solution. In view of the long distances to be covered in the overall facility and the huge data volumes to be transmitted, evon decided to employ the PROFIBUS DP Master Stack from Softing Industrial Automation.

The Pfänder tunnel is not only one of the most important motorway connections between Germany and Austria, but is also used by many commuters to bypass Bregenz, the capital of the Austrian province of Vorarlberg. The construction of the tunnel with a length of approx. 6.7 km in the 1970s proved very difficult due to the geological conditions of the site, with increased swelling and water seepage potential. For cost reasons, only a single tunnel tube with one traffic lane in each direction was built at that time. Today about 30,000 vehicles, including approx. 5,000 trucks, use the Pfänder tunnel every day, often causing long traffic jams on both sides of the tunnel.

To ensure a smooth traffic flow and to reduce the risk of accidents in the tunnel, the construction of a second tunnel tube was begun in 2006. Following its completion and the termination of the refurbishment works on the existing tube in July 2013, the Pfänder tunnel now offers two lanes in both directions and traffic jams are largely a thing of the past.

All-new supervisory control system with control center integration

As part of the tunnel extension, the Austrian motorway operator Asfinag put an additional project out to tender: Installation of the electrical and mechanical equipment in the new tunnel tube and renewal of the entire technical equipment in the existing tube. This included power supply, lighting, ventilation, and safety equipment as well as the supervisory control system. The contract for the implementation was awarded to Dürr Austria GmbH; the supervisory control system and the integration with the tunnel control center were developed by the Austrian software company evon GmbH. Founded in 2009 as a vendor of automation software and services, evon with a staff of 30 is today specialized in state-of-the-art technologies for traffic engineering, building management systems and the process industry.

It only took evon two years to implement the highly complex supervisory control system in both tunnel tubes and to integrate the Pfänder tunnel into the tunnel control center. As the key component, evon used their XAMControl control system which supports distributed automation solutions. Thanks to its hot standby redundancies at all levels, it meets the requirement for highest availability of the entire system. Based on an open database model for storing historical data, reports, and configurations, XAMControl leverages the latest technologies and standards, such as the .NET software platform from Microsoft, and provides data visualization functionality.

The implementation of the supervisory control project had some special challenges in store for evon. These included, for example, the long distances to be covered in the overall facility, which had a length of about 10 km, as well as the great number of sub-components to be integrated, such as lighting, ventilation, video, energy, hazard alert system, traffic technology, and emergency call system. Interdependencies between the various sub-components and a consistently high network quality through redundant optical rings, separation through virtual LANs as well as continuous monitoring of the network in-

Figure 2: In the tunnel control center, all data and information for monitoring the Pfänder tunnel are consolidated.

frastructure also had to be considered in detail. Moreover, the overall system had to be installed in two separate construction stages: First in the new tunnel tube and then in the refurbished existing tube, with a partly split infrastructure while traffic continued. In addition, XAMControl has to process a very large amount of data in the Pfänder tunnel application: 141 tunnel control units are connected to the network, and the visualization of the tunnel state comprises 200 process diagrams. 45,000 external system data items are used, which need to be reliably processed and managed. Another essential requirement was the integration into the tunnel control center, which is located at the motorway maintenance center in Hohenems. The requirement includes the provision of all acquired data and information, as this is the only way to ensure that on-site operation can be reduced to emergency situations.

Redundant system for highest availability

The connection of the various field devices in the Pfänder tunnel is based on PROFIBUS DP technology with baud rates of 1.5 MBaud and 93.87 kBaud in the fieldbus, respectively. All in all, the various PROFIBUS configurations with their copper or optical fiber cables use 129 PROFIBUS DP slaves whose cycle times are < 20 milliseconds.

The requirement for highest availability and stability of the entire supervisory control system – which is key to ensuring reliable 24/7 tunnel control – had an impact on the design of the PROFIBUS DP network. It was intended to implement a redundancy solution with two PROFIBUS DP Masters, which is able to switch over seamlessly from the active master to a backup master, if needed. This means, in particular, that after the redundancy switchover, each PROFIBUS DP device continues to work and transfer its data without interruption and without requiring reparameterization of the field devices. As master redundancy has not been specified in the PROFIBUS DP standard, evon had to find a way to implement the required functionality.

evon found the ideal solution at Softing Industrial Automation who offered the desired redundancy functionality for Softing's own PROFIBUS DP Master. This way, all that was left for evon to do was to integrate the new functionality into the XAMControl supervisory control system. For this, a sample program was provided by Softing, which served as the basis for the desired extension of the state machine in the PROFIBUS DP Master driver of the XAMControl system. Using this extension, it was possible to create a redundancy solution with a XAMControl station as the active master and a second XAMControl station as the backup master. The two PROFIBUS DP Masters in this redundancy solution are interconnected via a redundant connection, i.e. an Ethernet connection for the continuous exchange of the current process image and system states. The backup master also uses the redundant connection to monitor the availability of the active master (see Figure 1). A switchover of the active role occurs if the backup master receives better quality PROFIBUS signals than the active master.

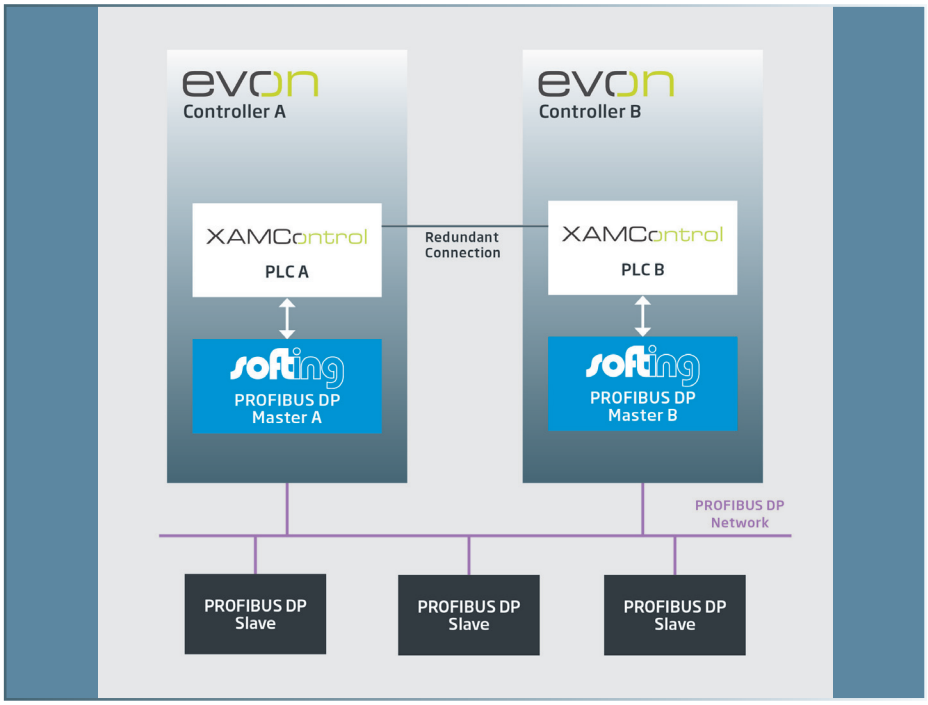

Figure 3: For the implementation of a redundancy solution, the active PROFIBUS DP Master and the backup master are coupled using a redundant connection. The redundancy application ensures the exchange of status information and the active master switchover in case of a failure.

Continuous data exchange instead of reparameterization

Using two PROFIBUS DP Masters and switching between the active and the backup master alone does not provide the required redundancy functionality yet. It is also necessary to include all field devices in such a way that switching over to the other PROFIBUS DP Master will not result in a default restart of the PROFIBUS DP slaves. This behavior can only be achieved if the backup master adopts the bus address of the previously active master, and thus seamlessly continues the cyclic data exchange after the switchover. If the peripheral devices had to be reparameterized first – as defined by the PROFIBUS DP standard – monitoring gaps and temporarily incorrect initial values would occur, which may cause malfunctions in the supervisory control system.

The PROFIBUS DP Master available from Softing, as well as the Softing PCI interface card employed in the XAMControl supervisory control system support the required redundancy functionality. The backup master fully initializes itself without becoming active in the PROFIBUS DP network. It receives the current process image in regular intervals from the PROFIBUS DP Master via the redundant connection, allowing for a seamless switchover at any time. To ensure the redundancy functionality, it is also necessary to analyze the state of the backup master to find out whether its bus interface is still operational. For this purpose, the backup master initially uses a different bus address than the active PROFIBUS DP Master so that the two masters can exchange special test frames based on PROFIBUS FDL. This process not only checks the local bus connection, but also the PROFIBUS segment between the two masters. The backup master only adopts the bus address from the active master when a redundancy switchover occurs. A special function then allows the backup master to take over the preset master parameterization and to immediately start the data exchange based on the current process image held by the backup master. This ensures that the field devices connected to the PROFIBUS DP network remain unaware of the switchover. The use of Softing's PCI interface card in the Pfänder tunnel application additionally required API support to enable the integration of the PROFIBUS DP Master functionality into XAMControl. This API was also provided by Softing in close cooperation with evon.

As a result, the PROFIBUS DP interface card from Softing was successfully integrated into XAMControl and the requirements placed on the Pfänder tunnel supervisory control system and the integration with the tunnel control center were completely fulfilled. Gerald Ebner, the responsible evon developer, is satisfied with the cooperation with Softing: "We decided to adopt Softing's solution because this company has a long-standing PROFIBUS experience and offers a suitable redundancy solution. Moreover, the PROFIBUS DP Master stack could be integrated directly with XAMControl through an interface. During the implementation phase, we received excellent support from Softing and all our questions were answered speedily and in a straightforward manner, always providing suitable solutions." For Andreas Leitner, Managing Director at evon GmbH, the possibility to also apply this solution to other projects is equally important: "We've been able to seamlessly implement the interface from our Pfänder tunnel application into other projects without a need for modifications. For example, these projects can access PROFIBUS via small compact controllers, PC interface cards, or also via PROFIBUS remote interfaces in the Ethernet network. This way, we are well prepared for the future."

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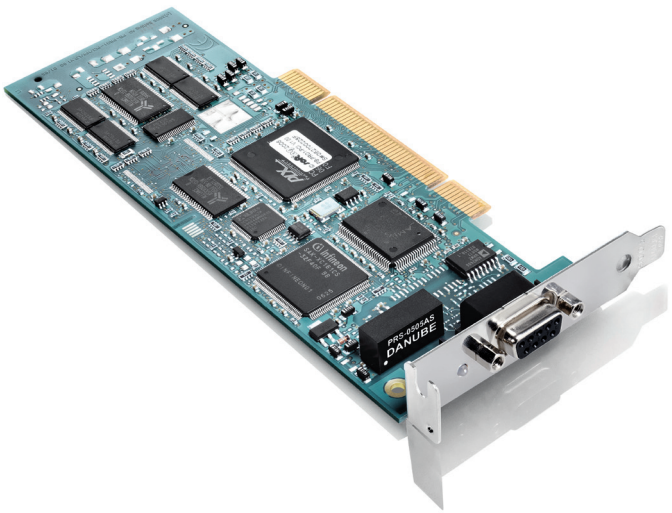

Figure 4: Softing's PROFIBUS DP interface card