DETERMINATION OF QUALITY INDICATORS OF CONTROLLED ELECTRIC DRIVES AT THE DESIGN STAGE BY THE METHOD OF CIRCUIT SIMULATION

V. Sleptsov, A. Ablaeva
MIREA – Russian Technological University, Moscow, Russia

ablaeva@mirea.ru

I. INTRODUCTION

At present, in industry the most widespread are flexible production systems, in which automated electric drives are the energy basis. In this case, the most common type of automated electric drive is an controlled electric drive (a drive closed in terms of the frequency of rotation of the shaft of the executive motor) – CED.

A lot of companies in developed countries are engaged in the development of CEDs - INDRAMAT, Siemens (Germany); Fanuc (Japan); Artech (Bulgaria), Triol (Russia), etc.

Due to the fact that the characteristics of technological machines largely depend on the quality indicators of electronic components, serious attention is paid to the issues of their improvement and regulation. This is how GOST 27803-91 “Adjustable electric drives for metalworking equipment and industrial robots. Technical requirements". It indicates the main technical characteristics of the CED and the ways of their determination, which should include the following: the speed control range, the coefficient of unevenness of the rotation frequency and the frequency bandwidth of the CED.

To determine the real quality indicators of the developed and produced electronic devices, rather complicated and expensive stands are used [1]. Therefore, an urgent and important task is the development of a mathematical and software apparatus that allows analyzing the quality indicators of a CED at the stages of development, manufacture and operation.

This work analyzes the quality indicators of a controlled electric drive based on an S-220-60-VD-2 servo amplifier and a KM-090-32-02 valve motor, built according to a typical scheme similar to EPS-B1-0D75AA (Germany).

II. MATERIALS AND METHODS

To carry out circuit simulation, a mathematical model of the CED was developed. The authors found that for circuitry modeling of such a CED, the most convenient is the mathematical model of a valve motor (VM), described by the equations presented in [2].

The developed mathematical model of a controlled electric drive in the form of a structural diagram can be represented as in Fig. 1.

III. RESULTS

The following designations are adopted:

Wrs(S), Wrc(S) – transfer functions of the speed controller and currents; Кpsa, Кpsb, Кpsc – transfer ratios of phase current sensors; F1 - nonlinearities of the "limiting" type of the signal; F2 – non-linearities of the PWM "relay" type; F3 – PWM nonlinearity; F4 – nonlinearity of positive signal extraction; Кrps – transmission coefficient of the rotor position sensor; Кss – transmission coefficient of the speed sensor; A_{PWM}, T_{PWM} – PWM amplitude and frequency; Urs, Uss - signals of speed setting and from the speed sensor; Urca, Urcb, Uurc, Ucsa, Ucsb, Ucsc – assignment signals and from phase current sensors; Usr – signal from the speed regulator; Urm - torque setting signal; Ucr – signals from current regulators; Uy – control signals; Utvg –

signal from the triangular voltage generator; Usa, Usb, Usc, Isa, Isb, Isc – phase voltages and currents; V, P – speed and position of the motor shaft.

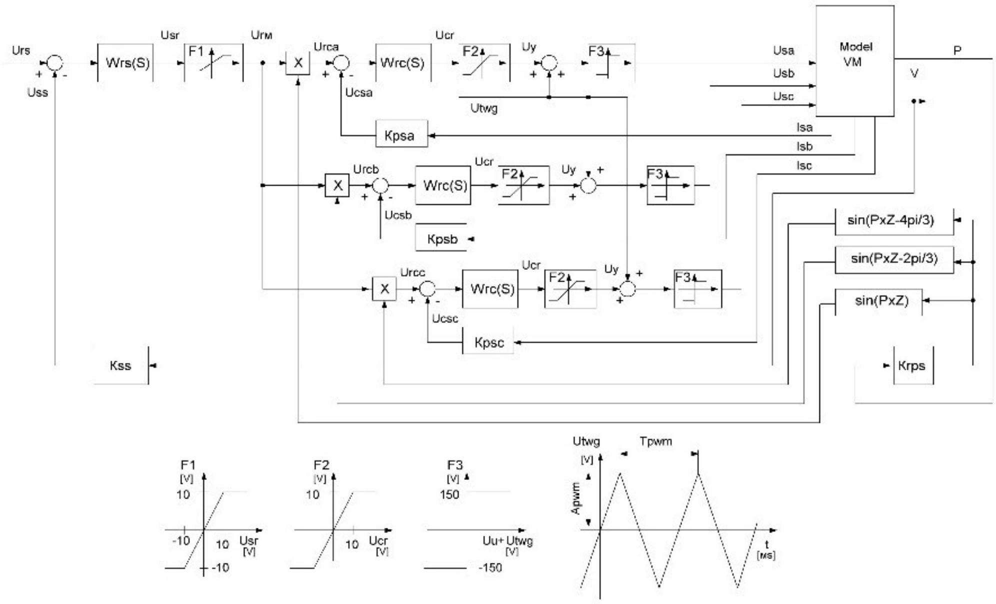


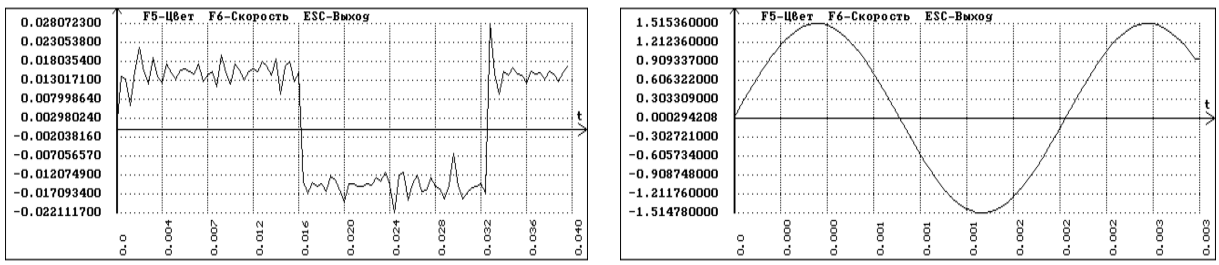
Figure 1. Mathematical model of a controlled electric drive with three current loops

The transfer functions of the phase current regulators are selected from the conditions for adjusting the circuits to the technical optimum, the transfer function of the speed controller is selected from the conditions for adjusting the circuit to the symmetric optimum [3].

Mathematical modeling of the CED will be carried out in accordance with the requirements and methodology set forth in GOST 27803-91:

- determination of the tachogram of the CED after the signal Urs (t) = +/- 0.001 V is fed to its input and the determination the coefficients of uneven rotation from the obtained tachogram;
- determination of the tachogram in the CED after the signal is applied to its input Urs(t) = 0.1×sin(3000×t) and the determination of the frequency bandwidth from the obtained tachogram.

The simulation results are shown in Fig. 2.



a) b)

Figure 2. Tachograms at Urs (t) = +/- 0.001 V – a), at Urs (t) = 0.1 × sin (3000 × t) – b)

IV. CONCLUSIONS

Analysis of the obtained tachograms allows us to draw the following conclusions:

- the range of speed control of the considered electric drive is 10,000;
- the coefficient of unevenness of the rotational speed does not exceed 25%;
- the bandwidth of the frequencies is 480 Hz.

It should be noted that experimental studies of the prototype of the CED under consideration confirmed the correctness of the calculations – the range of the electric drive rotation frequency control was 10,000, but the frequency bandwidth was 450 Hz.

REFERENCES

[1] V.V. Sleptsov, A.G. Shmeleva, A.A. Galemina “Development of a stand for determining the technical characteristics of speed-controlled electric drives”, Instrumentation, Vol. 4 pp. 26-32, 2017.

[2] O.A. Rokachevskii, V.V. Sleptsov, A.E. Ablaeva, S.A. Kanaev and O.V. Moskalenko "Metrological assurance of the characteristics of electric drives at the design stage", Journal of Physics: Conference Series, Vol. 1889, ICMSIT-II 2021, pp.3-6. 2021, doi: 10.1088/1742-6596/1889/4/042057.

[3] V.V. Sleptsov, O.A. Rokachevskii, A.E. Ablaeva "Development of a highly efficient electric drive with a brushless motor", Instrumentation, Vol. 10, pp. 26-29, 2017.