Service system and monitoring of information terminals for protection of railway lines of long-distance trains

S M Kuznetsov¹, A V Myatezh¹, M V Rozhkova¹, S A Tenkovskaya², E V Akifeva³, A V Ivanov³

¹Novosibirsk State Technical University, 20, Karla Markska Av., Novosibirsk, 630073, Russia
²Industrial University of Tyumen, 38, Volodarskogo str., Tyumen, 625000, Russia
³V.A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences, 65 Profsoyuznaya street, Moscow, 117997, Russia

E-mail: mbv5@mail.ru

Abstract. The paper proposes the innovative system of connecting digital terminals to a personal computer of a traction substation and a power dispatcher via remote access thus expanding control and observation over the system and facilitating the operation with In-Ter device. The real time work of In-Ter terminals can be performed by a power dispatcher and can be monitored by an engineer of the technical department of the energy service of an enterprise. This option will allow obtaining useful information quickly and changing the protection settings of a terminal if necessary, analyzing the compliance of loadings, emergency currents and settings in the technical department of the energy service of the enterprise to decrease cases of false activation of protection.

1. Introduction

At present, the railway transport is a strategically important object of economy of any state that has a have a marked impact on the development of the country in general. Over the past ten years the cargo turnover on Russian Railways has considerably increased, alongside with the increase of train mass, modernization of the locomotive park, increase of the service speed, rise of requirements to reliability of the power supply system. The increase of the train mass led to the increase of current loading in contact network. Current loading became commensurable with short circuit currents in a remote point of the traction network, which reduced the reliability of the power supply traction system. The system “traction substation – traction network – electrorolling stock (TS – TN – ES) has frequent failures of its separate elements caused by external influences, human errors, wear of its separate elements followed by short circuits. The latter ones cause currents, which size near TS of railroads electrified on direct current can make 20-50 kA, and in a remote point at tires of a neighboring substation – 2-6 kA. In this case the minimum short circuit currents can be commensurable with long admissible load currents. Emergency modes lead to equipment failures in the place of isolation damage, to increased wear of the switching equipment and to disturbance in train service. To prevent such consequences in a system the protection shall disconnect the damaged element over a centisecond. Protection is a widespread type of automatic equipment ensuring reliable functioning of the system “traction substation – traction network.
– electroring stock”. It is in continuous mode of service or standby for operation. It operates if the control parameters exceed the set value (setting).

Currently there are many types of protection systems, which use the parameters of the traction network (current, voltage, resistance) and the secondary factors (time-current, wire temperature, electromagnetic processes, etc.) connected with operating parameters, certain dependences as control values. Over the past 10 years there appeared many new types of protection systems reacting to two and more indicators: remote, multi-parameter according to indicators of the transition process, which control not only the current of a feeder, but also its change in time, voltage in the traction network and its spectral components. Some types of protection systems provide direct or indirect control over the temperature of a contact wire.

Hence, the system of on-line monitoring of the traction network and control of its parameters seems an extremely relevant task.

When digital terminals were adopted [1-3] to control, automatize and diagnose feeders of the traction network located along the railroad this led to a problem of ensuring continuous monitoring of changes of feeder current and voltage, i.e. monitoring to identify operating features of any part of the traction network, to analyze information on currents and voltage of the traction network and to develop suggestions on the choice or correction of digital protection settings.

The main stages of the traction network monitoring are as follows:
- development of the scheme of continuous monitoring over the studied object (scheme of remote access);
- connection to a digital device and monitoring of the traction network.

In the existing system when PC is connected to a substation the control of a terminal is completely ensured by this PC, and the power dispatcher cannot operate terminals of substation feeders. Remote access – are programs or functions of operating systems providing access to a computer of a substation, and through it to a terminal via the Internet or LAN.

2. Theory
Systematic monitoring of parameters of contact network feeders implies continuous connection of the power dispatcher PC located in the control room with a terminal, for example, TSZAF type (feeder digital protection and automation unit). This task requires the system of remote access, which implies that all devices of digital automatic equipment and protection of contact network feeders are related and connected through a coiled pair via RS-485 interface to the public computer of a substation, and through it by communication channels – to the terminal of the power dispatcher or other central control unit.

Fig. 1 shows the block connection diagram of remote access of the device on the example of experimental TSZAF-3.3 system for railway transport.
Signals from current and voltage sensors get to BZA into the module of the protection controller module (PCM) where current and voltage are measured and derivative parameters (resistance, speed of current increment) are calculated. The results are used in protection algorithms and are transferred to the automatic equipment controller (AEC), which transmits them to the control unit (CU) for display representation. The controller processes protection algorithms and makes the decision on emergency shutdown of instantaneous circuit-breaker.

The automatic equipment controller performs the following functions:

- processing of automatic equipment algorithms;
- control over a switchboard cell;
- logic processing of information received from input cards of discrete signals (IC1);
- forms control and alarm signals, which are transferred to output relays and switches in the input card (IC2);
- connects with the control unit, automated control systems and PC via channels in series.

The control unit performs the following functions:

- local control of instantaneous circuit-breaker with indication of its state;
- alarm system of emergency shutdowns;
- display of current information on current and voltage of a feeder in a contact network.
In order to connect to the personal computer of the substation via the com-port a converter of RS-485/RS-232 interface is installed.

The computer is connected to the local network or to an exit into global network – the Internet. Having parameters and passwords from the computer of a substation, it is possible to enter the PC of a substation and to control all processes registered by a digital device in the remote access mode.

This mechanism of implementation, namely the integration into the process of control and management of the remote access system considerably facilitates work with the studied feeder and will allow controlling loads and emergency shutdowns of feeders in real time 24 hours in day, i.e. without delay.

Besides, by means of a special software for a specific TSZAF-3.3, In-Ter or any foreign analog it is possible to record transient values of current and voltage.

The computer continuously registers current and voltage for each feeder. The start and the end of record depends on individual current settings for stationary and emergency modes, i.e. it is regulated as necessary.

3. Experimental results

The connection between digital terminals and PC of the traction substation is formed via the system of remote access (Fig. 2), which allows monitoring and operating In-Ter devices. At the same time the function of control/monitoring of terminals in real time can be built-in in the power dispatcher or imposed on engineers of the technical department of the energy service of the enterprise.

As it is known the digital terminals connected to the computer of the traction substation via the system of remote access opens possibilities for expeditious monitoring and control of In-Ter.

The solution of the objective defines the following algorithm of actions, namely entry to DCS via the Internet, start of a special software, start of a chosen terminal, prescription of the MODBus address to terminals of feeders.

The addresses are assigned depending on the number of the substation feeder of the traction network.

Figure 2. Scheme of remote access to TSZAF units.
The algorithm of address assignment is implemented depending on the number of the substation feeder of the traction network. After the terminal is chosen a researcher or a power dispatcher can control a particular device, change the setting of some feeders if necessary due to changes of a power supply circuit or handling of super-heavy trains, monitor current parameters, control voltage level at certain circuit units, and study data recorded oscillogram archive thus addressing data on the server.

4. Discussion of results
The accumulated data on the condition of a feeder of the traction network shall be analyzed together with train situation over a controlled period of time thus revealing incidents in the chosen intersubstation zone. Upon their analysis these data shall be discussed with competent experts.

Based on the analytical data of oscillograms it is possible to correct settings and to record automatic (remote) change of settings in the parameter chart over the period of emergency situation (for example, movement of a double train, works on railways causing speed restriction, etc.) [9, 10].

5. Conclusion
The proposed and tested complex of control, protection and automation of transport power supply system may be regarded monitoring. Remote access considerably increases the efficiency of new equipment – digital terminals. The number of false shutdowns of feeding switches decreases, the quality of power supply and stability of the TS-TN-ES system increases, thereby increasing the efficiency and performance of the entire system.

References
[1] Bykadorov A L, Zarutskaya T A, Muratova-Milekhina A S 2015 Increase of efficiency of short-circuits fault location in traction networks of alternating current on the basis of information technologies. Bulletin of transport of the Volga region 6(54) 15-19
[2] Filyushov Yu P, Zonov P V, Malozemov B V, Wilberger M E 2011 Energy efficient control of an alternating current machine. The Polzunovsky Herald. 2011 2 45-51
[3] Kuznetsov S M 2005 Traction network protection of SC current. (Novosibirsk: NSTU) p. 352
[4] Kuznetsov S M 2011 Setting of electronic security with simulation model corrected. Transport Science, Technology, Management. VINITI 12 30-34
[5] Kuznetsov S M, Demidenko I S, Yaroslavtsev M V and Krivova A O 2009 Mathematical model study of traction network dynamics of direct-current railway with train starting. / Scientific transport problems of Siberia and Far East. NSAWT 2 324-327
[6] Malozymov B V, Vorfolomeyev G N and Schurov N I 2005 Reliability and diagnosing electrotechnical systems. In the collection: Proceedings - 9th Russian-Korean International Symposium on Science and Technology, KORUS-2005 347-350
[7] Ivanov G Ja, Malozymov B V 2005 Reliable power saving electric drive of wide application. In the collection: Proceedings - 9th Russian-Korean International Symposium on Science and Technology, KORUS-2005 330-332
[8] Shchurov N I and Wilberger M E 2011 Spectral analysis of rectifier unit current for unbalance and non-sinusoidal supply voltage Transport: science, technology, management 12 41-43
[9] Mischenko T M 2011 The mathematical stimulation of transient process in a.c. - system “electric-traction network - LOCOMOTIVE”. Transport: science, technology, management 12 105-109
[10] Anurov V I 2008 Modeling of transient processes in case of short circuit in the traction network and the presence of electric locomotives on the feeder zone. Electro. Electrical engineering, electric power industry, electrotechnical industry 2 16-18
[11] Safiullin R N, Afanasyev A S 2018 Integrated assessment of methods for calculating harm caused by vehicles in transport of heavy cargoes IOP Conference Series: Earth and Environmental Science 194(7) 072011
[12] Afanasyev A S, Egoshin A M, Alekseev S V 2018 Justification of logistical approach application in road safety management *IOP Conference Series: Earth and Environmental Science* **194**(7) 072001