IMPROVED HIGH-FREQUENCY MODEL OF ASYNCHRONOUS MOTOR

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Justification. PWM (pulse-width modulation) drives, static power converters and induction motors are widely used in various industries due to their suitable characteristics and flexibility. The effects of high-frequency voltage components introduced by the PWM method are usually not taken into account when analyzing the electromechanical characteristics of the motor. Conversely, the dV / dt supplied to the motor introduces a small amount of high-frequency leakage currents flowing through the scattered capacitor between the stator winding and the motor housing. Because the motor housing is usually connected to ground through a ground circuit, high leakage currents present in the electrical network can cause electromagnetic interference. In recent years, problems caused by high-frequency components and corresponding leakage currents have been analyzed by other researchers. This paper presents a high-frequency model of an induction motor. In particular, the main purpose of the presented work was defined, namely, to show that there is a general model that allows us to simultaneously consider the behavior of electric machines at high and low frequencies, and can be used in a wide range of systems analysis. The proposed high-frequency model is based on concentrated parameters and is related to the classical model of quantitative data, it is accurate in the frequency range from a few hertz to a few megahertz, the model is shown in Figure 1. This type of model avoids the use of distributed parameters. problems. In this work, satisfactory results were obtained by simulation in Simulink MatLab [1].

Aims and Objectives of the Research. Analysis of frequency characteristics of electric machines depending on the change in the state of insulation.

The operation of an electric machine with moistened aged insulation leads to its rapid destruction and is dangerous due to the higher probability of accidental failure, so the problem of assessing the moisture content of aged insulation is relevant and requires new ways to determine the possibility of its further operation. Humidification of insulation with changes in climatic conditions has a significant impact on the condition of the insulation structure. For new insulation, this problem is not so acute compared to moistening old insulation.

Materials and research results. High-frequency phenomena include two main capacitive effects:

1. Capacitance between the winding and ground
2. Interturn capacitance of the winding

Obviously, both capacities are essentially distributed, but, as mentioned earlier, the proposed approach is based on concentrated parameters [2]. Figure 1 shows the high-frequency phase diagram used with the following concentrated parameters:

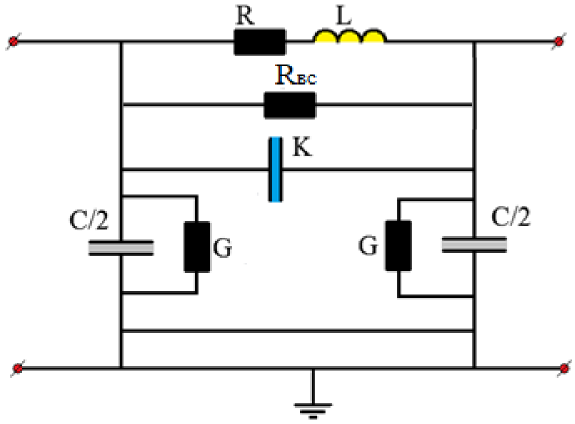

Figure 1 – Equivalent scheme with concentrated parameters:

R_{BC} – eddy current resistance;

R is the phase resistance of the stator and rotor;

L – inductance;

K is the longitudinal capacitance representing the interturn distributed capacitance

C is the transverse capacitance representing the distributed capacitive pairs between the winding and ground;

G is the conductivity, which is the eddy currents inside the magnetic circuit and the housing.

The parallel inclusion of the elements of the substitution scheme L and K, as well as C and G, are common and do not require explanation. The parallel rather than sequential inclusion of the elements L i r follows from simple physical considerations. The eddy currents induced in the steel sheets of the stator and rotor are, as it were, secondary currents of the transformer. As is known, an equivalent transformer substitution scheme is conveniently represented in the form of a parallel connection of the reactance corresponding to the primary winding and the load resistance representing the secondary winding [3].

It is important to emphasize that the values should be considered as values related to the phase connected by the star. The winding to the distributed tank was represented by two combined tanks of the same magnitude, the first of which was connected between the phase terminal and ground, and the second - between the neutral of the motor and ground. An engine connection to the star is assumed, but the delta connection of the engine does not invalidate the model. The resistance of the phase R and the induction of the phase Ld is the parameters of 50/60 Hz obtained in tests with a closed rotor. As the results of the experiment showed, the response of the engine fades rapidly over time. Typical values of resistance R are too low to explain the attenuation observed [4].

Analysis of the physical phenomenon leads to the assumption that the attenuation factor is related to the fact of energy dissipation at high-frequency eddy currents. As a consequence, the resistance R, which is a vortex current, must be connected in parallel with the leakage inductance [5]. To characterize the motor in the high frequency range, we can estimate the frequency response of the two impedances defined in Figure 2 (a, b):

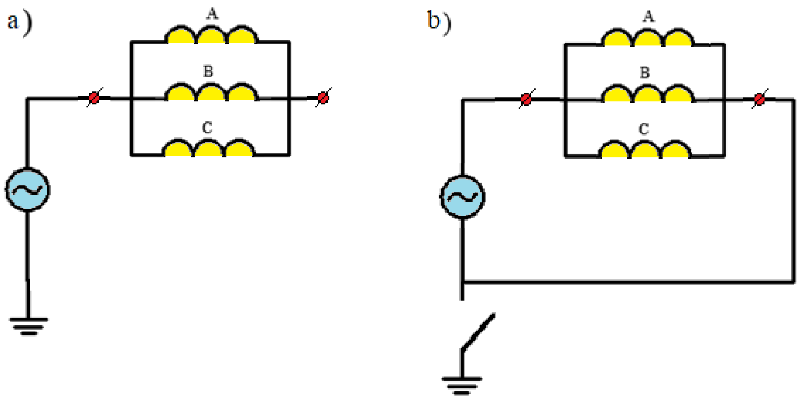

Figure 2 – Connection for impedance measurement: a) Zwg; b) Zwn.

Impedance Zwn, measurement between three phases, which are connected together with the motor neutral, with floating ground (a).

Impedance Zwg, a measurement between the three phases that are connected together and the ground terminal, with the floating neutral of the motor (b).

The estimation of the parameters included in the substitution scheme was calculated according to the frequency characteristics recorded on the 4A80A4 engine, according to the Kaganov method [4].

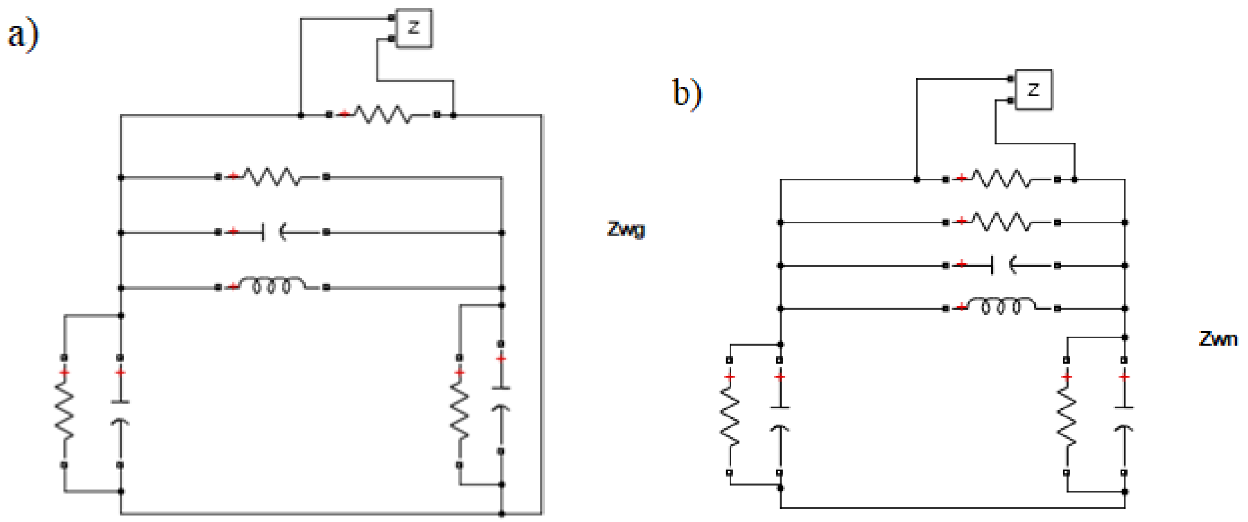

Figure 3 – Wiring diagrams for Matlab: a) impedance Zwg; b) impedance Zwn.

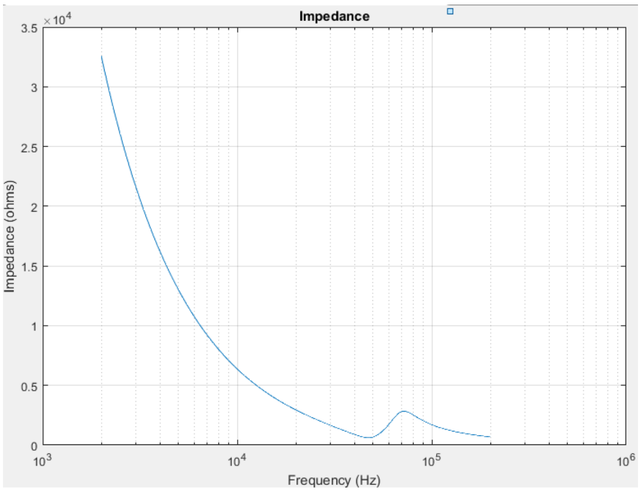

Figure 4 – Simulation results on the frequency response of the impedance Zwg

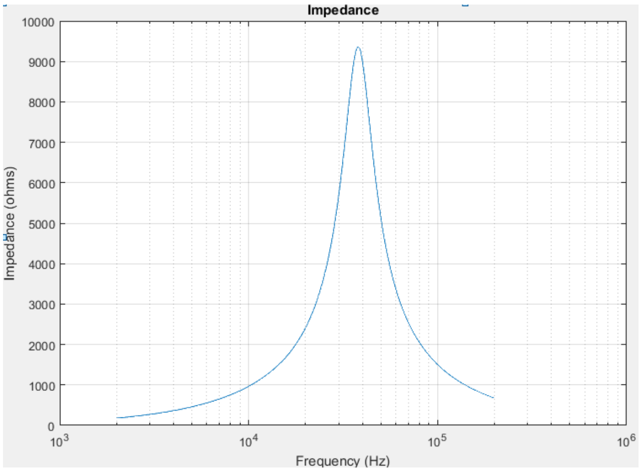

Figure 5 – Simulation results on the frequency response of the impedance Zwn

Conclusions. The article proposes a high-frequency model for an induction motor based on concentrated parameters. The results of experimental and software modeling on motors of different sizes are well consistent in both frequency and time. The proposed high-frequency model can be added to the known dynamic model. You can get a comprehensive model that allows you to analyze high-frequency and low-frequency phenomena with standard simulation software.

References

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