# TELEPERM® XS

## System Overview

### Overview

<table>
<thead>
<tr>
<th>I&amp;C solutions based on TELEPERM® XS</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety I&amp;C systems</td>
<td>6</td>
</tr>
<tr>
<td>Comprehensive I&amp;C based on SPPA-T2000 and TELEPERM® XS</td>
<td>8</td>
</tr>
<tr>
<td>Control of safety-related auxiliary and ancillary systems</td>
<td>9</td>
</tr>
<tr>
<td>Nuclear instrumentation</td>
<td>10</td>
</tr>
<tr>
<td>Turbine I&amp;C</td>
<td>11</td>
</tr>
</tbody>
</table>

### System design and mode of operation

<table>
<thead>
<tr>
<th>System design and mode of operation</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computers</td>
<td>12</td>
</tr>
<tr>
<td>Input/output modules</td>
<td>13</td>
</tr>
<tr>
<td>Communication</td>
<td>13</td>
</tr>
<tr>
<td>Gateway interface to the process computer</td>
<td>14</td>
</tr>
<tr>
<td>Interfaces to the field</td>
<td>15</td>
</tr>
<tr>
<td>Standard packaging system</td>
<td>16</td>
</tr>
<tr>
<td>Installation in third-party cabinets</td>
<td>17</td>
</tr>
<tr>
<td>Subracks</td>
<td>17</td>
</tr>
<tr>
<td>Operation and monitoring in compact systems</td>
<td>18</td>
</tr>
<tr>
<td>The TELEPERM® XS Qualified Display System (TXS-QDS)</td>
<td>19</td>
</tr>
</tbody>
</table>

### Engineering, testing and documentation

<table>
<thead>
<tr>
<th>Engineering, testing and documentation</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project management</td>
<td>20</td>
</tr>
<tr>
<td>Engineering</td>
<td>21</td>
</tr>
<tr>
<td>Simulation and testing</td>
<td>22</td>
</tr>
<tr>
<td>Documentation</td>
<td>24</td>
</tr>
</tbody>
</table>

### Safety features and architectures

<table>
<thead>
<tr>
<th>Safety features and architectures</th>
<th>26</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architectures</td>
<td>26</td>
</tr>
<tr>
<td>Self-monitoring</td>
<td>27</td>
</tr>
<tr>
<td>Deterministic system behavior</td>
<td>28</td>
</tr>
<tr>
<td>Diversity and handling of common-cause failures</td>
<td>28</td>
</tr>
<tr>
<td>Additional measures using equipment diversity</td>
<td>29</td>
</tr>
<tr>
<td>System security</td>
<td>29</td>
</tr>
</tbody>
</table>
Qualification
- Qualification Concept 30
- Hardware qualification 31
- Software qualification 32
- Plant-independent integration and system test 33
- Two-stage licensing 34
- Keeping system qualification up-to-date in the long term 35

Operation
- Virtually no maintenance 36
- Extended test intervals 37
- Troubleshooting 38
- The service unit 39
- User interfaces of the service unit 40
- The diagnostics interface 41

Long-term support for TELEPERM® XS
- Long-sighted replacement strategy for components 42
- Configuration management and change procedure 44
- Support and information 45

Hard- and Software
- Computer and communication components 46
- Input/output modules 46
- Signal conditioning 47
- Neutron flux instrumentation modules 47
- Signal logic, isolation and output modules 48
- Subracks, packaging system, test equipment 49
- Software packages 49

System data
- Supply voltage 50
- Climate 50
- Seismic certifications 50
- Grounding and shielding 50
- Performance data 50
- Standard cabinet SC 9422 50
- Wall-mounted enclosure SWE 12 50
TELEPERM® XS is AREVA’s I&C system platform for safety I&C in the nuclear power plant. It comprises all the necessary hardware and software components, including the software tools required for engineering, testing and commissioning, operation and troubleshooting.

TELEPERM® XS is suitable for new plants as well as for the upgrading and modernization of existing nuclear power plants of virtually all types and from all main suppliers.

The first TELEPERM® XS systems were put into operation more than ten years ago and have been working very reliably ever since. More systems and new applications are implemented each year, and have promoted AREVA to market leader in the field of digital safety I&C.

This success confirms the future-orientation of the design principles. Building on this sound basis, TELEPERM® XS is subject to continuing development. The experience gained during engineering, installation and operation guides our development towards optimum fulfillment of customer requirements.

This brochure provides an overview of TELEPERM® XS focusing on:

- I&C solutions and applications
- System design and mode of operation
- Engineering and documentation
- Safety concept and architectures
- Qualification
- Operation
- Long-term support

It also provides information about system data, and the hardware and software components of the system platform.
TELEPERM® XS is used for implementing various types of I&C systems in the nuclear power plant. The main applications are:

- Reactor protection system/ESFAS
- Reactor control and reactor limitation systems
- Neutron flux measurement
- Core monitoring
- Rod position monitoring
- Emergency diesel generator control

AREVA knows the requirements of each of these applications and can offer you the optimum architecture for your plant.

**Safety I&C systems**

Typical applications are in the areas of reactor protection systems and ESFAS (Engineered Safety Features Actuation System). These place the most stringent demands on system reliability, fault prevention and fault control.

**TELEPERM® XS fulfills these demands by means of:**

- The ability to implement structures with high levels of redundancy in accordance with plant requirements
- High software and manufacturing quality
- Early detection of faults due to extensive self-monitoring
- Isolation of redundant subsystems through use of fiber-optic cables
- Prevention of fault propagation by means of intelligent signal status processing
- Systematic handling of priorities between systems of different safety classes

The safety-related features of TELEPERM® XS are qualified according to the highest safety standards.

The redundancy structures are determined by the safety concept of the plant covering a wide variety of combinations like:

- Single failure
- Single failure combined with maintenance/repair
- Failures caused by fire or other internal hazards
- Common-cause considerations.

The system architecture also pays attention to other basic conditions, such as the availability of separate rooms, cable routes and installation space for backfits.
Modernization of the supplementary reactor protection system in the German nuclear power plant Philippsburg 1 based on two independent 3-channel systems

A small number of examples can verify the flexibility of TELEPERM® XS:

- The reactor protection system of the Westinghouse PWRs Beznau 1 and 2 (Switzerland) was modernized using a 4-channel TELEPERM® XS system.
- A three-channel reactor protection system was installed in the VVER440 plants Paks 1–4 (Hungary).
- The supplementary reactor protection system in the German boiling water reactor Philippsburg 1 was modernized with a 2 x 2-out-of-3 structure using TELEPERM® XS.

Redundant structures are also an essential feature for reactor control systems and multi-channel reactor limitation systems as featured particularly in German nuclear power plants. 4-fold redundant systems are used here as well.
Comprehensive I&C based on SPPA-T2000® and TELEPERM® XS

In conjunction with SPPA-T2000®, TELEPERM® XS supports the configuration of an integrated overall plant architecture.

TELEPERM® XS was developed and qualified for applications in the field of safety I&C of the highest category (see “Note” on page 9). The scope of modernization projects frequently includes lower classified and non-safety functions which can then also be implemented cost-effectively with a minimum number of interfaces using TELEPERM® XS.

However, the SPPA-T2000® from Siemens Energy is the preferred system platform used for the operational I&C of new plants and for comprehensive modernization projects, e.g., in VVER plants Tianwan 1 and 2 in China, the Munich FRM-II research reactor, and the EPR projects Olkiluoto 3 in Finland, Flamanville 3 in France and Taishan in China.

TELEPERM® XS handles safety-related automation tasks from signal acquisition and distribution through to drive control interface and priority functions.

SPPA-T2000 covers all operational automation applications of nuclear power plant processes such as the control of auxiliary systems, complex open and closed-loop controls, operation and monitoring of the overall plant in a VDU-based control room.

SPPA-T2000 is connected to the drive control interface and priority modules of TELEPERM® XS via PROFIBUS DP. The PROFIBUS link also implements the isolation between the two systems.

* Previous name: TELEPERM® XP
Control
of safety-related auxiliary and ancillary systems

Controls for emergency diesel generators gate reactor protection actuation signals with safety-related protection interlocks. They also assume the actuation of a large number of auxiliary systems with operational functions.

This function package can be implemented as a compact solution in one TELEPERM® XS cabinet with an integrated local control station.

Similar compact solutions are possible for the actuation of other subsystems, such as the control of safety-related ventilation systems or the control of backfitted residual heat removal or emergency feedwater systems.

An example of functions of this kind is the Keowee hydroelectric power plant used for the emergency power supply at Oconee nuclear power (USA). Here too, a compact TELEPERM® XS system reliably handles the open and closed-loop controls.

Note:
- “Safety I&C” is a generic term comprising I&C systems important to safety of categories A, B and C as defined in IEC 61226.
- Typically, non-safety functions are implemented using a dedicated I&C system platform. This also may extend to functions of categories C and B.
- Several terms are used for these functions according to national practice like “standard I&C”, “plant control system”, “non-safety I&C” or – as in this brochure – “operational I&C”.

The Keowee hydroelectric power plant controlled by means of TELEPERM® XS is used for the generation of emergency power for the Oconee nuclear power plant.
Many of the state variables in reactors are measured by means of sensors and transducers which output standard 0/4–20mA signals. In addition to the standard modules used for acquiring these signals TELEPERM® XS also provides modules for the conditioning of special signals from the nuclear instrumentation.

The most important applications include:

- Excore neutron flux measurement, comprising source, intermediate and power range channels
- Incore neutron flux measurement for determining reactor power and power density distribution
- Inductive measurement of rod positions in a pressurized water reactor

The associated conditioning modules form part of the TELEPERM® XS system platform. They are subject to long-term maintenance in conjunction with the system platform and are optimally configured for use with the other TELEPERM® XS hardware and software components.
Turbine I&C

Teleperm XS suits a wide range of structural requirements and features extremely powerful computer and communication components. These properties can also be used for non-safety applications in which high levels of reliability and performance or short response times are especially important.

The turbine controller based on Teleperm XS ensures levels of control quality unattained before thanks to innovative algorithms. Due to its capability of implementing multi-channel structures in an extremely compact design, Teleperm XS also meets the requirements of the turbine protection system.

Increase in control quality thanks to new Teleperm XS turbine controller: Load rejection to house load and frequency regulation service before and after

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Increase in control quality thanks to new Teleperm XS turbine controller: Load rejection to house load and frequency regulation service before and after

Teleperm XS
Computers

Typical TELEPERM® XS systems consist of distributed (stand-alone) computers which handle tasks such as:

- Acquisition of process signals
- Signal conditioning, filtering and processing
- Actuation of final control elements
- Annunciation of process conditions and faults

The individual computers communicate via serial buses. Each of these computers consists of a selection of input/output modules, communication modules and processing modules which is determined by the number of communication links to be operated and the required processing power.

The core of each computer is the processing module, a module with a 32-bit processor. The automation program is loaded from a FLASH memory and is executed cyclically. This involves:

- Control of input/output modules
- Processing of the automation program and selftest routines
- Data exchange with the help of communication modules and bus connections

Input/output modules

The entire spectrum of standard signals can be acquired directly by the TELEPERM® XS input/output modules (see section “Hardware and software” for an overview).

The modules are based on microcontrollers whose firmware is executed on a strictly cyclic basis. The firmware performs the actual input/output functions and also tests the input/output channels and the connection to the processing module. This extremely high level of self-testing extends the cycle of additional periodic tests to several years.
Communication

In addition to the TXS backplane bus used for communication within in the subrack, TELEPERM® XS features two serial bus systems. These are based on standardized ISO/OSI layer 2 protocols and use TELEPERM® XS-specific protocols for the application layer.

1. TXS Profibus (L2) is based on the PROFIBUS standard EN 50170 with a master-master FDL protocol (Field Data Link) for ISO/OSI layer 2. TXS Profibus is operated at 12 Mbit/s. Connections are implemented as electrical two-wire connections using piggyback modules for the SVEx processing module and electrical/optical interface modules.

2. TXS Ethernet (H1) is based on the standard Ethernet in accordance with IEEE 802.3 and uses the LLC (Logical Link Control) protocol on layer 2.

The hardware used comprises communication processors, transceivers and switches which act as media converters between electrical and optical segments and as network nodes.

Whereas TXS Profibus is used for data exchange between the individual computers of a TELEPERM® XS system, TXS Ethernet is primarily used for the connection of external computers with standard Ethernet interfaces, such as gateways, the TELEPERM® XS service unit and the TELEPERM® XS Qualified Display System (QDS).

All the connections between cabinets, in particular those to independent subsystems, are implemented by means of fiber-optic cables. This ensures galvanic isolation and overvoltage protection and rules out electromagnetic interference.
Instead of hardwired connections, a gateway is used as the interface to the operational I&C or the process computer. It is implemented on industrial PC hardware. Unidirectional solutions may be provided as well as bidirectional ones, depending on the requirements. The standardized, widely used Modbus protocol is used as the reference solution.

With smaller systems, however, it may be more economical to extract analog and binary signals from the TELEPERM® XS system and to read them back in via the existing data acquisition equipment of the process computer.
Interfaces to the field

Signal acquisition and conditioning

Standard 0/4–20 mA field signals are acquired via the TELEPERM® XS signal conditioning modules. They can be distributed to lower-classified I&C systems with the aid of isolation amplifiers as decoupling devices.

A gateway solution is also possible as an alternative.

Drive control and priority management

With many switchgear systems, protection and monitoring functions are integrated directly in the switchgear unit. In this case, only a limited scope of drive control functions are implemented in TELEPERM® XS. The switchgear unit is connected directly and the required monitoring and actuation functions are executed on the TELEPERM® XS computer.

In other cases a separate drive control interface level is necessary. Where final control elements are used by both the operational I&C and the safety I&C, the priorities assigned to the individual commands must be managed.

The TELEPERM® XS system platform features special drive control and priority modules for this purpose.
Standard packaging system

I&C cabinets of the type SC 9422 (2200 x 900 x 400 mm), degree of protection IP30, are usually used for the configuration of TELEPERM® XS systems. The cabinet features cable clamps with a shield bus, infeed terminals and fault annunciation equipment.

The cabinet is designed to provide earthquake resistance. The cables and power supply are generally fed in from below. The subracks are installed in the middle section of the standard cabinet. To the right and left of these is space for the installation of terminal blocks and transceivers.

Various types of terminals are used for connecting peripheral cables. Other connection methods, such as Maxi-Termi-Point, are also possible. Field cables must be shielded twisted core pairs. Buses are implemented using electrical connections inside the cabinet and fiber-optic cables outside the cabinet. TELEPERM® XS can be used in plants with large-area grounding as well as in plants with a central grounding point.
Installation in third-party cabinets

Certain basic plant conditions may necessitate other arrangements. This is often the case with backfitting and modernization projects. Individual subracks can be installed in frames, for example, which are then fitted in existing cabinets as complete mounting units. Here the terminal blocks of the old cabinet often continue to be used and the cabling can also be retained.

TELEPERM® XS subracks are qualified as stand-alone units so as to minimize the associated planning risks. Only a very limited amount of special qualification documentation is required if subracks are installed in third-party cabinet systems.

Subracks

Various configurations of subracks are available. The basic version for one computer features a continuous backplane bus with 21 slots.

Expansion subracks can be connected to provide more slots for input or output modules when large quantities of signals are to be acquired.

Other variants are for instance:

- Partitioned subracks for two smaller independent computers (each with 10 slots and own fan unit and power supply)
- Hybrid configurations, such as the compact combination of a computer with the associated signal conditioning module

Configurations may also consist of solely passive modules. This may be applied for backfitting of individual limit values in an analog reactor protection system, for small stand-alone control systems or other special requirements.
Operation and monitoring in compact systems

An operator interface often needs to be implemented as a local control station. A computer integrated in the TELEPERM® XS cabinet provides an economical and compact human-machine interface here. A panel PC handles the gateway function to the TELEPERM® XS computer, the data management for logs and trend curves, and controls the touch screen.

This ergonomic solution combines monitoring, operation, testing and fault diagnostics. The WinCC software package from Siemens is generally used for this purpose as it permits simple adaptation to a wide range of applications. Solutions not only include the display of process variables, they also support manual control of plant systems via TELEPERM® XS.
The TELEPERM® XS Qualified Display System (TXS-QDS)

For post-accident monitoring systems, documented qualification in accordance with nuclear codes and standards is of primary importance for the indication equipment, too. The TELEPERM® XS Qualified Display System uses powerful, qualified VDUs and display computers and a software package developed and tested by AREVA.

It clearly represents the process information in task-oriented displays tailored for the specific application. Post accident recording is also performed by this system, paperless for up to 72 hours.

QDS displays are created using a graphics editor. They can be tested in simulation mode already on the design workstation.

Typical architecture using QDS for VDU-based display and operation.
Project management

Safety I&C projects are implemented in time-staggered phases.

In the **requirement specification** and **system specification** phases, the safety engineering concept is agreed upon, the I&C system architecture and the standard circuits are defined, and the process engineering tasks are fixed. Systematic procedures and the use of database-assisted tools ensure high quality.

The specific experience and requirements of the operating staff are also taken into account here. An important result of this step is the assessment documentation required by the licensing authority for review and approval, as well as the specifications for continuous quality assurance.

In the **detailed design** phase, the hardware is specified in detail, the manufacturing documents are created, and **procurement and manufacturing** are initiated. At the same time, the application software is engineered using the SPACE* tool suite and is already subjected to intensive testing with the help of simulation during this early phase. Detailed analyses required for the licensing procedure are prepared. The strict configuration management and the change procedure start at this phase at the latest.

Hardware and software are **integrated** in the test bay prior to delivery. The interaction between the hardware and the pretested application software is checked in detail using test bay simulators.

This procedure complies with all relevant safety I&C engineering standards and forms the basis for all projects. Adaptations are made for country and customer-specific requirements, the licensing procedure and for the schedule situation in each case.

A phase model of this kind ensures that errors and needs for changing the specification are identified early, and makes a major contribution to the avoidance of pitfalls. This guarantees a high level of quality for the supplied systems.

* SPACE: Specification and coding environment

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*Standard project management process for safety I&C*
An essential element for the fast and error-free engineering of TELEPERM® XS I&C systems is integrated tool support.

The basic principle is simple. The main work steps are performed using the SPACE editor:

- Function diagrams are created which specify the I&C functions in the form of connections between parameterizable function blocks.
- The system structure is defined graphically in terms of computers, communication links and input/output modules, and is specified in network diagrams.
- The allocation of software functions to hardware components is performed by assigning function diagrams to processing modules and by assigning signal codes to the channels of input/output modules.

This hardware and software definition is stored in a project database. The use of a database permits the efficient execution of subsequent work steps, such as:

- Automated consistency checks
- Calculation of computer and network loading with the help of special analyzers
- Generation of documents and lists for interface handling, cabinet design and test specifications.

This project database also acts as input for the code generator, which generates the application-specific code in accordance with simple structured rules. This code is subsequently compiled and linked for the I&C system.

In addition to the actual engineering of an I&C system, the project database also supports simple and standardized connection of test, parameterization and diagnostic equipment during implementation and operation.
Connection of field cables to the ERBUS TXS test machine
Simulation and testing

The SIVAT software package allows the engineered I&C functionality to be tested by simulation. SIVAT uses the TELEPERM® XS code generator for generating simulation-capable code from the engineering data stored in the project database.

The objective is to prove that the functional requirements laid down by the process engineers have been translated into function diagrams without errors, and that these function diagrams provide the functionality required in terms of input and output response. Process models can also be linked into the simulator to perform closed-loop tests.

Running pre-programmed test scripts ensures that simulation runs are traceable and repeatable. All test results are recorded in log files and plots for further evaluation.

Simulation tests with SIVAT have shown to be an indispensable advantage when systems already in operation in the power plant need to be modified, e.g. due to operational optimizations. In this case, simulation results prior to and after modification can be compared to verify that no inadvertent changes have been introduced to the I&C functions.

ERBUS TXS is the system for integration tests in the test bay. Like SIVAT, it accesses the project database and permits efficient test preparation and execution. Equipped with very accurate input and output modules for the simulation of plant interfaces, it serves for input/ output testing and function testing of the entire I&C system. The number of I/O channels on the ERBUS TXS test machine can be adapted to the requirements of the application. ERBUS TXS can also be used for periodic testing in connection with the service unit.
Engineering, testing and documentation

**Documentation**

The system documentation forms the basis for licensing and acceptance as well as for efficient operation, long-term maintenance and support. It determines and describes the technical solution, forms the basis for cabinet manufacturing, records tests, installation and commissioning.

The documentation is prepared concurrently with system development and project execution and is used by our engineers themselves during subsequent phases. This ensures consistency, completeness and correctness. Our experience with I&C projects of all scales is also reflected in the quality of the documentation. This ensures straightforward licensing, enables efficient implementation and minimizes errors and eases operation and service.
Integrated documentation forms the basis for system implementation, testing, qualification and long-term operation.

AREVA

- Has successfully implemented a large number of projects of all scales to schedule
- Reliably calculates the time required for the individual phases
- Supplies the documents required for licensing
Maximum safety requirements are imposed on reactor protection systems. A wide range of fault and failure combinations determined by the safety concept of the plant must be covered. Typical examples include single failure and maintenance, single failure and fire, or external events, such as aircraft crash and earthquake. This results in a redundant system design with physically separated, electrically isolated and independent subsystems.

Separation between the acquisition and actuation levels is common to both the reactor protection system and the limitation systems. TELEPERM® XS acquisition computers read in the sensor signals and make them available in all the redundant trains. This helps to avoid spurious tripping in the event of failure of one or more sensors.

Architecture and circuit variants with special failure characteristics available as standard for TELEPERM® XS include:

- Master-checker configuration with processing modules connected in parallel which monitor each other
- Voter configurations with redundant masterchecker pairs (2 x (2-out-of-2))
- Hot standby computer pairs with automatic switchover in the event of a fault

The independence of redundant subsystems is achieved by the use of fiber-optic cables for bus connections and by means of software measures. All incoming messages are checked for readability, valid identification and data validity. Only valid information is used in subsequent processing steps. A validated signal is extracted from redundant signals in majority voting logic (e.g., 2-out-of-4), or a substitute value is input if necessary. This ensures that response will be as specified even in the event of major fault situations.
Self-monitoring

The standard mechanisms include:
- Cyclic testing of program memories
- Permanent communication monitoring
- Monitoring of cycle time by means of software and a hardware watchdog
- Automatic testing of the watchdog
- Self-testing of the inputs of input modules
- Automatic readback of the outputs of output modules.

If faults are detected, the outputs are brought into a safe state

The engineered monitoring functions comprise mechanisms like:
- Synchronism monitoring of redundant sensors
- Measuring range monitoring
- Readback and comparison of relay contact status for relay actuations
- Travel time monitoring for actuators

TELEPERM® XS features a large number of standard self-monitoring mechanisms, some of which form part of the system platform and some of which are configured by means of application-specific engineering.
Safety features and architectures

Deterministic system behavior

The high reliability of the hardware components is supported by design measures in the software which ensure deterministic system behavior. These are easy to understand and form a sound basis for system qualification.

The most important of these features include:

- Strictly cyclic processing of application software
- Bus systems with a constant load
- Complete absence of process-driven interrupts
- Static memory allocation
- No processing of absolute time or date
- No long-term data storage and no use of external data storage media

Diversity and handling of common-cause failures

In addition to random failures and internal/external events, the common-cause failure must also be taken into consideration in the design of safety systems. “Functional diversity” is a preferred measure, especially in connection with postulated design errors.

This involves dividing the I&C system into independent subsystems which, although equipped with the same hardware and system software, execute different I&C functions for handling one and the same event. It is assumed that the same hidden fault will not take effect simultaneously in two different functions at the same time, causing both of them to fail simultaneously.

For functional diversity, different trip criteria for protection functions are selected for each accident and assigned to independent subsystems.
Additional measures using equipment diversity

Depending on the plant design, equipment diversity may be a supplementary measure for risk mitigation. Despite similar engineering principles, the hardware and software of TELEPERM® XS and SPPA-T2000 exhibit equipment diversity. An obvious solution for plants with both system platforms would therefore be to implement the ATWS* system or additional diverse measures in SPPA-T2000 technology.

In case of more extreme failure postulates for software based systems, the TELEPERM® XS modules for signal conditioning and stand-alone signal processing may be used. Together with the analog processing module SPAM1 and the logic module SPLM1 they constitute a sub-family of TELEPERM® XS, supporting the implementation of analog and binary circuits without using computers.

The degree of self-monitoring known from the computerized modules is not available. However, they support efficient small-scale solutions.

System security

“Protection against unauthorized access” is also essential for plant safety. The most important of these protection measures include:

The most important of these protection measures include:

- The engineering computer and the service unit are installed in the secured area and protected against unauthorized access.
- Access is controlled by administrative and technical means.
- The loading of software and parameter changes is only possible in accordance with clearly defined procedures.
- Changes are only possible in one train at a time, and this must be released especially for this purpose.

The monitoring and service interface computers (MSI) of the safety I&C act as a data processing barrier to protect against unauthorized access via external communication links or the gateway.

* Anticipated Transients Without Scram
The TELEPERM® XS system platform has been specially developed for use in the safety I&C of nuclear power plants. Development and engineering process have been set up to meet the requirements of all relevant international nuclear codes and standards. In order to demonstrate compliance with the relevant international codes and standards, a generic process of independent assessment was implemented at the beginning.

**Qualification Concept**

In an early step, the German “Gesellschaft für Reaktorsicherheit” GRS certified the suitability of the design principles of the system platform for the implementation of I&C systems with maximum safety requirements in nuclear power plants.

The generic qualification of TELEPERM® XS has been performed as a set of type tests of its hardware and software components, considering the international standards. In addition, the most important functional properties of the system platform were demonstrated in a plant-independent integration test.

The comprehensive qualification of the components and functions of the system platform combined with excellent operating experience reduce the costs and risks for the application-specific licensing procedure to a minimum.

The platform qualification activities will go on in the course of continuing development and long-term system support, thus ensuring the high standard of qualification of our safety I&C in the long term.
Hardware qualification

The hardware components of TELEPERM® XS are designed for installation and operation in air-conditioned electronic equipment rooms. For hardware qualification a blanket approach was taken regarding ambient conditions covering the requirements of international standards (IEC), selected national standards (KTA, IEEE) as well as requirement profiles of I&C tender specifications. See section “System data”.

Qualification comprises a theoretical and a practical part. In the case of TELEPERM® XS, these analyses and all the practical tests of the components were performed or supervised by experts from the German TÜV Nord and TÜV Rheinland technical inspection agencies.

Extensive test reports issued by the TÜV agencies and summarized in certificates attest the positive result of these qualification tests. They can easily be referred to during licensing procedures.

Hardware Qualification Methodology
Based on: IEC 60780; KTA 3501; IEEE 323
Common requirements: EN 61131-2; EN 50178; KTA 3503; EPRI TR-107330

**Theoretical Assessment**
- Agreement on test program
- Critical load analysis
- Failure rate calculations

**Visual Inspection**
IEC 60664; IEC 60529
- Quality of manufacture; creepage distances and clearances
- Class of protection, insulation

**Functional Test**
- Operation in acc. with data sheet under nominal and limit conditions

**Electrical Test**
- Power consumption under nominal/minimum/maximum conditions
- Disturbances in power supply
- Heating, insertion/withdrawal

**Climatic Tests**
IEC 60068-2-xx; EPRI TR 107330
- Cold; dry and damp heat
- Temperature changes
- Long-run test (1000h)

**Mechanical Tests**
IEC 60068-2-yy; IEC 980; IEEE 344
- Oscillating stress (seismic, vibrations)
- Transportational stress
- Shock stress

**Electromagnetic Compatibility**
EN 61000-4, -6; EN 55011; EN 55022; EPRI TR-102323; MIL STD 461, 462
- Emitted interference:
  - Conducted, field
- Immunity to interference:
  - Burst, surge, field, discharge
The most important requirements for safety I&C software are defined in IEC 60880. They form the basis for the TELEPERM® XS safety features described above.

IEC 60880 requires a structured development process with thorough documentation of all design and development steps, as well as verification and validation of the development results in accordance with the phase model. The development of the safety-related software components of TELEPERM® XS accurately adheres to this.
Plant-independent integration and system test

TELEPERM® XS safety I&C systems use the same tested and qualified software components over and over again. All the engineered functions are based on preprogrammed modules which are simply interconnected by an automatic code generator. The engineering data specified on function and network diagrams and stored in the project database are used as input.

No manual programming is therefore neither necessary nor allowed. This ensures that simple code structures are always produced which fulfill the highest test requirements.

And, of course, this approach also ensures that the implemented function is completely documented in graphical form.

The reusable software components, i.e. the function blocks and system software components, have been qualified in a generic and plant-independent way in a manner consistent with German KTA 3503.

Similar to the hardware qualification, software qualification also consists of analytical investigations and practical tests.

The theoretical tests performed by the GRS/ISTec* and TÜV** Nord have proven that:

- The development documentation is consistent from the requirement specification through to the design and implementation documentation.
- All the required tests have been performed and appropriately documented.
- The software complies with the required design principles.

Furthermore, the generated code has been subjected to a tool-based analysis for representative applications and checked for compliance with specifications.

Initial qualification was finished by a plant-independent integration and system test as a supplement to component qualification. This test verified the most important system features based on a representative hardware architecture:

- Deterministic system behavior due to strictly cyclic processing of the software
- Non-retroactive data transfer between redundant systems
- Effectiveness of internal fault propagation barriers
- Tolerance of the overall I&C system to single failures of processors and buses
- Effectiveness of self-monitoring
- Fail safe behaviour
- Suitability of the engineering tools.

With the further development of TELEPERM® XS, every evolution of hard- and software components and their compliance with the overall system platform features is verified, and tests are performed which carry forward the validity of the initial test results.

* ISTec: Institute for Safety Technology, Germany
** TÜV: Technical Inspection Agency, Germany
Two-stage licensing
for TELEPERM® XS

TELEPERM® XS I&C systems are qualified and licensed in two stages:

- Generic qualification of the system platform (components and system features)
- Application-specific design of the architecture and implementation of the concrete I&C system

The main advantage of this approach is that the suitability of the hardware and software components of the system platform for safety-related tasks and the essential aspects of platform integration have already been verified in a generic way and are thus available to all projects as a feature of TELEPERM® XS.

This significantly reduces any licensing risks for the utility. Since the generic qualification documentation is referenced in application-specific licensing, the focus can be placed on I&C system design and implementation. TELEPERM® XS has already been licensed in a large number of countries based on its generic qualification, e.g. in Argentina, Bulgaria, China, Germany, Hungary, Slovakia, Sweden, Switzerland and the U.S. At present, licensing is on the way in France, Finland and the United Kingdom.

Generic qualification in the U.S. was performed in the run-up to the first TELEPERM® XS projects. This relied on the test reports and results of the initial qualification performed in Germany. The American licensing authority Nuclear Regulatory Commission (NRC) confirmed the acceptability of the TELEPERM® XS system platform for safety I&C applications. Licensing requests have been approved on this basis for the modernization of the emergency power control system in Keowee and of the reactor protection system in Oconee.
Keeping system qualification up-to-date in the longterm

Project management and operating experience, coupled with rapid developments in the electronics market, have led to continuing development of the TELEPERM® XS system platform.

The processes and procedures introduced during initial qualification form the basis for all further developments. Whenever changes are implemented, each development step maintains the standard of qualification which has been attained. All future qualification-relevant changes and results of continuing component development will be assessed by independent inspectors, such as TÜV and GRS/ISTec. In this way, safe and reliable operation of TELEPERM® XS I&C systems is ensured over their entire service life.

The established qualification processes and the growing fund of experience are guarantees that future licensing procedures will be straightforward and low risk.
Virtually no maintenance

TELEPERM® XS safety I&C systems require virtually no maintenance and allow a major reduction of service effort compared with predecessor hardwired systems.

TELEPERM® XS hardware components are robust. While conservatively calculated failure rates are already very low, the actually observed rates are even significantly lower.

Only a small number of preventive maintenance tasks are required, such as the inspection of electrolytic capacitors which will be required after about ten years of operation for the first time or the replacement of fans. These simple tasks take next to no time and are possible without an interruption in plant operation.

Theoretically calculated and observed failure rates of hardware components (Status: 2010-06)
Extended test intervals

TELEPERM® XS reduces periodic testing to a minimum:

- The majority of the I&C functions is implemented in software which has been submitted to validation tests, which is not subject to ageing and which cannot change. For this reason no software functionality tests are required, only identity and integrity tests of the loaded software based on the evaluation of checksums.

- Communication equipment, input/output modules and processor hardware are continuously in operation and are checked by extensive self-monitoring functions. No additional tests are required.

- Self-monitoring functions on the TELEPERM® XS computer cover close to 100% of the testing requirements. They have never failed to identify a hardware fault in any plant to date.

- Functions outside the scope of self-monitoring, such as the input circuitry of input/output modules or decoupling diodes, undergo overlapping tests in the course of the periodic testing of sensors and final control elements. The testing frequency is determined by the reliability of the field devices in this case.

- Due to the high level of reliability of system components and the wide scope of the self-monitoring mechanisms, it has been possible to extend the intervals for periodic testing to several years in some cases.
Hardware components are monitored by the mechanisms implemented in TELEPERM® XS and faults are annunciated by means of group alarms in the process computer or via the hardwired alarm annunciation system.

Subsequent troubleshooting is initially performed with the help of the TELEPERM® XS service unit, which identifies faulted hardware components in the entire system. Cabinet fault lamps and fault alarms in the I&C cabinet then locally guide the service staff to the defective components which need to be replaced.
The service unit

The service unit is the universal tool during the operation of a TELEPERM® XS I&C system covering all tasks required for:

- **Fault diagnostics:** Should a fault or failure occur, the affected area will quickly be located with the help of the Service Unit. The monitoring mechanisms specified in function diagrams and the diagnostic messages of the TELEPERM® XS system software are called up and displayed to the maintenance staff.

- **Parameterization:** All the settings to be changed during operation, such as calibration factors or controller settings, are defined in the function diagrams in the form of changeable parameters and can be read out, changed and verified via the service unit.

- **Periodic testing:** The service unit can be used to initiate test steps and to read back test results. An ERBUS test computer can also be integrated into the test configuration to inject test signals.

Software changes which may become necessary due to operational optimizations or process engineering changes in the plant extend beyond the scope of parameterization. The SPACE engineering tools and the SIVAT simulation tool are used in such cases. These tools and the project database are stored on an engineering computer. Following modification, the service unit is used to upload the new software to the online system.

The service unit is perfectly integrated in the TELEPERM® XS system architecture. It is specified in the network diagram and connected to the automation computers via TXS Ethernet. The code generator automatically generates all data and communication structures necessary for integration. As soon as powered up, the service unit has a complete and correct replica of the I&C system thanks to its ability to access the project database.

Display and tracking of online values via dynamic function diagrams

Dynamic function diagram display on the TELEPERM® XS service unit
User interfaces of the service unit

**Dynamic function diagram display** enables online visualization of all functions and signals implemented in the TELEPERM® XS computers. The Diagnostics- and Maintenance-Server DIMAS* supports commands entered via a command interface for accessing processing modules and for reading out fault logs. Complex and repetitive functions are described in scripts, which can be executed automatically.

DIMAS also supports implementation of an easy-to-understand graphical representation of the states (faults, operating mode) of the processing modules. Components which are faulted or whose availability for use is restricted due to maintenance activities are immediately apparent. Menus and dialog masks enable system monitoring and test execution without programming knowledge.

Not everything can be effectively handled purely with standard dialogs. Additional input masks and display screens customized for the specific application simplify testing, online parameterization and diagnostics.

Support for parameterization and testing activities by means of customer-specific graphical dialogs.

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* DIMAS is the successor of the alphanumeric and graphical service monitor (ASM, GSM)
The scope of dynamic function diagram display and DIMAS dialogues is limited to the function scope implemented in the computers through to the connectors of the input/output modules. A special diagnostics interface, the TDI, transfers the comfort known from the service unit to the testing of peripheral modules.

All module input and output signals relevant for function testing and fault diagnostics can be displayed on a PC or a notebook. The TDI is also used for setting parameters implemented in hardware.

The diagnostics interface extender TDI-Ext is an expansion for the TDI which also allows to inject analog and binary test signals. This makes it possible to design application-specific diagnostic and test interfaces for all peripheral modules.

The human-machine interface to the diagnostics interface is created using LabView® and can be adapted to suit the requirements of the individual application.

Together the service unit and the TDI are the perfect support for the plant staff during operation. They replace the use of potentiometers and voltmeters on the I&C cabinet.
The first TELEPERM® XS systems have been in operation for many years. The feedback obtained from operation as well as the anticipated needs of future applications lead us to continuing development of the system platform. Redesign of existing components leads to functional enhancements, and new components with new features are developed. All these activities are coordinated with the requirement for ensuring the long-term spare part supply for existing installations.

By this, AREVA makes sure that spare parts and system expertise will remain available over the long term, and that the expansion and modification of existing systems will remain possible. Our aim is that plants can be operated safely and reliably with TELEPERM® XS until the end of their service life, especially in the case of modernization projects.

Assurance of long-term supply of spare parts based on early development of successor solutions
Long-sighted replacement strategy for components

Every component is subject to a life cycle of development, series production and spare parts supply.

AREVA monitors the production of the individual components, implements active warehousing and initiates the development and qualification of follow-on solutions in good time.

The most important goal of continuing development is always compatibility to predecessor components or at least availability of a replacement solution which can be easily integrated in existing systems.

This concept of continuous innovation enables AREVA to ensure the competitiveness of the system platform, the expansion of the field of application, and the long-term supply of spare parts.

The second generation of input/output modules has been designed following the second generation of processing and communication modules. These too offer compatibility with predecessor models, improved performance features and an extended application range.

Components of different generations can generally be operated together. This limits conversion work to what is absolutely necessary in the event of upgrades to new components.
Configuration management and change procedure

AREVA registers the hardware and software versions on delivery as a basis for planning spare parts requirements and for determining the compatibility requirements of new solutions to be developed. All this is controlled by the TELEPERM® XS configuration management and change procedures.

TELEPERM® XS configuration management handles the administration of all hardware and software components (e.g. processing module SVEx, software function block 2 out-of 4, input/output software driver) and their versions. It supplies information as to which versions of the various components can be operated together and regarding the qualification status which has been attained.

It also acts as the basis for the TELEPERM® XS change procedure, which coordinates the planning and tracking of all changes and new developments in the TELEPERM® XS system platform. Operating experience and innovative ideas are entered here, in addition to demands for compatible part solutions and expected add-ons and extensions.

Continuing development of TELEPERM® XS likewise meets market requirements and ensures long-term support of existing installations.

Control of continuing development of TELEPERM® XS in consecutive development stages based on the TELEPERM® XSS change procedure
Support and information

The supply of spare parts is only one aspect of long-term support. Our modular training program covers all aspects of TELEPERM® XS, e.g. engineering, operation and maintenance.

The internet-platform „TELEPERM® XS Customer Portal“ provides extensive information on TELEPERM® XS.

Project experience is evaluated and made available to customers together with information about further developments and innovations, e.g. within the framework of “TELEPERM® XS User Group Meetings”.

When new hardware and software versions are implemented, procedures and support for efficient integration minimize any disturbance to plant operation.

AREVA

- knows the requirements of plant operation.
- has detailed knowledge of the TELEPERM® XS system platform.
- knows the installed systems.

This puts AREVA in a position to provide support with modifications long after the handover to the customer and to supply compatible solutions even after decades have passed.
**Computer and communication components**

**SVE2**  
Processing module for operation on TXS backplane bus  
- Processor: AMD K6-2E  
- Frequency: 266 MHz

**SL22**  
Communication module as piggyback module for processing module, for 12 MBit/s TXS Profibus networks (successor type to SL21)  
- Bus interfaces: 2  
- Combinable: Up to 4 SL22/SVE2

**SLM2**  
Electrical/optical converter for 12 MBit/s TXS Profibus networks (successor type to SLLM)  
- Electrical connections: 1  
- Optical connections: 2

**SCP3**  
Communication processor for 10 MBit/s TXS Ethernet for operation on TXS backplane bus (successor type to SCP1, SCP2)  
- Electrical connections: 1

**SES1**  
Switch and media converter for 10/100 MBit/s TXS Ethernet networks  
- Electrical connections: 3  
- Optical connections: 2

**SEPC2**  
TXS embedded PC, e.g. for implementation of gateways, for installation in TXS cabinets  
- Ethernet-ports: 3  
- Profibus-ports: 2  
- Other ports: DVI, VGA, USB, PS2, serial, parallel

**Input/output modules**

**SAI1**  
Analog input module (successor type to S466)  
- Channels: 16 (single-ended input) or 8 (differential)  
- Voltage measuring: 0…125 mV; 0…1.25 V; 0…2.5 V; 0…5 V; 0…10 V; 1…5 V; -125…125 mV; -1.25…1.25 V; -2.5…2.5; -5…5 V; -10…10 V  
- Ranges: 0…2.5 V; 0…5 V; 0…10 V; 1…5 V; -125…125 mV; -1.25…1.25 V; -2.5…2.5; -5…5 V; -10…10 V

- Current measuring ranges: 20 mA; 50 mA  
- Compatibility mode: with S466

**SAO1**  
Analog output module (successor type to S470)  
- Channels: 8  
- Voltage outputs: -10…10 V/3 mA  
- Current outputs: 20 mA/750 Ω; 50 mA/300 Ω  
- Compatibility mode: with S470

**SDI1 und SDI2**  
Binary input module (successor types to S430, S431)  
- Channels: 32  
- Signals: 24 V/7 mA (SDI1-24)  
- Current outputs: 24 V/0.7 mA (SDI2-24)  
- Optical connections: 1  
- Compatibility mode: with S430/S431

**SDO1**  
Binary output module (successor type to S451)  
- Channels: 32  
- Signals: 24 V/250 mA max (SDO1-24)  
- Current outputs: 48 V/125 mA max (SDO1-48)  
- Compatibility mode: with S451

**SGPIO1**  
Multi-purpose module with counter, analog and binary inputs and outputs  
- Counter: 4 × RS422, 10 MHz or 4 × TTL, 10 MHz or 4 × 24 V, to 25 kHz  
- Analog inputs: 4 × 0…10 V  
- Binary inputs*: 4 × 24 V  
- Analog outputs*: 4 × 0…10 V/3 mA  
- Binary outputs*: 4 × 24 V

* in preparation
Signal conditioning

SAA1
Analog signal conditioning module with voltage supply for transducers, low-pass filter, test sockets and overvoltage protection
- Channels: 2
- Transducers: 20 mA, 2- and 4-wire circuitry
- Voltage output: 0...2.5 V
- Current output: 20 mA
- Overvoltage: 230 V (inputs)

SNV1-2,5, SNV1-10
Standard signal multiplier, for analog signal distribution. Includes galvanic isolation and overvoltage protection
- Input: 0...2.5 V, 0...10 V, 0(4)...20 mA
- Output: 4 x 0(4)...20 mA
- Overvoltage: 230 V AC/DC (outputs)

STT1
Temperature transducer
- RTDs: Ptxxx, Nixxx in 2/3/4-wire circuitry
- Thermocouples: K, J, B, E, N, R, S, T etc.
- Combination sensors: RTD and thermocouple
- Output: 0...10 V or 4...20 mA
- Reference point compensation: internal or external

SBC1
Binary signal conditioning module with contact power supply, open-circuit monitoring, non-coincidence monitoring of changeover contacts, simulation inputs
- Connect power supply: 48 V or 24 V
- Inputs: 1 changeover contact or 2 single contacts or 2 electronic contacts

SCR1
Module for the inductive position measurement of control rods in pressurized water reactors, with synchronization logic
- Exciter outputs: 2 x 0...200 mA/31 Hz
- AC inputs: 2 x 4, 0...22 V/100 Hz
- Voltage outputs: 2 x 4, 0...10 V

SSC1
Signal conditioning for active and passive sensors, with stand-still/speed monitoring
- Frequency/speed: 0...30 MHz / 0...6000 U/min
- Sensor power supply: 20...30 V, 100 mA
- Analog output: 0...10 V / 4...20 mA
- Pulse output: 0/24 V and RS422

Neutron flux instrumentation modules

SCV1P
DC amplifier, signal conditioning for neutron flux detectors such as ionization chambers or cobalt self-powered neutron detectors
- Channels: 3
- Input: 0...3 x 10^-6 to 0...1 x 10^-2 A
- Output: 0...10 V

SCV1B
DC amplifier similar to SCV1P, but with integrated floating high-voltage supply, e.g. for fission chambers
- High voltage: 200 V

SCV2
DC amplifier, signal conditioning for neutron flux detectors. Automatic measuring range changeover. Additional isolated output for connection to backup or ATWS systems
- Channels: 1
- Input: 0...10^-2 to 0...10^-3 A
- Output: 0...10 V

SPSR1
Preamplifier, signal conditioning for pulse detectors
- Channels: 2
- Pulse rate: 1 MHz

SSR1
Pulse amplifier and discriminator, for source range measurements and activity monitoring. An audio channel can be connected
- Channels: 2
- Pulse rate: 1 MHz
- Pulse interval: >150 ns
- Frequency divider for output: 1:1, 1:5
- Output: RS422, TTL

SPWR1
Preamplifier for fission chambers
- Channels: 1
- Pulse rate: 1 MHz
- AC: 5 μA
### Neutron flux instrumentation modules (Continuation)

**SWR1**
- Pulse and current amplifier module for wide-range channels with fission chambers. Additional isolated output for connection to backup or ATWS systems. An audio channel can be connected.
  - Channels: 1
  - Pulse rate: 1 MHz
  - Pulse interval: >100 ns
  - Frequency divider for output: 1:1, 1:5
  - Output of frequency path: RS422, TTL
  - AC path: 2...200 kHz
  - DC path: 0...20 mA
  - Output: 0...10 V

**STG1**
- Test signal generator for periodic testing of neutron flux instrumentation modules and detectors. With voltage ranges and pulse outputs compatible with the modules listed above

**SHV1, 2**
- High-voltage sources compatible with the instrumentation channels listed above
  - Outputs: ±1.5 kV/20 mA; 4.5 kV/0.5 mA

### Signal logic, isolation and output modules

**AV42**
- Module with drive control function and integrated prioritization for actuation of open or closed-loop control actuator by the safety I&C. With Profibus DP interface for actuation by operational I&C and with a connection option for mosaic control tiles.
  - Field contact power supply: 48 V (torque and limit switch)
  - Inputs for safety I&C: 4
  - Control tile connections: 2
  - Profibus DP interface: 1

**SRB 1/2**
- Relay output module with isolated changeover contact assemblies and positive-guided checkback contacts
  - SRB1: Loads from 20 mA to 5 A DC/24 V, 5 A AC/230 V, 0.3 A DC/220 V
  - SRB2: Loads from 1 mA to 0.3 A AC, DC/60 V

### SPLM1-xxx
- Logic module, available in various preprogrammed variants, for the implementation of hardwired logic functions in single-channel or two-channel design
  - Number of subsystems per module: 2
  - Binary inputs: 2 × 16
  - Binary outputs: 2 × 8
  - Open collector outputs: 2 × 2
  - Non-coincidence monitoring: integrated, with provision for deactivation

### SPAM1
- Programmable module for analog signal processing, with simulation inputs and test sockets
  - Analog inputs: 4 × 4...50 mA; 0...20 mA
  - Binary inputs: 4 × 24 V
  - Analog outputs: 4 × ±10 V/3 mA
  - Binary outputs: 4 × 24 V/100 mA
  - Analog switches: 4
  - Threshold monitor: 2
  - MIN/MAX selection: 1
  - Voltage dividers: 2
  - Adder/subtractor/average: 1
  - Integrator with reset: 1
  - Amplifier with multiplier: 1

### SOBx-24, SOBx-48
- Overvoltage barrier, for analog and binary signals
  - Channels: 12
  - Overvoltage: 230 V AC/DC
  - Rated voltage: 24 V DC or 48 V DC
  - Rated current: ≤150 mA
  - Residual voltage: 40 V (at 24 V rated voltage)
  - 80 V (at 48 V rated voltage)

### SDMx
- Diode modules for signal isolation and implementation of simple signal logic operations
Subracks, packaging system, test equipment

**SCBU1**
19” fusing unit with electronic miniature circuit-breakers (thermal miniature circuit-breakers on request)

**SCSU1**
19” power supply unit with diodes for redundant 24 V DC cabinet power supply, also includes power supply filters

**SCSU2**
19” power supply unit with converters for cabinet power supply at 115/230 V AC

**SCMUx**
19” cabinet monitoring unit with modules for cabinet annunciation system, self-monitoring and load current deactivation

**SRACK 1/2**
19” subrack with backplane bus, power supply, monitoring unit and fans for 21 or 2 × 10 modules

**SR-3U, SR-6U, SR-9U, SR-12U**
19” subrack for 3 or 6 U signal conditioning, logic or output modules

**TDI**
Diagnostic interface which allows to connect a PC to peripheral modules for reading out diagnostic information, for module parameterization and testing

**TDI-Ext**
Expansion module for the TDI which allows to inject analog and binary test signals

Software packages

**TELEPERM® XS CORE Software**
SPACE editor, block libraries, code generator, compiler and linker, service unit software and prelinked system software for the engineering and generation of an executable TELEPERM® XS system

**TELEPERM® XS SIVAT**
Simulation package for the testing of engineered TELEPERM® XS systems with simulation control and libraries

**TELEPERM® XS Gateway**
TELEPERM® XS gateway software with shared memory interface for the TXS side of a gateway

**MODBUS Gateway**
Gateway software for the connection of TELEPERM® XS systems to third-party systems via Modbus/TCP

**Other Gateways**
Customer-specific adaptation, on request

**TXS-QDS Production software package**
Software for the development and modification of QDS applications. Includes editor for QDS displays, code generator, compiler and linker, also includes prepared QDS system software

**TXS-QDS Runtime software package**
Software necessary for the operation of QDS. Comprises bootloader and service-unit software

**SIMGEN**
Package for the generation of TELEPERM® XS code for training simulators. Supported simulator control systems: on request

**ERBUS TM and ERBUS SCU**
Software package for ERBUS TXS test system for performing integral system tests and periodic testing

**TDI1-SW**
Diagnostic software for TDI1, for operation of TDI1 diagnostic interface on a PC
The components of TELEPERM® XS have been qualified for the environmental conditions listed below. The respect of these conditions has to be ensured by the design of the individual I&C system.

**Supply voltage**
- System voltage: 24 V DC
- AC/DC converter solutions: 115 V AC
  230 V AC
  other voltages on request

**Climate**
**Operation in air-conditioned rooms**
- Ambient temperature: 0…55 °C
  air intake to subrack
  0…45 °C
  in electronic equipment room
- Relative humidity: 5…85 %

**Seismic certification**
The TELEPERM® XS hardware is robust and is designed to withstand seismic stress.
The type testing of the modules includes vibration tests:
- Sine sweep tests in accordance with KTA 3503 and IEC 780
  - Frequency range 2…35 Hz (1 octave/min.):
    Acceleration 2 g in mounting position
  - Frequency range 5…100 Hz (10 octave/min.):
    Acceleration 2 g
- Three-axis tests in accordance with IEEE 344 and EPRI TR 107330
  - Frequency range 1…35 Hz:
    Acceleration up to 14 g
- Tests for transport stress have also been performed (resistance to vibration, shock stress)

**Grounding and shielding**
TELEPERM® XS is designed for I&C rooms in normal industrial ambient conditions. Additional protection circuitry may need to be implemented in the event of conditions imposing greater stress.
TELEPERM® XS may be used in plants with large-area grounding as well as in plants with a central grounding point.

Signal cables must be shielded.

The components of the system platform meet the requirements of standards EN 55011, 55022 and EPRI TR 102323.

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**Performance data**

**TXS computers**
- Processing modules: up to 8
- Cycle time: 5…1600 ms
  typically 50 ms
- Communication cycle: typically 50 ms
- Number of function diagrams per VE: typically 20…40
- Number of function blocks per diagram: typically 20…30

**TXS Profibus**
for internal system communication
Protocol: Profibus FDL in accordance with EN 50170 for ISO/OSI layers 1 and 2 and TELEPERM® XS-specific application layer
- Media: Electrical, optical
- Data rate: 12 Mbit /s

**TXS Ethernet**
for the connection of monitoring and service interface computers and gateways, TXS-QDS and service unit
Protocol: CSMA/CD, LLC in accordance with IEEE 802.3 for ISO/OSI layers 1 and 2 and TELEPERM® XS-specific application layer
- Media: Electrical, optical
- Data rate: 10/100 Mbit/s

**Standard cabinet SC 9422**
- Height × width × depth: 2200 × 900 × 400
  (Other dimensions on request)
- Degree of protection: IP30
  (Other dimensions on request)
- Current consumption: typically 550 W
  max 1280 W
- Mass: typically 300 kg

**Wall-mounted enclosure SWE12**
- Height × width × depth: 800 × 600 × 400
- Mounting space: 84HP, 13U
- Degree of protection: IP53
- Variants: SWE 6, SWE 9
Interested in further details or is there anything else that AREVA can do for you? Please contact your regional sales manager or

AREVA supplies solutions for power generation with less carbon. Its expertise and unwavering insistence on safety, security, transparency and ethics are setting the standard, and its responsible development is anchored in a process of continuous improvement.

 Ranked first in the global nuclear power industry, AREVA’s unique integrated offering to utilities covers every stage of the fuel cycle, nuclear reactor design and construction, and related services. The group is also expanding its operations to renewable energies – wind, solar, bioenergies, hydrogen and storage – to be one of the leaders in this sector worldwide.

With these two major offers, AREVA’s 48,000 employees are helping to supply ever safer, cleaner and more economical energy to the greatest number of people.