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White Paper
safetime

Will the future power industry be safe?

WITH

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Risks of Blackout

Smart-grids vs Power Distribution

1µs accuracy

Robust Synchronization Backups from NMI, NPL …

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Time & Energy

Will the future power industry be safe?

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The Risk of Blackout

"Blackout", a scientific thriller by Mark Elsberg, depicts what seems to be one of the darkest power failure scenarios with fake time and desynchronization as its potential perpetrator. The author describes brilliantly a situation in which an unexpected, prolonged power outage occurs causing the gradual collapse of everyday life. Phones, television, and the Internet begin to fail. Communication comes to a halt. Lack of power makes it impossible for gas stations to operate, thus bringing the transport and supply to a standstill. One of the protagonists of the book, an ex-hacker, formulates a thesis on a terrorist attack as a reason behind the blackout.

To understand blackout threat, we must see the difference between what is now and what will happen shortly. The near future new distributed smart grids, which is widely known in the media, is substantially different from the current power distribution systems one. By the definition, it is made up of "*smart grids, where communication between all energy market participants exists to provide energy services, thus ensuring cost reduction, efficiency improvement, and integration of distributed energy sources, including renewable energy*." It brings along numerous advantages but requires a very solid and robust synchronization infrastructure foundation so that we do not allow the better to be the enemy of the good. Critical attributes ensuring smart grid stability include the exact time, stable frequency and theirs highly accurate synchronization.

Smart-grids vs Classical Power Distribution

When it comes to the traditional power industry, electricity is generated by a power plant (the production), distributed by an operator (the distribution), and finally, it's us (the consumers). One-way power supply to homes and plants has worked out perfectly well for over a hundred years; today, however, it is no longer enough. The developing economy necessitates a growing electricity demand. Infrastructure development related restrictions are also emerging. A discussion of solutions is hindered by the need to protect the environment, which is to serve future generations.

Fortunately, what we are witnessing are changes and transition of the power industry to a new era of Industry 4.0. Today, photovoltaic panels are installed on roofs, we see a growing number of landscapes filled with a wind turbine or biogas plants. These new sources allow us to increase the pool of energy to be used by society.

The primary role of standard power plants will be reduced in the intelligent distributed power industry of the future, Electricity will be generated simultaneously by multiple equivalent plants. These "power plants" will undoubtedly be located at great distances from each other. Contrary to modern distribution, electricity will have to be transmitted bi-directionally and these directions will change over time on a dynamic basis. Principles similar to railroad traffic management will apply here with the difference being that the equivalents of the "switches" must be switched simultaneously on both sides of the "track" with an accuracy of a millionth of a second (microsecond, 1μs). This operation is carried out by IED (*Intelligent Electronic Device*) relays – - the switches. It's challenging Elproma NTS-5000 (www.elpromatime.com) grandmasters to nanoseconds to appoint IEEE C37.238 and IEC61850 norms.

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The accuracy of 1μs for IEEE C37.238, IEC61850

Why is the 1μs accuracy of such great significance? A longer interval leaves the transmission line open for too long, causing a power outage. Since there are a lot of simultaneous power producers and consumers in a smart grid, time and synchronization of IEDs relay switches are particularly important. In addition to local deficiencies, mismanagement may lead to undesirable accumulation of surplus energy. Energy management will be based on balancing energy surplus and deficiency. Extreme levels of these parameters may trigger safeguards leading to an uncontrolled domino effect of failure that may even result in a blackout. There can be neither too much nor too little energy in the system. The network must always contain "just the right" amount of energy which itself is seamless and time-varying. Smart grid control will probably focus on minimizing the losses and maximizing the efficiency of power transmission (active power vs. reactive power). This goal is achieved both through the ability to make a precise impact on the efficiency of current generating sources (e.g. one can either slow down or periodically switch off wind turbines to ensure protection against energy surplus), and through the dynamics of changes in power distribution line connections paths completed with the use of IEDs. Therefore, to make the right decisions one should the actual condition, a definite piece of information "here and now" - both on the local and remote levels.

Phasor Measurement Units (PMU) equipped with local clocks are used to measure the status of the current. As in the case of IEDs. i.e. connection setup devices. The system monitoring process assumes that the post-filtering information (e.g. data arriving with an unacceptable delay) is very likely to reflect the actual energy condition. On this basis, the control station extrapolates the situation at the next moment in the future by issuing line control instructions to the IED. This is how time-varying variable, dynamic power transmission structure in the smart grid, the stability of which depends on time and synchronization.

Note: https://www.gsa.europa.eu/newsroom/news/demetra-delivers-dividends-elproma

As the results of DEMETRA Project 2015-2016, Elproma has developed new range of PTP servers for smart-grids including NTS-5000 grandmaster and new NTS-pico3 family of slave time servers.

Until quite recently, it was thought that synchronization would be ensured by a GPS (or other GNSS) system. However, it turned out that jamming the GPS signal is not that big of a challenge and can be completed with the help of inexpensive, so-called jammers available widely across the Internet. One may also falsify the GPS signal by substituting his own time and position data. This technique is called "*spoofing*" and it forms a particular risk to the smart grid energy industry since jamming can be counteracted while spoofing is not so easy to identify and fight. Effective spoofing results in a miscalculation of delays of PMU data incoming via a computer network. This will generate unwanted rejection of the correct information and incorrect acceptance of the bits of information traveling too long. Consequently, energy mismanagement will exist that may cause a failure or even a blackout. Loss of the true chronology of events in the LOGs due to desynchronization will become an additional problem. This, in turn, will make it impossible to identify the problem because as it will disturb the logic during the analysis process. In desynchronized LOGs, one may observe a strange phenomenon in which "the effect precedes its cause."

Robust synchronization backup from NMI & NPL

Hence, wherever the safety of economically important systems is at stake, hybrid methods for delivery of time should be applied with the use of GNSS satellite systems and a local atomic cesium clocks at the same time. Official time set in national metrology institutes in the majority of countries will play a specific role. In Europe, this role has been played for 100 years by the Royal Observatories, National Physical Laboratories and Central Office of Measures. In US such role belongs to NIST.

The distribution of official time via network, i.e., an atomic reference UTC pattern featuring high accuracy and first and foremost stability (invariability) levels, is a very difficult technical task with only several countries capable of dealing with this problem nowadays. The UK, Italy, The Netherlands, Poland, France, Germany belongs to a group of well-prepared European countries. The dissemination of the national time scale UTC(k) is nowadays more frequently than ever before. Finally, the EU GALILEO is slowly acting EU official time reference that together with GPS and national UTC(k) network time distribution with special time auditing facility creates new powerful and robust synchronization reference for smart-grids.

It is believed that the native power industry evolving towards smart grids will rely on this solid foundation of time and frequency. The main and regional systems must be protected tamper-proof and protected against external interferences – the time and synchronization must be safe.

Finally, let's go back to the classic power industry and try to figure out if and where it requires accurate time and synchronization. Today, the most important place where synchronization is required is the classical generator turbines. They must rotate simultaneously – precisely 50 times per second – to generate 50Hz AC voltage.

Moreover, accurate time is needed to supervise the distribution and automated readouts (the so-called a smart metering) and measurement processes. Time is also used by billing and automatic point location systems on high wear and tear lines and high transmission line interruption risk. However, in these cases, there is no need for synchronization with high accuracy. Although no high-accuracy synchronization is needed in the aforementioned cases, the Industry 4.0 smart grid power generation will require the provision of an identical time pattern over an extensive (the so-called the time domain) area to allow each distributed, equivalent power source to generate 50Hz AC voltage. This frequency is defined by a technical standard documents and protected by law. For this reason, we would like to re-emphasize the current and future important role of time and National Measure Institutes providing official UTC time.

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