The Evolving Timing Requirements of IEC 61850:

The Challenges and Benefits

Intelligent electronic devices and networks are becoming an increasingly common presence in modern society and our day-to-day lives. Scary to some people, but also convenient and essential for future endeavours like the decarbonisation of transport or the intelligent generation and distribution of power.

IEC 61850 is an international standard defining communication protocol for intelligent electronic devices at electrical substations. As the standard evolves, so does its timing requirements to ensure the reliability, efficiency, and safety of modern electrical power systems. IEC 61850 is huge and multifaceted. It consists of an impressive body of recommendations, rules and protocols. Timing issues account for as little as 5 percent of IEC 61850, but are nonetheless essential for the reliability, efficiency and safety of modern electrical power systems.

In this white paper, we are going to take a closer look at the evolving timing requirements of IEC 61850. What challenges do they pose? And what are the benefits of the IEC 61850 standard when it comes to timing? Read on and find out!

Why was the IEC 61850 Standard Created?

The IEC standard suite 61850, often loosely referred to as the "digital substation" standard within the power/energy engineering community, was created to drag analogue processes into the bright dawn of the contemporary digital era. The standard sets out to define the communication between intelligent electronic devices (IEDs) in substations and related automation systems that might include fault and condition monitoring and equipment protection systems.

It specifies Ethernet communication and suggests multiple protocols, including MMS (Manufacturing Message Specification), GOOSE (Generic Object Oriented Substation Event), and Sampled Values (SV) along with a data modelling concept based on logical nodes (LNs) & data objects (DOs).

The standard also defines SCL, an XML-based language used for describing the configuration of substation automation systems.

The aim of all this technological hocus-pocus? Providing a much more accurate monitoring of power flows to enable better management of the whole grid. The old model of centralised generation and one-way distribution of power has been replaced with much more distributed generation. This occurs both at a high level (big offshore wind farms, large solar farms) and on a more localised scale (residential solar photovoltaics and battery storage).

The result? A bidirectional flow of energy. In the past, power would only flow from the grid into a residential property. Nowadays, properties that produce excess energy may pass power back up to the grid. This causes a big problem for the old generation and distribution systems that have been designed and installed maybe decades ago based on a one-way flow of power. In the new situation, things are all over the place. Therefore, accurate timing is essential to create and maintain a proper balance between the input that the energy distribution network receives and the output that it sends out.

IEC 61850 and Timing

Time synchronisation is also covered by the IEC 61850 standard, since accurate timekeeping is the bedrock on which modern power grid operations rely. Devices and networks must work in unison and must be able to make split-second decisions to ensure excellent grid stability and reliability. IEC 61850 lays the groundwork for a sophisticated time management framework using several components and technologies.

Precision Time Protocol (PTP)

The IEC 61850 standard employs the precision time protocol (PTP) as the preferred mechanism for achieving accurate time synchronisation. PTP synchronises devices by exchanging time-stamped messages over the network. When you're dealing with voltages in smart, bidirectional power grids, the required accuracy is often less than a microsecond in the time stamp. PTP can deliver the sub-microsecond level synchronisation that is crucial for modern grid operations.

Grandmaster Clocks

IEC 61850 synchronisation also relies on a designated grandmaster clock which serves as the ultimate and overarching time reference within the network. This hugely reliable clock disseminates precise time information to all devices in the substation.

Hierarchy of Clocks

In huge networks, there is often a hierarchy of clocks. Primary and secondary clocks support the grandmaster clock, ensuring an even higher degree of redundancy and reliability. A hierarchical clockwork structure can effectively safeguard a power network against single points of failure. A common example of single point of failures are the intentional or accidental disruption of GPS signals or the spoofing of GPS-based networks and time management systems.

The Timing Benefits of IEC 61850

The creation and utilisation of the IEC 61850 has several significant advantages from a time synchronisation viewpoint.

First of all, IEC 61850-compliant networks assure that every piece of exchanged data is accurately time-stamped. This allows you to check and reconstruct the chronological order of events within your network. Ideal for troubleshooting, but also very welcome when it comes to providing critical insights into grid behaviour during transient and normal conditions.

The IEC 61850 standard also lays the solid groundwork for a wide and diverse plethora of crucial grid advancement technologies and applications, such as phasor management units, grid monitoring, thorough fault analysis, and wide area protection. All of these contribute greatly to the overall stability, reliability and safety of a power grid. Accurate timing also affects cybersecurity. It enables the correlation of events across different devices, aiding in the detection of anomalies or potential security breaches.

Timing and IEC 61850: The Challenges

Finding your way in the maze of timing and IEC 61850 comes with its own set of challenges. When things are operating normally, everything in the timing department usually falls neatly into place. The tricky thing is that there are some significant performance parameters that are (as yet) not specified in any standard. These issues are mainly focussed on what happens after an outage that renders the reference clock unreachable. How do the IEDs clocks move to sync with the reference clock when it reappears? Suddenly with a (possibly large) step in their time base or do they slowly re-sync to the clock? If moving slowly, at what rate? These differences can affect a specific service significantly.

Different manufacturers have implemented all these mechanisms, leading to the situation where all clocks might take a while to re-sync to the reference, but are all showing (sometimes out of spec) different time offsets. A limited interoperability between the solutions of different manufacturers makes the smooth exchange of messages more difficult. If different clocks in the substation are locked to the reference clock with different variable offsets, errors and failures are a serious risk.

We also see that the power industry is very risk averse. That’s understandable, since power and electricity are necessities of life in our modern day and age. And if things go very wrong in a power station, power shortages, short circuits, and even explosions are very real danger scenarios. Luckily,

various user groups within the power industry are currently engaging with the wider time and sync community to better define and standardize post-recovery behaviour.

Getting a Grip on Evolving IEC 61850 Requirements: How Chronos helps

The timing requirements of IEC 61850 have gradually evolved to support the growing complexity and criticality of modern power systems. Precise time synchronisation, low-latency communication, and robust network design are crucial for maintaining the reliability and efficiency of electrical substations and broader smart grid infrastructures. As technology advances, these requirements will continue to change and adapt to new realities, ensuring that the IEC 61850 standard remains relevant in the face of new challenges and opportunities.

At Chronos, we are happy to guide you through the often complex and tricky landscape of IEC 61850 and high-precision time synchronisation. This is what you can expect of us:

- A lot of experience. We have been around for over 35 years, accumulating a lot of knowledge about various timing issues (network design, atomic clocks, sync audits, time and frequency distribution, SiteTime, CentreTime, CityTime, TrustedTime).
- We have a global footprint and contacts or partnerships with all the major industry players. At the same time, we are accessible and not enormous (30+ employees). Count on quick response times and a lot of personal attention when it comes to solving all your timing issues.
- Working closely with our customers and their evolving requirements, our team of technical experts provide complete solutions from network design, solution specification, installation and commissioning, and 24/365 support, delivering the best possible performance for timing and navigation applications.

More information

Would you like to know more about IEC 61850 and its relation to timing issues? And would you like to discover our services and expertise? Then don’t hesitate to contact us. Give us a call at +44 (0) 1594 862200 or send an email to sales@chronos.uk.