SIEMENS energy

Integrated controls for synchronous condensers

Omnivise Portfolio





How Omnivise T3000 supports grid stabilization

The principal duties of synchronous condenser stations are to generate or absorb reactive power and thus control the voltage level in the grid, to provide short circuit power for voltage stabilization during transients and to provide synchronous inertia which can be multiplied if an additional flywheel is attached.

By supplying reactive power to the transmission line, synchronous condensers contribute to voltage control. Like all assets within power grids, synchronous condensers require a reliable and highly redundant control system to monitor and automate processes; regulate and adjust or maintain conditions or system behaviors in asset operation; and collect, tag, and archive data. This control system not only has to enable efficient operation of the synchronous condenser, but it also must set the basis for a smooth integration of the synchronous condenser into the overall control system of the grid. Unlike other components, such as protection devices or switches, synchronous condensers are rotating machinery, and thus they do not follow an on/ off principle but rather must be gradually adjusted to operate efficiently.

With a lifetime of over 20 years, synchronous condensers require a flexible and scalable control system which is open and can adapt to future options.

Synchronous condensers provide improved voltage regulation and stability by absorbing or generating reactive power, as well as improved short-circuit strength and frequency stability by providing synchronous inertia.

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Control modes of synchronous condensers of efficient grid support

When it comes to grid control and the operation of a synchronous condenser, its control functions are of utmost importance. Synchronous condensers must fulfill multiple tasks in grid management, and it is therefore essential that they are equipped with control capabilities for a variety of control modes such as:



Voltage Control: First and foremost is maintaining voltage levels within a defined range. This critical aspect of grid management prevents equipment failure and power outages to ensure that the system operates efficiently and reliably.



Reactive Power Control: The provision of reactive power to the system can reduce the amount of reactive power needed from the source and improve the overall power factor within grids. This makes reactive compensation support one way that grid operators can improve the stability and efficiency of the system, while also reducing energy costs and minimizing the risk of equipment failure.



Inertia Response: The large amount of kinetic energy stored in the synchronous condenser provides synchronous inertia which helps to maintain the system frequency. This property, inertia, can help to absorb transient power imbalances to keep large power systems stable and reliable in case of sudden changes in supply or demand. An additional flywheel increases the stored rotating energy and therefore even strengthens the inertia response. This happens intrinsically, as per the synchronous machine's physics, without any controller involvement.



Fault current capacity increase: System strength is an indication of the system's inherent robustness to voltage disturbances. It is typically measured by short circuit level (SCL) which is sometimes referred to as fault current. SCL indicates the amount of generation which can provide fast reactive power within the timescales of a voltage dip.

Systems with many distributed generators have low short circuit levels. To address this issue, grid operators take steps to improve the short circuit strength of the system and install synchronous condensers where needed.

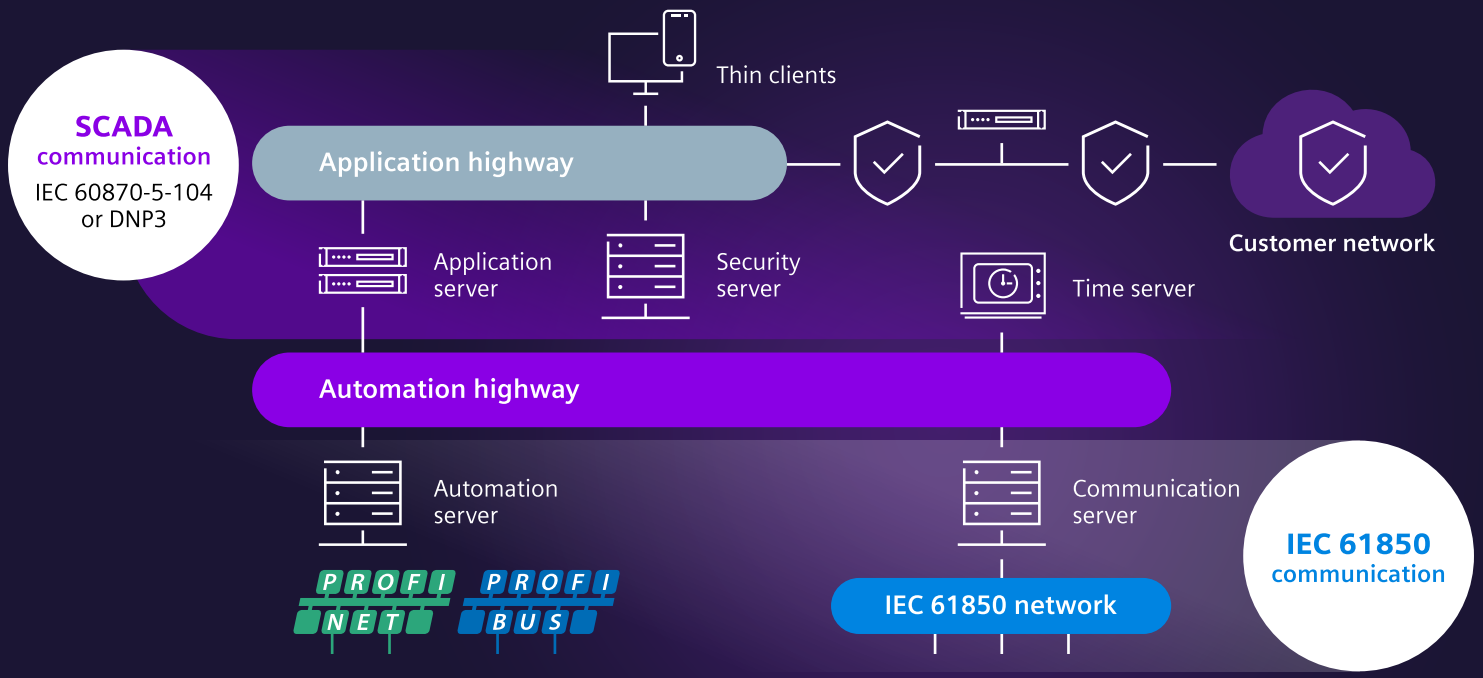
Essential requirements for control systems

To handle all these tasks in an efficient and reliable way, a control system must meet multiple requirements:

- Fast and failsafe operation of rotating equipment
- Integration of electrical controls including excitation system and substation automation
- Remote operation
- Compliance with cybersecurity regulation and standards
- Maintenance approach covering the entire life cycle of the main equipment
- Remote maintenance and system diagnostics

All these requirements are covered by the Omnivise Portfolio. It brings along all the technical prerequisites to operate synchronous condensers flexibly, safely, and reliably.

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The Omnivise T3000 control system

The Omnivise T3000 control system is at the core of the Omnivise family of solutions. This integrated control solution offers the possibility to simultaneously manage electrical equipment and fast control loops.

The T3000's system architecture, remote access, service concept, and cybersecurity features are among the factors that make it the perfect fit for synchronous condenser operation, now and in the future.

Integrated system architecture

For the different technical areas covered by the T3000, there are typically numerous subsystems in place. The coordination of rotating, switchgear, metering, and protection equipment, which may be divided among various manufacturers, is a challenge. The interfaces frequently are the weak points– data synchronization between systems is always an issue.

Omnivise T3000 overcomes these challenges by providing an integrated architecture. It supports various communication protocols, like IEC 61850, 60870-104, and DNP3. This enables seamless integration into the overall grid system.

The control system offers **one uniform HMI** for all functions: just a single Workbench for engineering, diagnostics, and operation. The advantages are obvious: Besides needing no extra hardware or even separate systems, fewer interfaces are required, which is beneficial in many ways. First ofall, less effort is required to keep data consistent, and the risk of intrusion is lowered. Secondly, the system makes it especially easy to implement engineering changes.

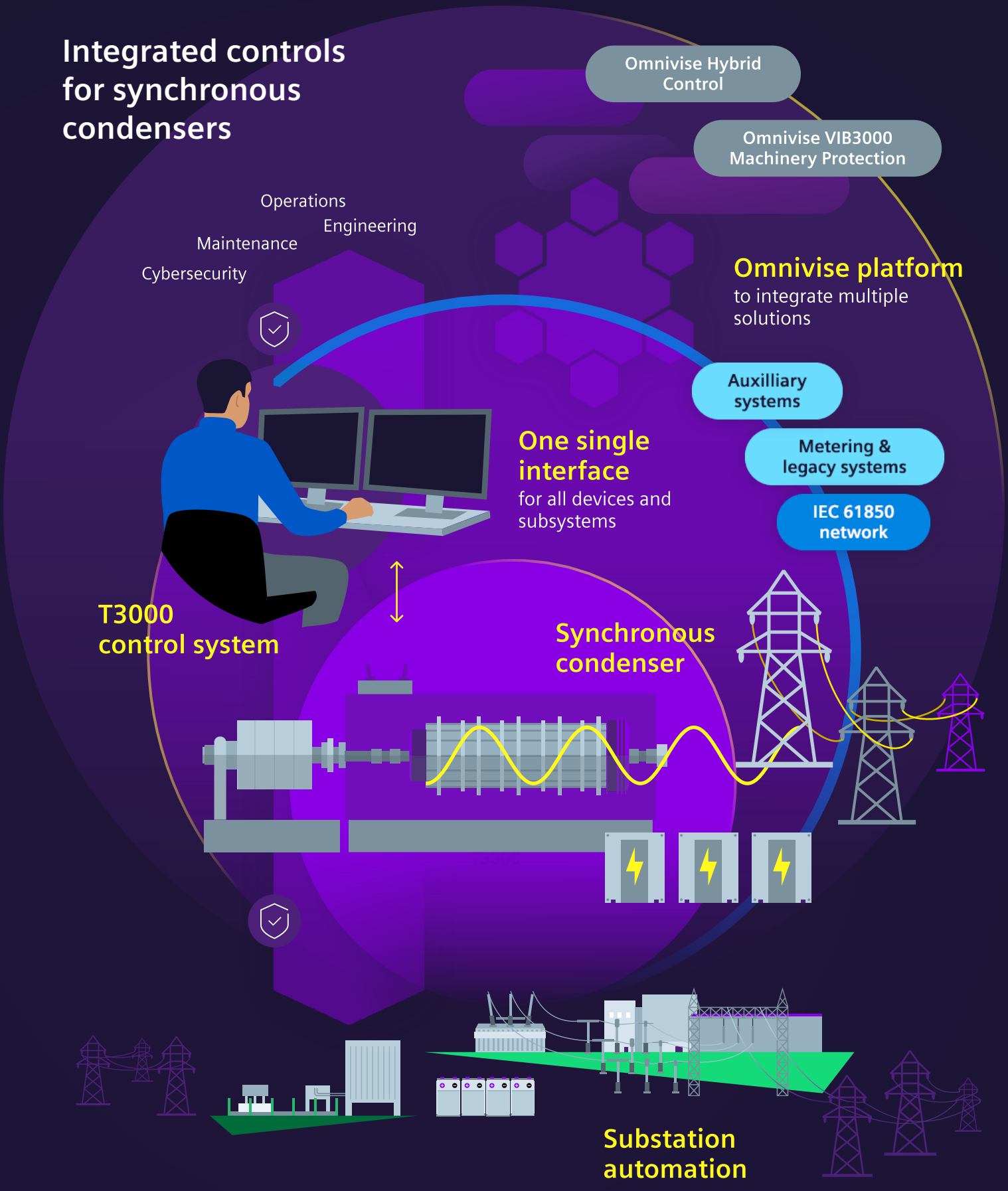
Omnivise T3000 relies on **one database**. All the data and information used in the system always comes from a central, single source. This leads to **consistent views** for all users and supports data integrity. As Omnivise T3000 serves as the single control system integrating all subsystems, there is **only one system to be maintained**. The flat system architecture, with a minimal number of components and interfaces, entails less engineering and system maintenance and administration efforts.

Working with a single control system also means that **only one control system lifecycle** must be considered. The T3000 I&C systems have been developed with a long-term horizon and are accompanied by support throughout the asset life cycle. This includes upgrades, migrations, spare parts concepts, and concepts for the transition to new technologies – from the first day of our cooperation. Innovations and further developments are designed so that they can be integrated without changing systems ensuring long-term stability through a future-proof system.

Omnivise T3000 system integration – system conform communication levels

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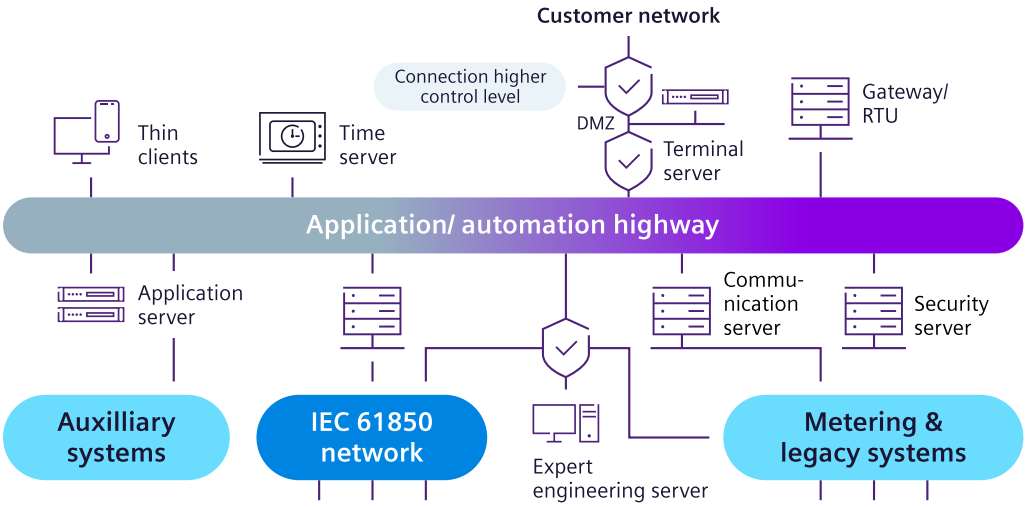
Integrated controls for synchronous condensers



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Built-in Substation Automation System (SAS) functionalities

Substations enable the real time monitoring and control of power flows in the grid. Substations are equipped with protection devices which enable fast emergency actions to protect the power grid from disturbances like short circuits and fluctuations in voltage and frequency. So-called Substation Automation Systems (SAS) are required to operate substations safely and reliably.



IEC 61850 integration of

- Protection devices
- High voltage switchgears
- Auxiliary third-party systems
- Power quality measurement device
- Fiscal metering
- Legacy RTUs

Complete substation automation functionalities for easy and intuitive operation and engineering

The Omnivise T3000 SAS includes the Instrumentation and Control systems (I/O interfaces to sensors and actuators, measurement devices, relays, controllers, and HMI interfaces) and the communication interfaces that facilitate monitoring, control, and protection of substations and the electrical grid with all necessary cybersecurity countermeasures. Omnivise T3000 thus provides complete substation automation functionalities and enables easy and intuitive operation and engineering.

In one system, Omnivise T3000 integrates functionalities of substation automation systems (SAS), all smaller automation functions, and the handling of interfaces to superordinated SCADA systems, trading departments, or grid operators. The Omnivise T3000 system for substation automation not only enables the integration of IEC 61850 protection devices and high voltage switchgears, but also facilitates the integration of auxiliary third-party systems, fiscal metering, power quality measurement devices, and legacy RTUs. This makes configuration and engineering in Omnivise T3000 very simple.

Consistent, end-to-end cybersecurity

Many of Omnivise T3000's most beneficial characteristics boil down to the fact that it is an integrative system. As T3000 integrates all subsystem, it is easy to secure. A single overarching control system means **only one "system under consideration"** in cybersecurity terms. Because T3000 is an end-to-end solution for the entire system, it automatically creates end-to-end cybersecurity. Protection and metering systems, for example, are automatically protected against cyber risks because they are integrated into Omnivise T3000.

The number of different national and international cybersecurity regulations is increasing, and these regulations tend to become more complex and tighter. As synchronous condensers are classified as "critical national infrastructure", all these developments affect operators of those assets as well. That is why we design the entire system according to **IEC 62443**.

The T3000 design and development takes into consideration multiple cybersecurity regulations and standards, like NIS, NERC CIP, and ISO/IEC 27001, which is supported by BDEW, to name a few.

Omnivise T3000 has been explicitly created for critical infrastructure. Fail-safe system components, built-in redundancy, and the T3000 security layer architecture all attest to this fact.

When implementing project specific solutions, our cybersecurity approach does not only consider standards, but it is also tailored to meet our customer's own company cybersecurity policies. Cybersecurity is an integral part of the Omnivise T3000 life cycle strategy, and cybersecurity is regarded as a process which stretches far beyond the imple-

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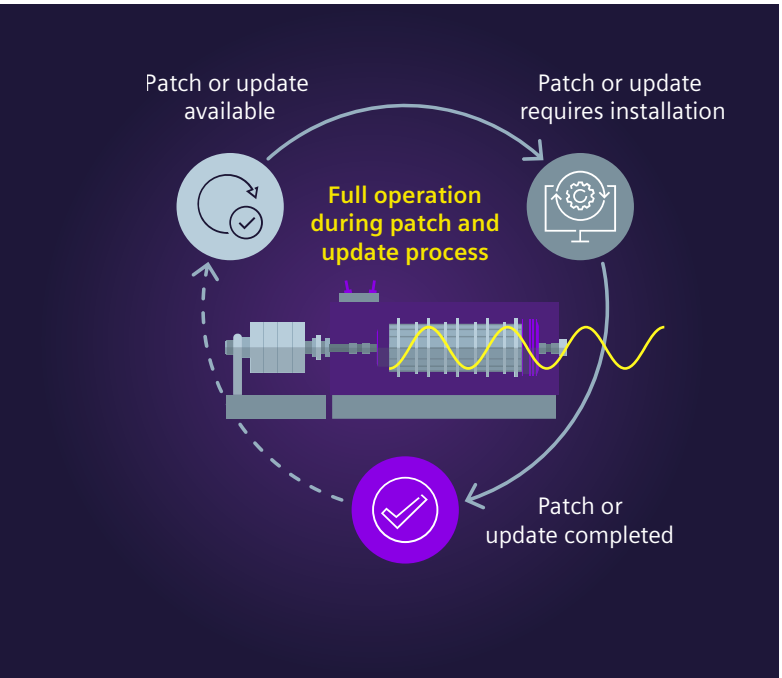
mentation phase. Our cybersecurity services ensure that system security is kept along the complete lifecycle of a synchronous condenser.

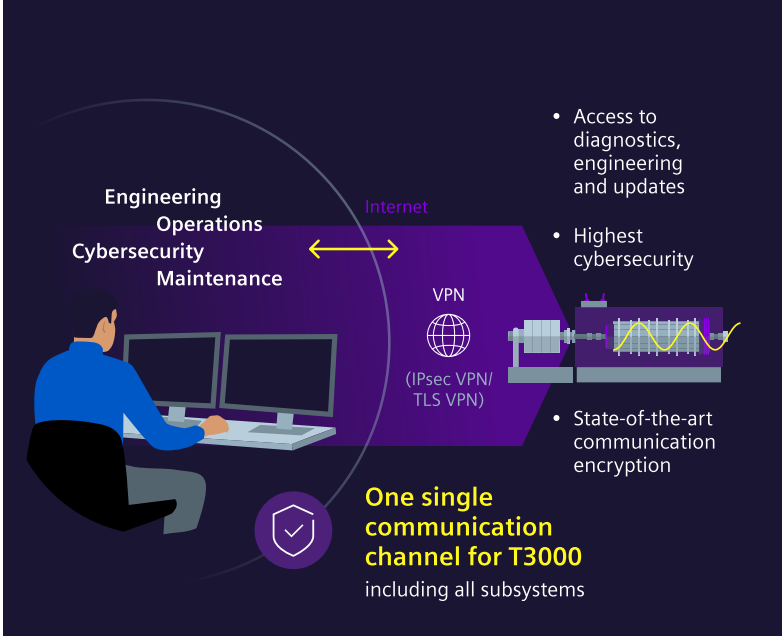
During project implementation or later as services, the Omnivise cybersecurity offerings include for example:

- **Zoning**: T3000 is built in a series of separate layers, each one having its own security safeguards, ensuring that compromise in one layer does not undermine the integrity of the whole solution.
- **Hardening**: Limiting the functionality of components and systems to their actual purpose provides the best protection against hackers. Hardening involves, among other things, removing unnecessary software, constant changes to passwords and cutting out unnecessary services.
- **Patching**: System and security updates and patches are vital to keep the cybersecure system secure and stable in the long-term.
- **Segregation**: Critical network elements are separated from the internet or other less critical networks to limit the group of people who can access critical systems.

Online patching and update capabilities

Since control systems are heavily software based, having the latest system and security patches installed is essential to keep the system up to date. Due to its remote access capabilities and redundant system configuration, Omnivise T3000 provides online patching capabilities and even online upgradeability. Updates or upgrades are possible at any time, online, during normal operation **with no downtime**. In other words: With Omnivise T3000, no specific outage is required for the synchronous condenser for control system maintenance purposes like patching or updates.





Easy remote access for remote operation and maintenance

Remote access significantly simplifies the operation of synchronous condensers. In many cases, both the TSO and maintenance teams would like to access the system remotely.

Omnivise's remote access concept not only facilitates remote operation (especially maintenance), it also contributes significantly to a secure overall solution for the entire system. Key to achieving this is the use of **a single communication channel** to external systems. Omnivise T3000 serves as one channel, the single endpoint for maintenance, engineering, and operations. With T3000, there is no need to juggle multiple channels to remotely access your system. Our target is to simplify operations by limiting the number of channels required for remote access.

While operations may not be a challenge, the engineering of different subsystems can be complex. Typically, each subsystem demands individual engineering tools, which results in opening multiple remote channels, thus increasing cybersecurity risks. But T3000 removes this complexity by providing a single channel for all your maintenance needs. All tools needed for the engineering of the different subsystems, such as protection devices, are accessible via the T3000 security server. This way, you can streamline your maintenance process and know that your system is secured.

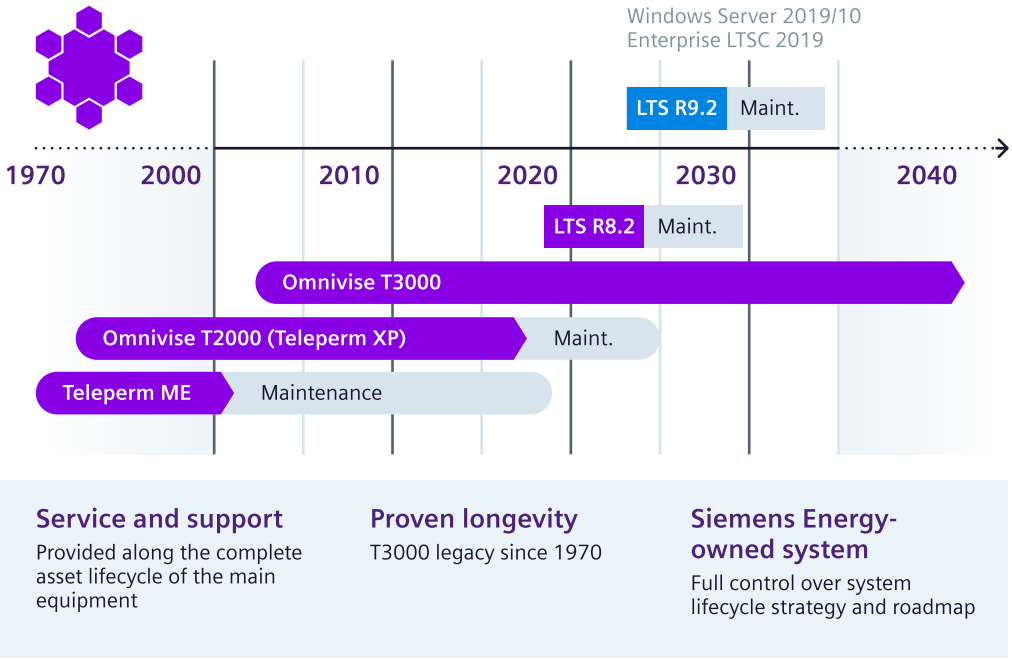
Supported by advanced SCADA functionalities and state-of-the art communication encryption functionalities, the TSO can access the system to determine setpoints for remote operation. Maintenance teams can get access the very same way for diagnostics and update purposes for all relevant subsystems.

While the T3000's remote access capabilities offer many advantages, customers may decide that this is undesirable. In these cases, we rely on data diodes or other methods to limit or even prevent the communication of the systems with the outside world.

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Coverage of the entire asset lifecycle

The lifespan of more than 20 years of synchronous condensers exceeds the lifecycle of control systems, which are typically in place for max 15 years. IT components have even shorter lifecycles of about 5 years. Due to its smart lifecycle concept, Omnivise T3000 has a lifecycle of more than 20 years as well. Coming from the power generation business, we are used to such lifecycles and the T3000 legacy has already proven the longevity of this control system.



Service and support
Provided along the complete asset lifecycle of the main equipment

Proven longevity
T3000 legacy since 1970

Siemens Energy-owned system
Full control over system lifecycle strategy and roadmap

The T3000 system lifecycle strategy provided long-term support for the last decades

I&C system **services and support** are provided along the complete asset lifecycle of the main equipment.

We have always emphasized that the timing of a system upgrade should remain flexible: There is a long period when the maintenance phase for the previous system overlaps with the active phase of the latest control system version.

Full integration of add-on functionalities like vibration monitoring

Because Omnivise T3000 is a Siemens Energy-owned system, everything comes from a single source, and we maintain full control over the system lifecycle strategy and roadmap.

Omnivise T3000 has been designed with a platform approach from the very beginning, making the T3000 control system the center piece for many other solutions, ranging from digitalization solutions to machinery protection. The expandable Omnivise solution integrates multiple solutions, like the VIB3000 vibration and condition monitoring system, for example.

There is no doubt that it is a huge advantage to have an integrated vibration monitoring and condition monitoring system in place. For all rotating machinery such as synchronous condensers, vibration is always a major topic. Most solutions available on the market are technically separated from the control system: They are running on a different server with a different database and a different HMI. Omnivise VIB3000 vibration monitoring runs on the T3000 Application Server and it is therefore fully integrated into the T3000 control solution.

The machinery protection system Omnivise VIB-3000 is fully redundant and scalable, and is thus designed for extremely high fault tolerance. Safety levels for the system are extremely high thanks to its three fully configurable redundancy modes.

Omnivise VIB3000 can be easily extended by Omnivise CM500. This software makes the VIB3000 protection system a full-blown condition monitoring system. CM500 maintains high availability with real-time condition monitoring based on a wide array of tools and methods used for performing in-depth machinery analysis as well as machinery diagnostics.

Not only can additional functionalities be added, but the Omnivise T3000 system itself can also be extended to cover additional assets. Omnivise Hybrid Control is a possible extension of the T3000 core system which brings along asset optimizer capabilities to control and manage further grid stabilization equipment like capacitor banks, MSCDNs, BESSs, or reactors.

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Some of our reference projects

Killingholme, Uniper, UK: Rotating grid stabilizer for Great Britain

Uniper's Killingholme power plant is fired with natural gas. The Killingholme plant in Lincolnshire, UK, was commissioned in 1992 and supplies an electrical net output of 600 MW. Having previously been converted from Combined Cycle to Open Cycle operation, the project task was to convert the former Steam Turbine Generators to operate as synchronous condensers using an existing grid connection. The steam turbine generator with an additional flywheel is used as inertia to help balance grid frequency, without generating power. This way, grid stability services can be provided to the national grid.

In addition to a variety of technical equipment like transformers, excitation, generator protection flywheel, and switchgear and mechanical modifications, the fully redundant Omnivise T3000 control system (including vibration monitoring for the synchronous condenser and its implementation into the existing control room) was a cornerstone of the overall project solution.

Grain, Uniper, UK: New synchronous condensers at a traditional power generation site

The Grain power station is a modern natural gas-powered 1326 MW CCGT, with three units, which produce enough electricity to power around a million homes. The power station is the newest CCGT in Uniper's UK portfolio, having been commissioned in 2011, replacing Grain-A, an oil-fired station commissioned in the 1970s, which was closed in 2012 under the EU's Large Combustion Plant Directive (LCPD) legislation.



Killingholme Power Station in Lincolnshire, United Kingdom

Uniper was awarded four six-year contracts by National Grid ESO in 2020, to provide inertia services and voltage control to the grid under phase 1 of its Stability Pathfinder at both Killingholme and Grain power station sites. Rotating grid stabilization technology now provides stability services to maintain the frequency at 50Hz and help the grid meet the challenges of the energy transition.

To realize this project, Siemens Energy supplied, installed, and commissioned two new custom-designed synchronous condenser units on the site of the old oil-fired power station on the Isle of Grain in Kent. These units are connected to the existing grid connections at site. The new units are equipped with state-of-the-art Siemens Energy rotating machines, a flywheel, and the Omnivise T3000 control system, which enables efficient remote operation and builds the interface between the main equipment and the grid.

"I'm delighted that we've been able to work closely with Siemens Energy to create a bespoke solution that meets the needs of National Grid ESO, and which is the right fit for our Killingholme and Grain facilities."

Mike Lockett, Uniper UK Country Chairman and Group Chief Commercial Officer Power

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The future of controls in grid support – an outlook

The rising share of renewables will continue to put our grids through a stress test, and multiple measures must be taken in response, which will mutually support each other.

With the Omnivise T3000 control system supplemented by other elements of the Omnivise solution family, we can already implement hybrid solutions with synchronous condensers (for example, generation networks which consist of synchronous condensers and battery storage or combined cycle power plants (CCPP)). Omnivise T3000 provides an ideal, integrated solution by mastering the optimization between the fast control mechanisms that synchronous condensers are relying on and the slow controls of battery storage. This leads to a perfect interaction of synchronous condensers and battery storage to optimize grid support. Together, those systems can enhance short-circuit current, offer additional frequency support and system inertia, weaken undesired oscillation, and reduce reactive power control.

We will see more and more hybrid solutions for grid stabilization, with synchronous condensers at center stage.



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Published by

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For more information, please visit our website:
siemens-energy.com/omnivise-t3000

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