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USING SYNCHROPHASORS TO MONITOR THE QUALITY OF ELECTRICAL ENERGY IN ELECTRICAL TRACTION SUBSTATIONS

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***Abstract**: The paper presents aspects related to SCADA systems used for railway electric traction, monitoring the quality of electrical energy from electrical traction substations with the help of synchrophasors and SCADA systems. The SCADA architecture and the method of measuring the synchrophasors, the results obtained by the implementation of these technologies are presented. The SCADA system presented in the paper was applied in the railway energy dispatching station and in the national electric traction substations.*

***Key words**: electric traction substations, synchrophasors, supervisory control and data acquisition(SCADA), global positioning system (GPS), wide surface monitoring system (WAMS)*

1. Introduction

Traction substations are power plants where the electrical energy received from the power supply system at 110-220kV is adapted to the needs of electric traction and supplied to the contact line as a single-phase current of 25kV.

The electric traction is defined as the propulsion of vehicles with the help of electric motors fed by a contact line from electrical traction substations [1].

The electric cab is a propeller that transforms the electrical energy captured from the contact line into a mechanical work. Since the electricity supplied and the power dissipated cannot be separated, the quality of the electrical energy provided by the traction substations of the electric locomotives directly influences the efficiency of the electric motors.

Continuity in power supply and voltage level are the main parameters for determining the quality of electrical power. It has been shown that the 10% decrease in the supply voltage of an electric motor produces a reduction of the efficiency by up to 30%.

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2. SCADA Operation in Electric Traction Substrates

The SCADA system is designed to provide all the remote control and remote control functions of the power installations of the electric traction substations

The structure of the system is shown in Figure 1:

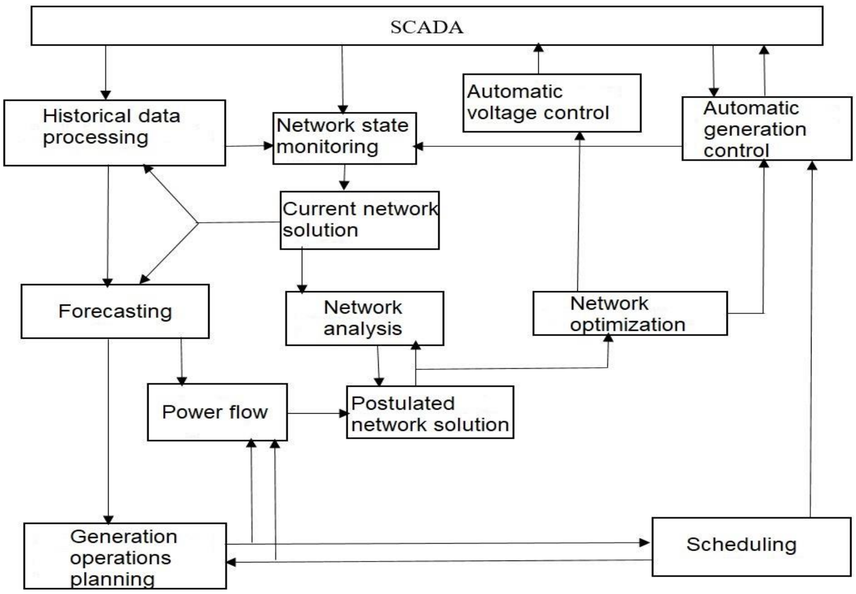

Fig. 1. *SCADA functions in a power system*

SCADA systems must be able to integrate at the software level the full range of functions required for the operative management of energy processes:

- operative tracking;
- event management;
- archiving;
- energy balance adjustment;
- status analysis;
- operator guide;
- diagnosis;
- economic functioning, etc.

All these functions aim to optimize the operation and operative management of systems as a whole by providing rapid and detailed data primary and processing, giving operators overall images, operative suggestions, and detailed interpretations of the actual situation on the tracked installations [2].

Distribution Management Systems (Distribution Management Systems) must provide primary operators with the tools they need to carry out the following global tasks from an economic point of view:

- Reducing financial losses and damages due to incidents, damages, disruptions;
- improving the quality of service;

- The possibility of postponing investments by better use of existing installations / equipment;
- minimizing energy losses;

DMS provides operators with two basic tools to enable operators to perform their tasks:

- Supervision capability, command - control and automation of the network;
- the ability to retrieve information from all computer systems.

3. Wide Area Measurement Systems (WAMS)

Wide area measurement systems include: advanced measurements, information tools and operational infrastructure that facilitate the understanding and management of the increasingly complex behavior presented by power systems. A WAMS can be used as an autonomous infrastructure that completes conventional supervision of surveillance and acquisition of system data. As a complementary system, a WAMS is specifically designed to improve the operator's real-time information about the status of the parameters. This is necessary for reliable and reliable network operation, to increase the quality of the supplied power.

Significant parts of WAMS are the units of measure (PMU). These are devices that provide voltage and current phasors measured at a certain plant synchronized with Global Positioning System (GPS) satellites.

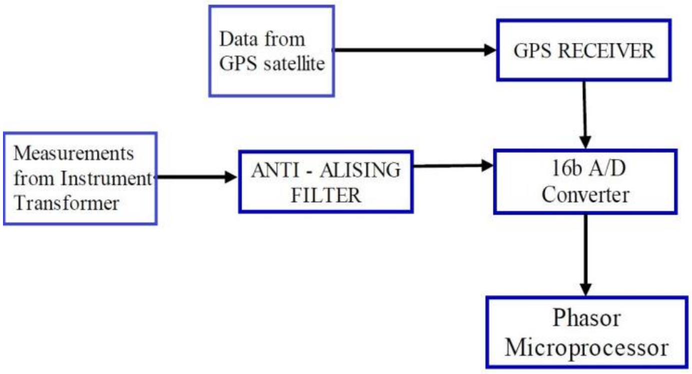

Fig. 2. *Basic architecture of a PMU*

A phasor is a mathematical representation of a sinusoidal waveform. The magnitude A is either the peak value or the RMS value of the sinusoid. The phase angle θ is determined by the sinusoidal and time reference frequency. This reference is arbitrary and is generally chosen to be convenient for particular situations.

Synchrophasors are phasors located at different points in space, defined by a unique time reference, established using GPS. Of course, the phase of a synchrophasor must be corrected so that it takes into account the delays caused by any type of timing introduced in the process of measuring it [3].

The angle of a synchrophasor is uniquely determined by the waveform, frequency system and measurement time. Thus, with a precise universal reference time, the angles of the power system phase can be accurately measured over a power system that brings a new perspective to the monitored power supply system [4].

The WAMS system is primarily designed to monitor global real-time EPS, it can perform between 6 and 60 measurements per second, and is ideal for measuring system dynamics. A great deal of information can be obtained at these rates using the PMU[5]. Figure 4 shows a wide area measurement systems using PMU and phasor data concentrators (PDC).

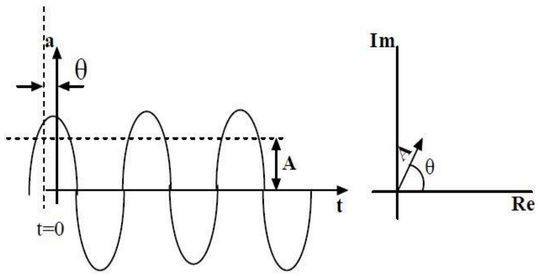

Fig. 3. *Phasor representation of sinusoidal waveform*

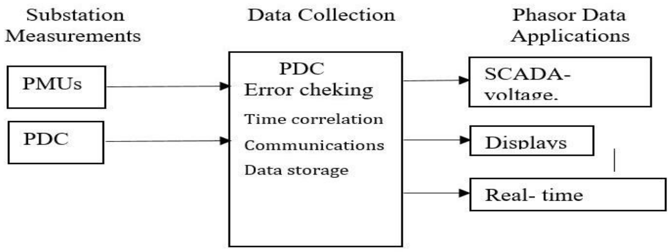

Fig. 4. *Wide area measurement system using PMUs*

PMUs are considered an important technology used by WAMS. This is why PMUs are installed and tested in different countries, applications such as real-time monitoring and post-disruption analysis demonstrate their importance [6].

In a general manner, PMU applications (Figure 5) can be divided into four major areas: state estimation, protection, surveillance and network control. These sections are neither exclusive nor exhaustive. In fact, a measure given by a device for the status estimator can also be used for a loop machine control or fact.

Status evaluation has become a critical function of the power application and power control centers. WAMS with Phase Measurement avoids convergence and topology errors encountered with traditional estimation.

The most commonly used estimation of phasor is discrete Fourier Transform (DFT). This technique uses the Fourier standard estimation applied over one or more cycles at the rated frequency of the system. With a sufficient and accurate sampling rate synchronized with UTC, it produces a correct and functional phasor value for most system conditions.

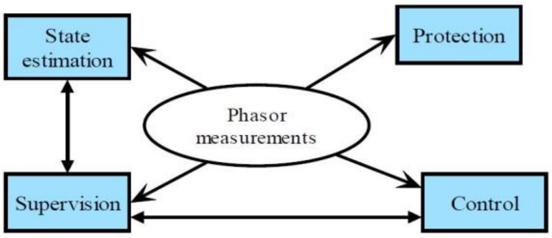

Fig. 5 *PMU application domains*

System control uses the progress of using the synchronized phaser, especially in an interconnected power system. The introduction of Phase Measurement Units (PMUs) into electrical traction substrates significantly improves the possibilities of monitoring the dynamics of the feed system. A number of synchronized phasor terminals installed in different locations of the power system provide important information about the power parameters, such as voltages, currents, active and reactive power, all based on the same GPS time reference.

4. SCADA and WAMS for Reliable Power System Operation

For secure power supply operation, the two monitoring systems (SCADA and WAMS) must work together perfectly. Data from all network components is collected using SCADA. You can build a status estimator to have a real-time performance image. This influences all the functions involved in system operation, as illustrated in Figure 6

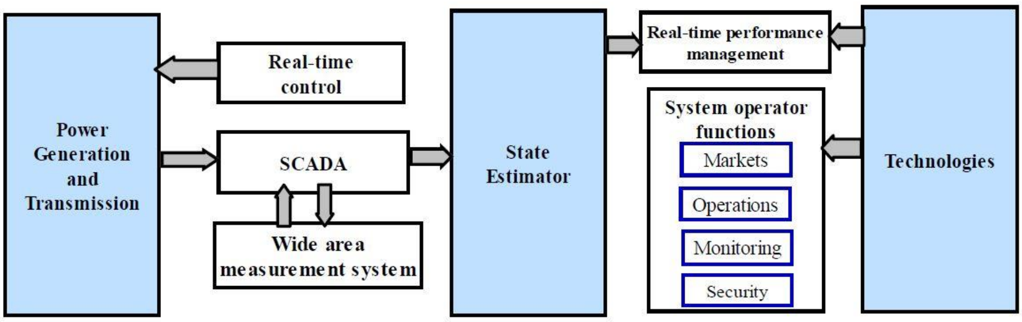

Fig. 6. *Power system operation*

Status evaluation, as a major function in any monitoring system, has shown improved action by using the PMU. Data from the interconnected electrical system is synchronously received at the state estimation center. Figure 7 shows a SCADA / PMU hybrid system to show the interactions between these two systems.

5. Conclusions

The energy management system, which is also the SCADA control center, is the heart of the network system. Its primary objective is to inform the system operator about the current state of the electrical network, to recognize possible threats to the integrity of the network. To avoid these threats, the SCADA state estimation function needs to continually improve. A solution, presented in the paper, is the real-time deployment of phasor measurements, it can be exploited to provide greater system security and stability. Synchronized use of SCADA / PMU data makes this system one of the most powerful monitoring tools and the control of the electric power provided by the electrical traction substations of the railway electric transport. The use of the current system conditions and the possibility of anticipating the problems before their appearance makes this system implemented at national level on the entire railway infrastructure.

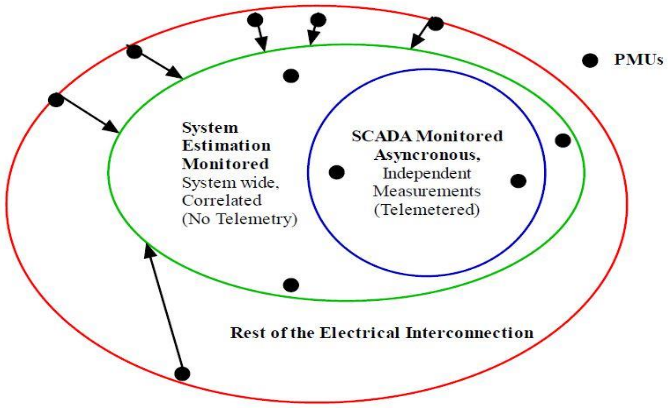

Fig. 7 Power grid monitoring

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