Modeling of a data exchange process in the Automatic Process Control System on the base of the universal SCADA-system

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Abstract. In the present paper the authors discuss some ways of solving energy saving problems in mechanical engineering. In authors’ opinion one of the ways of solving this problem is integrated modernization of power engineering objects of mechanical engineering companies, which should be intended for the energy supply control efficiency increase and electric energy commercial accounting improvement. The author have proposed the usage of digital current and voltage transformers for these purposes. To check the compliance of this equipment with the IEC 61850 International Standard, we have built a mathematic model of the data exchange process between measuring transformers and a universal SCADA-system. The results of modeling show that the discussed equipment corresponds to the mentioned Standard requirements and the usage of the universal SCADA-system for these purposes is preferable and economically reasonable. In modeling the authors have used the following software: MasterScada, Master OPC_DI_61850, OPNET.

1. Introduction

Energy saving is one of the modern developing areas of mechanical engineering. It is a global problem which scientists and engineers face continually in all mankind activity fields. The efficient progress of mechanical engineering is also impossible without an integrated energy saving approach taking into account that as a rule the energy part in the cost of a high technological product is relatively high and the actual task is its reduction in fabricating of high competitive products. An energy saving problem solution should be discussed in the wide aspect spectrum. To save energy in mechanical engineering not only the production technology [1], but also all processes of automatic control of the electric energy supply and accounting [2]should be efficient. This energy saving area is characterized by the development of Smart Grids – a new technological type of electric grids with more advanced efficient reliability and controllability parameters.

This approach considers the combined modernizing of electric grids of electric engineering companies [3, 4], automation of power engineering objects, transfer to the adaptive control system, elimination of manual control.

This process includes the usage of the smart electric energy accounting devices, application of digital measuring current and voltage transformers, development of fully automated digital substations design of new solutions, equipment, systems and methods of power transmission lines and transformer substation monitoring. Due to these demands we put forth our efforts in the applied scientific research and experimental works in the development of Adaptive Digital Combined Current and Voltage...
Transformer (ADCCVT) being the base of a smart electric energy accounting system of a substation [5].

2. Research Tasks
Substation Automation Systems (SAS) traditionally provide the servicing of the consumption current value; substation buses voltage control; switching apparatus status control; breakers; disconnectors; relay protection device control; telecontrol.

Such function set in the modern conditions is sufficiently limited and does not meet the current requirements in the power engineering object automation area. Since most of the objects recently began using the SCADA technology (Supervisory Control and Data Acquisition), we have obtained the ability to extend the SAS functions. The specific requirements should be applied to the technical software architecture.

IEC 61850 International Standard regulates the presentation of data about the substation as an object of automation, and the protocols of digital data are exchanged between the microprocessor intellectual electronic devices (IED) at the substation. The appearance of the mentioned Standard had become a challenging reason for the development of new generation of substations – a digital substation. A digital substation contains ADCCVT and has a structure as shown in Figure 1. Figure 1 is indicated by: I – Process level: 1 – switching substation, 2 – ADCCVT, 3 – switching devices, 4 – merging unit, 5 – remote terminal unit; II – Bay level: 6 – bay controller, 7 – relay protection and automation, 8 – others IEDs; III – Station level: 9 – server SCADA, 10 – workstation of operator.

![Figure 1. ADCCVT in the structure of the digital substation.](image)

Today it is high time to improve the whole spectrum of SAS parameters with the help of mathematic modelling and their deep research: high cost of equipment, long IED development and fabrication time, low universality of equipment. Fabricators of IED often interpret the IEC 61850 Standard
requirements in their own or even not in the right way, in the area where the model and the structure of data exchange between different IEDs are being described. In accordance with the differences in Standard understanding, the differences in the IEDs operation also appear. Thus the right modelling of the data exchange process may eliminate the errors or differences at the very basic stage of its development. As a result the ADCCVT – SCADA communication channel should provide the speed performance, synchronizing and noise immunity of metrological information transmission in accordance with the unified platform of IEC 61850 data exchange. The physical topology of Ethernet grid of the digital substation should be taken into account whilst developing its structure.

3. Modeling

SCADA-systems of power engineering objects today collect and archive all incoming data with a minimal available step without losing the information and protecting an unauthorized access, providing the recovery of the system operability after software or apparatus failure. This data set is excessive as a rule, however the information redundancy is directly connected with its quality and processing capabilities. This in turn allows presenting the information about the power object condition on all workstations of operators in the real time mode providing the scalability of systems.

Modeling of the data exchange process allows correcting all time delays, possible data losses, preliminary equipment adjustment. In case of the high accuracy ADCCVT provides a 0.2S accuracy class for current and 0.2 – for voltage, the time delays for the message transmissions are critical, as the measurement frequency is 12800 Hz. Each measurement in the high voltage part of ADCCVT needs 14 bytes. Accordingly the transmission data speed from the high voltage to low voltage part is 1400 Kbit/s. After transmission to the low voltage part, data are being transferred to the merging unit. Stream IEC-61850-9-2LE is being formed in the device – 4 currents and 4 voltages with the step of 80 points per period (for relay protection and automatic) and 256 points per period (for power quality and measurements). The speeds of transmission are 4 and 9 Mbit/s correspondingly, which require the increase of data processing time and grid operation delays.

We built a full model of the data exchange process in the ADCCVT–SCADA communication channel. In accordance with Figure 1 the structure of data exchange between ADCCVT and SCADA-systems includes a merging unit, process bus, relay protection and station bus. We modelled an OPC-server on the base of Master OPC DI_61850 (Figure 2), which simulated the operation of the merging unit. These messages of the IEC-61850-9-2 format were received by a universal Master Scada SCADA-system. To model the microprocessor relay protection operation, MasterScadarecoded the obtained data into MMS-messages of the IEC-61850-8-1 format.

![Figure 2. Window of Master OPC_DI_61850 operation.](image)
After recoding the SCADA-system is visualizing the measured current and voltage values. The charts are presented in Figure 3.

Figure 3. Window of SCADA-system operation. The charts of current and voltage.

Modelling also allows the preliminary adjustment of IEDs. To model the IED it is required to generate a SCL file describing in detail the operation of this device. Probable time delays during the data exchange between IEDs were programmed in the OPNET software. The window of the project is shown in Figure 4.
Results and Discussion

After modelling we took into account the following data: power of equipment (both grid and IEDs), minimum and maximum time of delay of the SCADA-system reaction on data received from ADCCVT. The results have shown that all data transmission delays for the used in the model IEDs meet the requirements of IEC 61850 Standard. The results are shown in Figure 5.

![Figure 4. Window of the project in the OPNET software.](image)

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![Figure 5. Dependence of delays in the ADCCVT – SCADA system on time whilst increasing the loading.](image)

The specific obtained result is a proved capability of universal SCADA-system usage for digital substation control. This is explained by the fact that although IEC 61850 Standard is oriented at integrated automation of substations and requires the functional compatibility of substations and a software from different developers, the consumer today can purchase mostly the software-hardware complex sets from leading World brands compatible with the mentioned Standard. Notwithstanding the declared compatibility with the Standard the software of the upper level in such complex set
prefers’ as a rule the data exchange with its ‘native’ devices. Due to the usage of the OPC-server compatible with any equipment meeting the requirements of IEC 61850 Standard, we can provide the capability of usage of universal SCADA-systems from any developers, which as a rule is more functional and less expensive than the software from ‘equipment fabricators’.

5. Conclusion
The described research has resulted in the following conclusions:
1. Energy saving is one of the important problems to be solved in mechanical and power engineering.
2. Mechanical engineering has wide perspectives in the search of energy saving ways.
3. One of the ways of solving the problem of energy saving in mechanical engineering is the intellectual electric energy accounting.
4. An increase of electric energy commercial accounting automation level could be reached by the development and usage of digital measuring current and voltage transformers.
5. To control the power engineering objects it is preferable to use the universal SCADA-systems which in most cases have more functionality and less price compared with SCADA-systems from equipment developers.

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References
[1] Pavlov K S and Khobotov E N 2015 Journal of Automation and Remote Control76(2) 292–303
[2] Furugyan M G 2015 Journal of Automation and Remote Control76(3) 487–492
[3] Genin V S, Koznov V V and Fel’dman S O 2015 J. of Russian Electrical Engineer.86(2) 79–82
[4] Berg V R and Gurov A A 2012 J. of Russian Electrical Engineer.83(1) 35–38
[5] Solomin E V, Topolskiy D V and Topolskiy N D 2015 Integration of adaptive digital combined current and voltage transformer into digital substation Ethernet grid Control and Communications (SIBCON), International Siberian Conference (ISBN: 978-1-4799-7102-2)