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APPLICATION OF AUTOMATIC CONTROL AND ELECTRICITY MEASUREMENT SYSTEM IN TRACTION POWER SUPPLY SYSTEM

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ABSTRACT

In that work the methods of organization an automatic control and metering system for electricity (ACMSE) in the traction power supply system of electrified railway transport are presented. We consider the installation of electricity metering devices on an electric rolling stock, similar in their metrological characteristics (accuracy class, minimum interval of reading, etc.). The definition of the level of consumption, specific consumption and unbalance of electricity for the traction of trains is given. Also, consumption of active and reactive electricity, power losses in the traction network, and the magnitude and duration of the regeneration regimes in AC sections are determined. The estimation of the level of power loss in the traction network under various schemes of connection of traction substations (circuits for connecting two-way and one-way power supply of the contact network) is considered.

KEYWORDS: *Control, accounting, Traction network, Reactive energy, Alternating current, Block diagram, Functional diagram, Synchronization, Measuring unit.*

INTRODUCTION

Today, railway transport is one of the most energy-intensive sectors of the economy of Uzbekistan. Therefore, the cost of energy savings is very high, given the constant growth of the electrified line landfill and the rise in electricity prices.

In this regard, the issue of introducing new technologies comes to the fore:

Firstly, these are technologies for improving electric traction systems, which make it possible to provide both the required load density, and high-speed traffic, and a decrease in energy consumption in operation;

Secondly, it is the implementation of controlled energy consumption, which is directly related to the creation of automated commercial accounting systems and energy-optimal transportation process.

The modes of operation of electric traction systems and external power supply, power flows and power quality, optimization of the power range of traction substations play a significant role in the automatic system for monitoring and metering electricity.

An effective means of reducing electricity bills is a high-tech commercial metering of electricity based on modern high-precision electronic meters, as well as servers and converting modems. This will create a modern 4-level automatic electricity metering system [1].

In general, the commercial metering system allows you to see the real consumption of electric energy in all areas of the railway transport.

Thus, by controlling this process, it is possible not only to significantly reduce the cost of purchased electricity, but also to ensure a decrease in consumption both in operational activities and in traction power supply [2].

To solve the issue of on-line monitoring of the distribution of electricity in the traction power supply system, it is required to carry out technical accounting together with the commercial metering of electricity, namely, to control the consumption of the overhead line feeders (OLF). Such an automated electricity metering system at the overhead line feeders (AEMSOLF) will allow not only to determine the amount of losses and the amount of imbalance, but also to identify power flows between substations that cause additional losses.

MAIN PART

Currently, when analyzing the operating modes of traction power supply systems, analytical and probabilistic-statistical approaches are used. Methodology, theoretical content and information and technological support for the functioning of automated control systems for electricity consumption in terms of traction power consumption are built only on the basis of information received from ACMSE [3].

The development of electricity metering systems at the overhead contact network feeders will make it possible to quickly analyze the operating modes of the traction power supply system as a whole, to compare the current indicators at adjacent substations, which will make it possible to analyze the electrical parameters of the networks.

The network of multifunctional electricity meters, synchronized with each other, located in various nodes of the power system, will provide real-time information about the current state of both individual objects and the entire power system as a whole. The proposed technique can be used both for determining the parameters of electrical modes and for the parameters of equivalent circuits of the traction network [4].

The task of obtaining synchronized measurements, which arises for distributed objects of the electric power industry, can be solved using the standard synchronization system existing in the data transmission system of “АО «ЎТЙ»”. This system provides synchronization accuracy up to 0.1 s. Global systems GLONASS and GPS make it possible to increase the synchronization accuracy by several orders of magnitude.

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The functional diagram of the electricity metering system on the overhead line feeders is shown in Figure 1. It is proposed to keep an operational record both at the terminals of rectifier (rectifier-inverter) converters, and at each feeder of the contact network [5].

Data from each meter is transmitted to concentrators, which store information for a given period, create archives, and transmit information to the upper level of the information system.

To implement the electricity metering system, the concentrators are connected to data collection and transmission devices (DCTD), to which AC meters of the ACMSE system are already connected. The use of ACMSE subsystems will allow to synchronously determine the consumption of electricity, both received from the external power supply system and supplied to the load. This approach makes it possible to determine the unbalance of electricity for each substation and to correct the level of unbalance in the contact network.

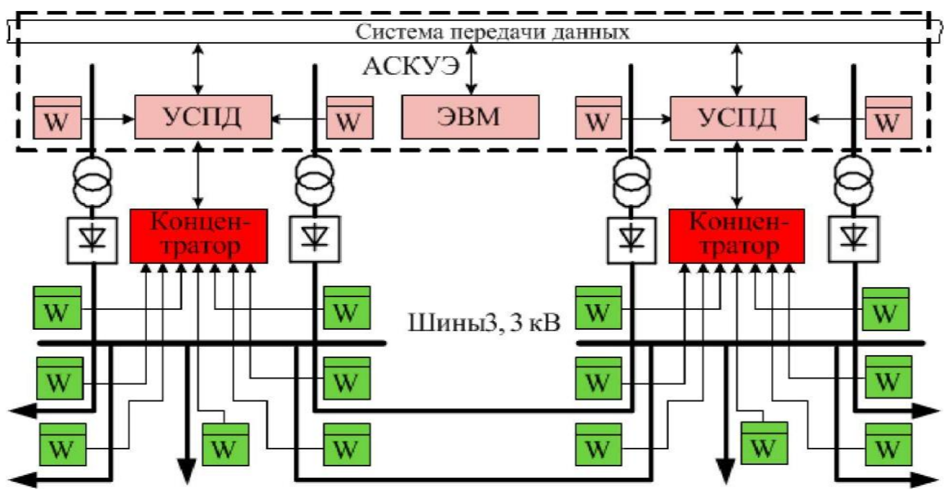

Figure 1 Functional diagram of the electricity metering system on the overhead line feeders

The block diagram of the electricity metering system on the overhead line feeders (OLF) is shown in Figure.

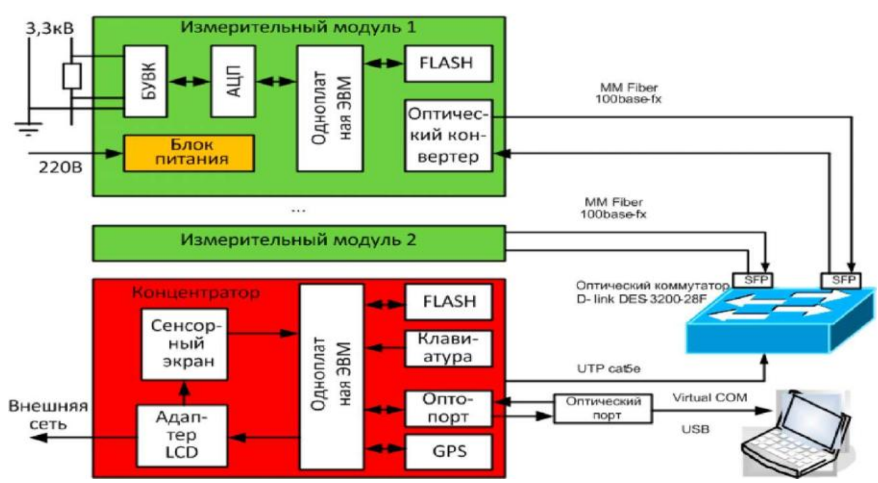

Figure 2 Block diagram of the electricity metering system on overhead line feeders.

The block diagram is built on the principle of a distributed computing system, which is determined by two independent conditions. The first condition is the galvanic isolation of the analog signal input circuits from the digital output circuits of the processed data with high requirements for the breakdown voltage. The second condition is that as the data is processed, the methods of this processing change, i.e. when analog signals are input, a continuous stream of data converted to digital form with uniform sampling is formed, however, after receiving the main calculated values, the task of archiving, managing data transfer protocols and managing the entire system as a whole appears. Therefore, the electricity metering system is divided into two parts.

The measuring unit consists of three parts: an analog-to-digital converter (ADC), a processing unit and an optical interface. The ADC converts signals proportional to voltage and current into digital readings. It provides temperature compensation for the error, as well as periodic correction of the additive error. The ADC is connected to the processing unit via the SPI interface. The measuring unit measures current and voltage signals, calculates active power based on instantaneous values of current and voltage signals, calculates effective values of current and voltage, load graphs. The data output period is 5 s, which facilitates the further calculation of the consumed energy.

The processing unit is implemented on a single-board computer "Tion-pro-28", which provides maximum processing, efficient distribution, archiving of data, and control of the device as a whole and support of exchange protocols via digital interfaces. This microcomputer is a highly integrated device and contains almost all the necessary ports to implement communication interfaces.

Data transmission to the hub is carried out using a fiber-optic communication line. The fiber-optic interface is based on the Net link HTB-1100 optical transceiver and the D-link DES-3200-28F optical switch. Information transfer is carried out using the Ethernet interface, which ensures high data transfer rate. The optical switch allows connecting up to 24 measuring units to the hub.

The concentrator is designed for collecting data from measuring units, archiving, building consumption graphs, and additional information processing, and calculating electricity consumption throughout the substation. Display of current values and local control is carried out using a touch screen. The optical port is a technological one and is intended for loading, debugging and configuring the program in the microcontroller.

The AEMSOLF communication via the existing DCTD with the upper-level subsystem is carried out via the RS-485 interface using the Modbus RTU protocol. The top-level software required for the operation of the system is installed on the same servers that are used in the ACMSE. The structure of the AEMSOLF hardware is given in the work published in the journal "Ecological Systems" [6].

Installation of electricity metering devices on electric rolling stock, similar in their metrological characteristics (accuracy class, minimum interval for taking readings, etc.) to measuring devices installed on the overhead line feeders, as well as providing the possibility of real-time monitoring of the location of electric rolling stock, will allow:

1) Determine the level of consumption, specific consumption and imbalance of electricity for traction of trains:

- Within the boundaries of inter-substation zones;

- Within the boundaries of service areas for locomotive crews;

- On the sections of the races of locomotive crews of adjacent railways;

- within the boundaries of tariff zones.

The availability of a database on electricity consumption at these sections, together with information on restrictions on the speed of train traffic, the provision of "windows", areas for the use of regenerative braking and other factors affecting the organization of train traffic will allow the development of targeted measures to improve the main indicators of the efficiency of using electric rolling stock and reduce the specific consumption of electricity for traction of trains according to the meters of traction substations, which in turn will lead to a decrease in the cost of the transportation process.

2) Determine the consumption of active and reactive electricity, electricity losses in the traction network, the magnitude and duration of the recuperation modes in the alternating current sections, which in turn will allow:

- To ensure quality control of the train running by the locomotive crew by monitoring the consumed and recovered electricity at the sections alternating current;

- To determine the standards for electricity consumption for running a train along a route with a complex track profile.

To estimate the level of electricity losses in the traction network for different schemes of connecting traction substations (schemes for connecting two-sided and one-sided power supply of the contact network), which in turn will make it possible to single out the values of equalizing currents (inequality of voltages on substation buses, power transit through the contact network) at different schemes for connecting traction substations and thereby determine the directions of combating them.

3)Obtaining the specified data will make it possible to promptly make decisions on the need to repair sections of the traction network, strengthen the elements of the contact network and develop instructions for locomotive drivers aimed at increasing the efficiency of using electricity for traction of trains.

4)The purpose of organizing electricity metering at the feeders of the catenary traction substations is to accumulate a database on electricity consumption for traction of trains for the development of organizational and technical measures to reduce the specific consumption of electricity for traction of trains, as well as to clarify the structure and reduce the level of unbalance of electricity for traction of trains, adopted by the meters traction substations and consumed by electric rolling stock counters.

FINDINGS

It has been established that the excess of the value of the unbalance of electricity for traction of trains over technological losses is spent on traction of trains uncontrollably, and, therefore, irrationally, ensuring control of this consumption of electricity will reduce the consumption of electricity for traction of trains according to the meters of traction substations.

It is shown that the simultaneous implementation of the AMSE OLF and AMSE EPS projects will make it possible to determine and further exclude from the structure of the unbalance of electricity for train traction the share of the commercial component of electricity losses caused by the error in metering, receiving and distributing electricity on 27.5 kV buses.

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