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INCREASING THE EFFICIENCY OF WORK OF LOCOMOTIVE ELECTRONIC EQUIPMENT BY USING PORTABLE DIAGNOSTIC DEVICES

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Annotation. This article discusses the current trends in the development of portable and stationary systems for diagnosing electrical and electronic units of locomotives built on integrated microcircuits, and also presents the authors' own model of a portable diagnostic stand for testing electronic devices and electrical circuits of locomotives.

Keywords: electronic equipment, portable (stationary) diagnostic device, electronic devices, electrical circuits, automated locomotive control, control circuits, driver's controller (KM), locomotive electronics unit (BEL).

Electronic devices and electrical circuits of a locomotive are essential components in the implementation of automated locomotive control.

Correct and durable operation of an electric locomotive is largely associated with the serviceable condition of the electrical control circuits. It has been found that a large share of failures consists of malfunctions of electrical apparatus and the locomotive control circuit. Reliable operation of electronics contributes to the reliable operation of traction rolling stock as a whole to the greatest extent. For example, when studying the distribution of locomotive failures carried out by the Krasny Liman locomotive depot of the Donetsk Railway during 2003–2004, it was found that the largest share was accounted for by equipment related to electronic devices (43%) [1].

It has been found that during locomotive operation the probability of failure of BEL and KM is rather high.

Driver's controllers – Driver's controllers (set-point devices) are intended for use on mainline and shunting locomotives as devices that set, according to the driver's command, the operating modes of the power equipment. They provide control of the speed and direction of locomotive movement [2].

Locomotive electronics units BEL are intended for contactless control of the locomotive electrical circuit. Locomotive electronics units (BEL) include a Ya0.PRTs cell and three USO key cells. The Ya0.PRTs cell, according to the logical signals of the driver's controller, controls the state of the channels of the USO key board and forms an information exchange channel between the BEL and GERSYS units based on the RS-232 standard protocol. The USO cell is intended for switching the power and auxiliary equipment of the locomotive and has six channels (power switches); the maximum current load of each channel (switch) must not exceed 3 A. The BEL unit has a single design solution for all types of locomotives equipped with a position set-point device [2].

If the locomotive is operated incorrectly by the driver, there is a probability that the semiconductor switches of the BEL will fail.

The following main causes of BEL failure in operation have been identified:

1. Short circuit in the locomotive control circuit.

2. A large voltage surge in the onboard circuit above 130 volts (as an example, this may occur when the locomotive is running on one section and starts the second section in traction mode in order to overcome a gradient. As a result of such manipulation, a voltage jump and an increase in currents in the traction-mode control circuit occur, which leads to burning out of the power reverse switches of both sections).

3. Testing with a megohmmeter without short-circuiting the semiconductor circuits of the plug connector disconnectors.

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4. Welding work without disconnecting the power supply of the BEL unit.
5. Poor contact or absence of contact in connectors and communication channels.
6. Overheating of contacts and/or their melting.
7. Electrical current leakage in the power-circuit control circuit.
8. Failure of a radio component due to service life.
9. Insulation breakdown.

The most informative diagnostic indicators of electrical control circuits are those indicators that describe the integrity of the electrical circuit, the absence of a short circuit and the quality of contact.

At present, the most popular, economically advantageous, low-labour, fast, reliable and dependable method of diagnosing control circuits is the method of diagnosing by means of portable or stationary diagnostic devices built on the basis of a computer (Fig. 1). A portable or stationary stand (unit) usually contains a controller (microcircuit) for storing electronic passports (NEP), a programmable microcontroller (microcircuit), an indicator and keyboard, and connecting wires with various interfaces, by means of which, while in the driver's cab, it is possible to synchronize with the locomotive through connectors. An onboard diagnostic system for electrical control circuits should be implemented on the locomotive, which would allow the driver, in emergency situations, to quickly and reliably locate the fault.

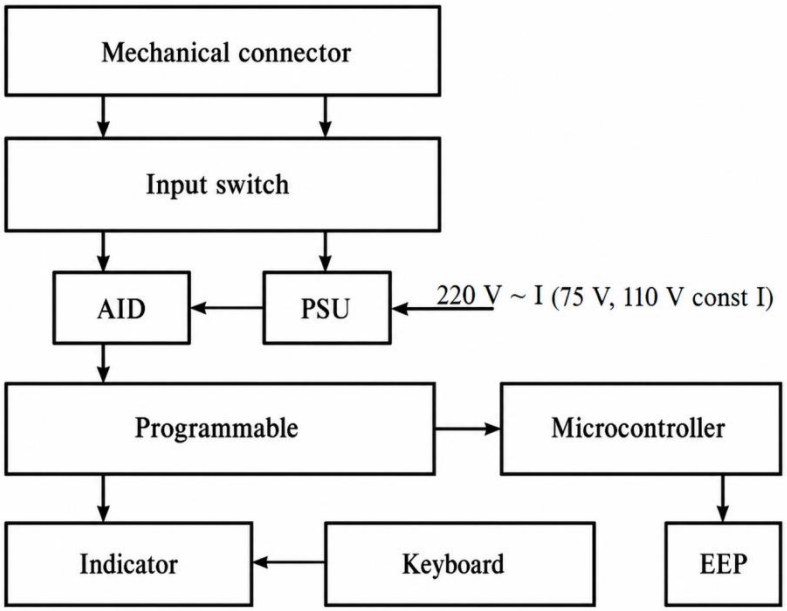


Figure 1: Structural diagram for diagnosing electrical control circuits of electric rolling stock using a computer-based stand: NEP – storage unit on electronic boards; ACI – alphanumeric information display indicator; PSU – power supply unit.

Equipment for technical diagnostics of electrical control circuits of electric rolling stock must meet the following requirements:

— acceptable diagnostic speed and reliability of results;
— provision of communication with external and internal diagnostic systems;
— reliable operation under operating and repair conditions [3].

The algorithm for diagnosing control circuits of electric rolling stock implies dividing the circuit into separate functional blocks.

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For each functional block, its own logic is created, in which its own control points are assigned and given an ordinal number. The numbering order is determined by the sequence of operation of electrical units and apparatus and by the switching of interlocking contacts. Each control point must have an output to the coupling unit with the diagnostic stand [3].

At present, several variants of devices for diagnosing electrical control circuits of locomotives are used on locomotives. From the point of view of joint operation with microprocessor equipment, the greatest prospects are offered by devices manufactured on integrated microcircuits (Fig. 2) [3].

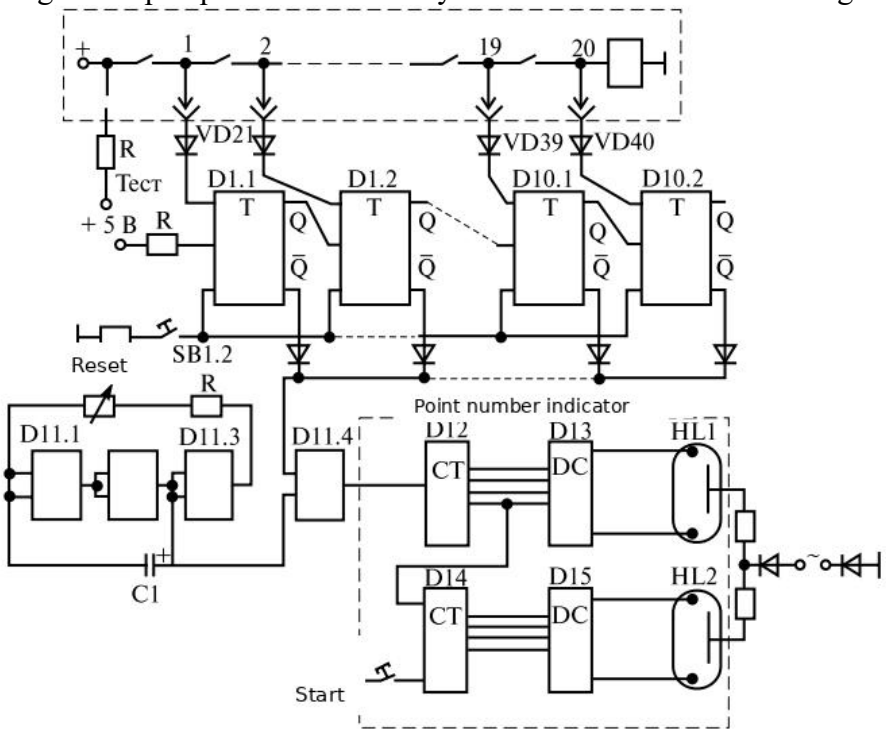


Figure 2: Schematic diagram of an electronic stand for diagnosing locomotive control circuits on integrated microcircuits.

A test signal is sent to the part of the equipment being checked; it passes through diodes VD21–VD40 and is supplied to the inputs of D flip-flops. Then, after processing, the signal from output Q switches on the clock-pulse generator D11 and the digital indicator (D13–D15) [3].

The absence of electrical contact in the diagnosed circuit is identified by the information on the indicator (control point number). When several faults are detected in the diagnosed electrical circuit, the following procedure is used: the first fault is eliminated, the device is returned to the initial position and repeated diagnostics are carried out; as a result, the control points are scanned until the next fault is detected. After completion of the control checks, the quality of elimination of the first and subsequent faults is assessed [3].

Such a stand is connected to the control points of the diagnosed electrical circuit by means of plug connectors, and as a result it becomes possible to evaluate the quality indicators of the insulation of electrical wires.

In the conditions of Uzbekistan, fast and reliable diagnostics of electronic locomotive control systems using modern stands is becoming an increasingly relevant and necessary task today.

The developed portable stand, made on the basis of a computer and microcontroller, makes it possible to carry out rapid diagnostics of BEL, KM or both of these devices in interaction in order to identify faults without dismantling them. This stand is equipped with a programmed microcontroller

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that processes the Gray output code from the position set-point device and also checks the toggle-switch position. Meanwhile, the Gray code is supplied to the BEL. Depending on the set-point position and the toggle-switch position, the BEL opens the output switches, which is displayed on the key indication board of the stand.

The schematic diagram of the stand is presented in Figure 3.

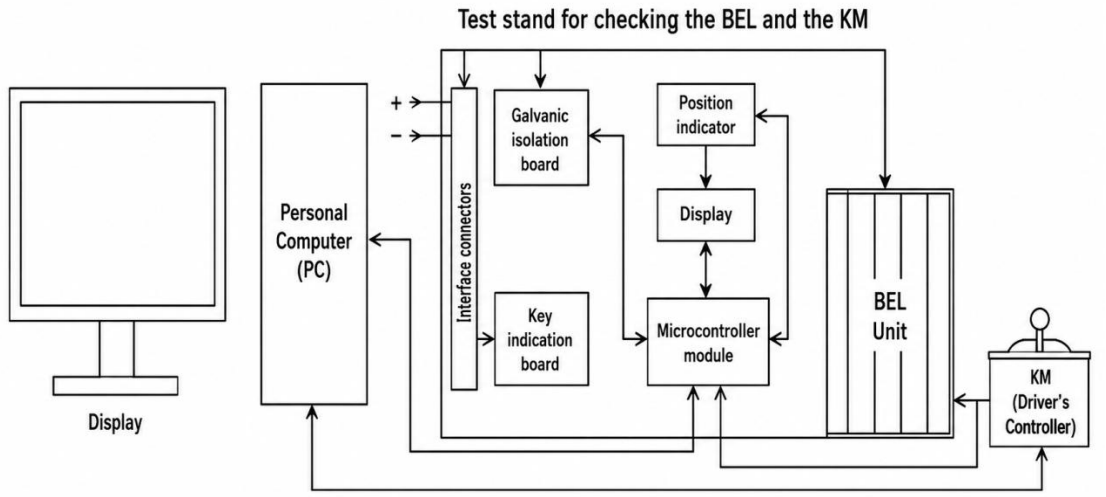


Figure 3: Schematic diagram of a portable stand for diagnosing BEL and KM.

The stand consists of a portable computer with a display, a microcontroller module, a display for showing graphical information about the direction of locomotive movement, a two-digit seven-segment indicator, a key indication board, a galvanic isolation board and a terminal connection block.

The developed stand has a universal power-supply system; therefore, it can be used at repair enterprises as a stationary diagnostic device powered from an industrial AC network with a voltage of 220 V, or it can receive power from the onboard DC network of +75 V or +110 V from the locomotive storage batteries, depending on the locomotive model, and without any energy conversions this stand can be used as a portable onboard diagnostic device for quickly finding faults in the electrical control circuits of a locomotive, for example on route in the event of a sudden failure of the corresponding equipment or electrical circuit.

Software, which is the authors' own development, has been developed for the microcontroller of this stand, and at present testing and trial operation of this stand are being carried out at the "Uztemiryo'lmashta'mir" Unitary Enterprise of "Uzbekistan Railways" JSC.

The stand has the following advantages:

1. The stand has no analogues (a universal power-supply system, proprietary software and the possibility of use on practically any model of locomotive used in the Republic of Uzbekistan).
2. Mobility (portable design).
3. Possibility of powering the stand from the locomotive onboard network.
4. Carrying out checks without dismantling equipment from the locomotive.
5. Minimization of the human factor.

Previously, before the appearance of such diagnostic tools, when the BEL failed it was necessary to check the entire circuitry of the unit by the continuity-testing method, each element separately, and only at specialized repair enterprises, which required large time and financial costs. The introduction of this stand into locomotive diagnostics and repair production will make it possible to reduce several

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times the time spent on locating the fault in the BEL unit. Checking the BEL and the set-point device without the stand (manually) takes approximately 6 hours, whereas with the help of the stand the entire check can be carried out in only 30 minutes. It follows from this that checking with the help of the stand, if the time for delivering the stand to the locomotive is neglected, takes up to 12 times less time.

This automation of the technical process of diagnostics and repair will provide its economic effect by saving funds for hourly wages paid to electronics workers and employees of electrical shops of locomotive repair and servicing enterprises of "Uzbekistan Railways" JSC.

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