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Improvement of a Power Source With a Self-Diagnostic System of a Complex of Vibroacoustic Diagnostics of Rotary Units of Traction Electric Motors of Locomotives

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Abstract: Introduction: The production of the analysis of the energy efficiency of the variants of the Energy Sources applied for driving in the rotation with the required frequency of the wheel motor units of electric locomotives and electric trains in the diagnostic position without disassembly of the bearings makes it possible to use the vibroacoustic diagnostic banks of the rotary units of the traction motors of locomotives with the best energy indicators. Two possible options of Power supplies are considered: a three-phase bridge rectification circuit controlled with a step-down transformer and a pulse converter that receives power from the network through an unmanaged three-phase bridge rectifier (Larionov Scheme) to drive the rotation with the required frequency of the wheel motor units of electric locomotives and electric trains in the bearing diagnostic position without disassembly. In both cases, it is assumed that the Power supplies receive electricity from a 380/220 V, 50 Hz network. A comparison of the proposed power supply options was made on the basis of an energy efficiency assessment. The power factor and the power loss in power supplies are used as energy efficiency criteria. A diagnostic power supply is offered. Materials and Methods: Analytical methods are used to determine the power loss in the transformer, the controlled three-phase thyristor rectifier, the unmanaged three-phase diode rectifier, the input filter of the pulse converter, the IGBT transistor and the reverse diode of the pulse converter. Results: the energy indicators were determined in tabular forms: power loss in the transformer, controlled three-phase thyristor rectifier, unmanaged three-phase diode rectifier, input filter of the pulse converter, IGBT transistor and reverse diode of the pulse converter. Based on the evaluation of the power indicators of the two variants of the power supply, it is concluded that it is appropriate to use a transformer-less circuit in the vibroacoustic diagnostic position of rotary units. Discussion: An energy-efficient power supply option for the non-disassembly vibroacoustic diagnostic position is proposed, which includes an unmanaged semiconductor rectifier and a pulse converter executed on an IGBT transistor. Conclusions: A diagnostic software has been developed for the pulse-controlled power supply selected according to the results of the calculations.

Keywords: Electrical composition, the sole proprietors, vibroacoustic diagnostics, bearing vibroacoustic diagnostics positions, Power supplies, rectifier, pulse converter, step-down transformer, diagnostic supply.

Introduction. The power supply (PS) is designed for the rotation with the required frequency of the wheel blocks and electric rolling stock motors (ERS) in the vibroacoustic diagnostic position of the bearings [1-5].

Two possible power supply options are considered:

- controlled three-phase bridge rectification circuit (Larionov bridge) with step-down transformer (Fig. 1, I);

- a pulse converter that receives energy from the network through an unmanaged three-phase rectifier bridge (Fig. 1, II).

In both cases, it is assumed that the IPS receive electricity from the 380/220 V, 50 Hz network.

The experience of the operation of the PS in the positions of the vibroacoustic diagnosis of locomotive depots allowed to determine the parameters of their load:

– long–term mode current - 100 A;

– the maximum voltage on the rectified current side is 180 V.

The purpose of the article is to analyze the proposed power supply options based on an assessment of energy consumption efficiency. The power factor and power loss in PS are used as criteria for energy efficiency.

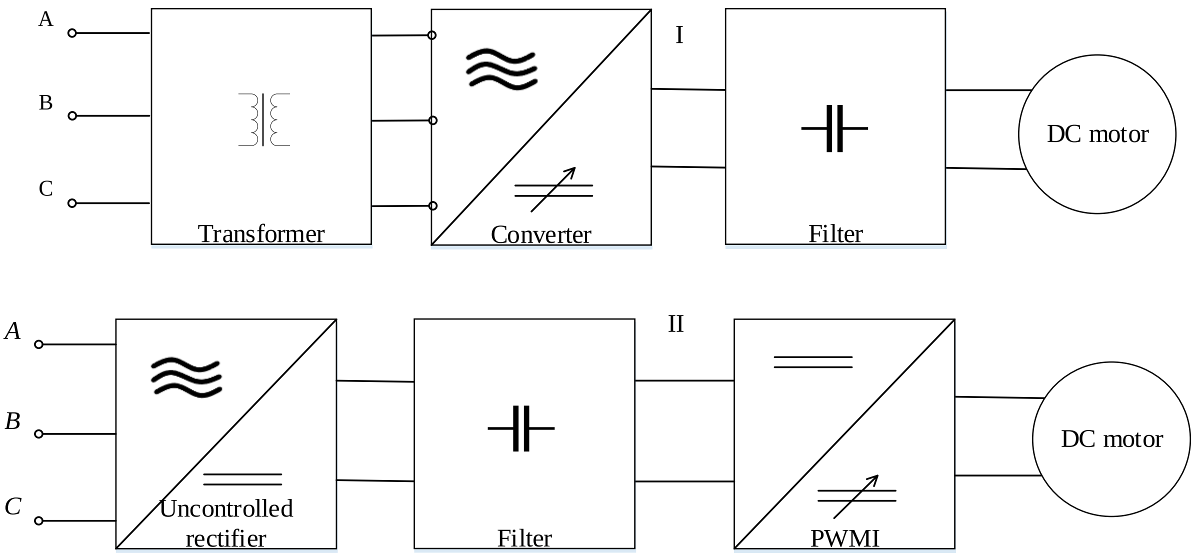

Fig.1. Controlled three–phase transformer rectifier (I) and transformer–free three-phase rectifier with pulse converter (II)

The evaluation of the power factor of the transformer power supply made in [2] showed that it does not exceed 0.73.

The experience of designing semiconductor converters shows that the use of pulse control systems is a radical way to increase the power factor.

The use of a combination of an uncontrolled rectifier and a pulse-width converter allows you to obtain a power factor of PS tending to 1.

The power losses in the transformer PS are determined by the sum of losses in the transformer and the controlled rectifier.

The results of the study. The estimation of power losses in the step-down transformer of the PS is carried out on the basis of the technical data of the three-phase converter transformer TS(Z)P – 40/0,7 – UZ (Table 1) [4-14].

Table 1 – Estimates of parameters of power supplies with a step-down transformer

Transformer power loss:				Losses in thyristors of the rectifier unit	Total power losses in transformer PS
in the windings	short circuit	idling	general		
P_w, W	P_{sc}, W	P_i, W	P_T, W	P_{Th}, W	P_{TPS}, W
871,31	1100	280	1151,3	214,3	1365,6

Power losses in a transformer–free power source include: power loss in an unmanaged three-phase rectifier, power loss in the input filter capacitor, power loss in the IGBT transistor and power loss in the reverse diode of the pulse converter (Table 2) [10-20].

Table 2 – Estimates of parameters of transformer-free power supplies

Losses in the uncontrolled rectifier unit	Ripple losses in the input filter capacitor	Loss power in a pulse interrupter formed by an IGBT transistor	Power loss in the reverse diode of the pulse converter	Total power losses in a transformer-free PS
P_{ur}, W	P_{CF}, W	P_{IGBT}, W	P_{VD0}, W	P_{TFPS}, W
197,05	1,69	46,85	72,93	318,57

Therefore, the total power loss in a power supply without a transformer is almost 4 times less than in a power supply containing a transformer and a controlled rectifier.

Based on the evaluation of the energy indicators of the two variants of the power supply, it can be concluded that it is appropriate to use a transformer-less circuit at the vibroacoustic diagnostic position of the bearings.

However, to ensure reliable operation of the power supply, the development of its diagnostic support is required [3].

The tasks of the diagnostic supply of the power supply are:

– determination of the state of the electrical insulation structure;

– control of the state of semiconductor devices;

– determination of the condition of electrical appliances;

– control the status of the input filter elements.

To solve the tasks, a system of technical diagnostics is proposed, which includes two subsystems:

– a set of intra-department diagnostic tools;

– built-in diagnostic system.

The set of intra - department diagnostic tools includes the following devices:

– megometer;

– multimeter;

– electronic oscilloscope.

The built-in diagnostics system is an integral part of the microprocessor control and diagnostics system (IPMC & D) (Fig. 2).

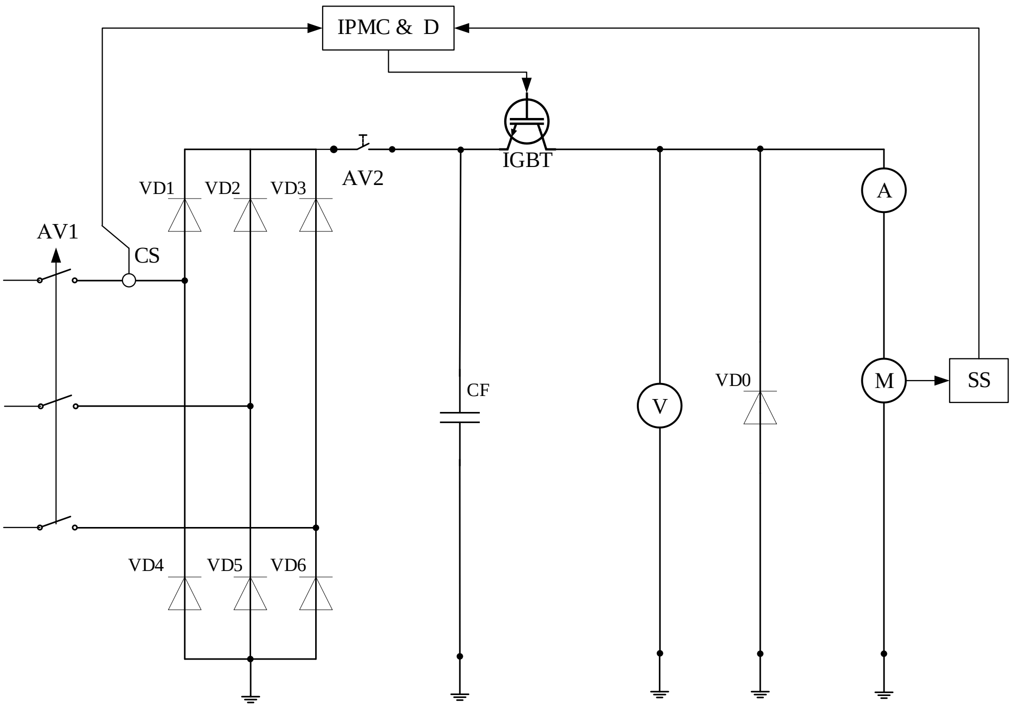

Fig. 2. Simplified diagram of a transformer-free power supply

IGBT – Pulse interrupter;

CF – is the capacity of the input filter;

CT – input current sensor;

SS – wheelset rotation speed sensor;

AV1, AV2 – circuit breakers.

IPMC is a single–circuit system for stabilizing the rotation speed of wheel pairs. The task of the IPMC is to ensure the required rotation speeds of wheel pairs at the position of vibroacoustic diagnostics (Fig. 3).

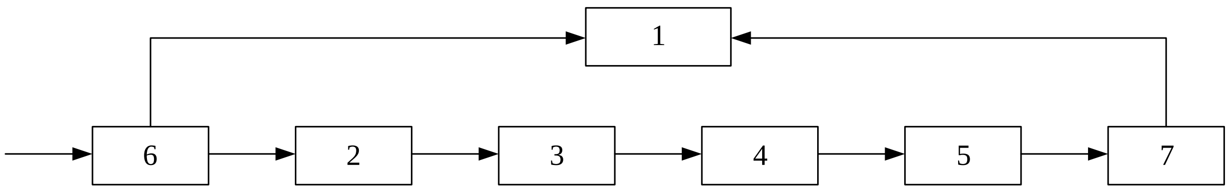

Fig. 3. Generalized structure of the power supply

1 – IPMC and D;

2 – unmanaged three-phase rectifier;

3 – input filter;

4 – pulse interrupter;

5 – load (wheel-motor unit);

6 – rectifier input current sensor;

7 – wheelset rotation speed sensor.

The block diagram of block D is shown in Fig. 4.

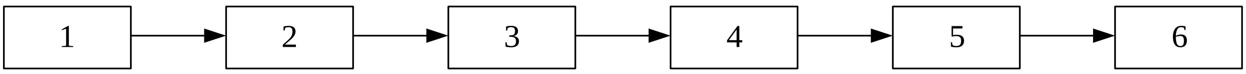

Fig. 4. Block diagram of block D

1 – rectifier input current sensor;

2 – input filter of block D;

3 – spectroanalyzer;
4 – the shaper of the ban on the work of the IPMC;
5 – IPMC;
6 – diagnostic operator.

Conclusions. If the rectifier or input filter malfunctions, the harmonic composition of the input current changes, which is a diagnostic sign.

The principle of operation of the unit is based on the harmonic analysis of the input current of the rectifier, the composition of which depends on the state of the rectifier, or filter capacitor.

Block D performs the following operations:

– highlights the instantaneous values of the input current of the rectifier;
– suppresses interference in the output signal of the current sensor;
– performs spectral analysis of instantaneous current;
– generates a signal to prohibit the operation of the IPMC.

The proposed diagnostic system will ensure optimal maintenance of the power supply during operation.

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