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Научный руководитель: В.В. Воробьева, к.ф.н., доцент каф. ИЯЭИ ТПУ.

DIAGNOSTICS OF INDUCTION MOTOR SHORT-DAMAGED ROTOR WINDING

Yu.Z. Vassilyeva
Tomsk polytechnic university
Institute of Power Engineering, Department of Power Grids and Electrical Engineering, 5A2G

Introduction

A squirrel-cage rotor damage is common and difficult to control during induction motors operation. This amounts up to 10% of the damage depending on the capacity and type of machine [1]. It is very difficult to identify squirrel-cage rotor mechanical damage because of the lack of information sources about the rotor winding electrical parameters. The main line of research in such damage diagnostics is stator currents and voltages frequency estimation [2], because any damage in rotor circuits distort a motor magnetic field, and therefore, distortion should be visualized in the stator currents and voltages depending on the type of a damage.

The induction motor feature is a variable rotor speed depending on the shaft load, and, consequently, damaged defect of rotor winding creates a distortion in the shape of the stator current with changeable frequency [3]. Using spectral analysis is justified for stationary signals, which are periodic. The presence of the Fourier spectrum instability in the stator current decomposition does not give an unambiguous interpretation of the "squirrel cage" technical state. A stator currents decomposition based on wavelet transform is a promising direction [4].

Problem statement

On the basis of experimental data to investigate the possibility of applying the wavelet transform to identify the diagnostic feature of short-circuited winding mechanical damage.

Experimental data and their processing

Figure 1 shows the waveform of the induction motor phase currents in the presence of cracks in the rotor winding bar.

The phase current signals were received via galvanically isolated current sensors and through the signals input card were fed from the AD conversion to the computer. Then arrays of digital values were processed in MATLAB in which there are various wavelet functions.

The continuous direct wavelet transform is carried out on the basis of the following formula:

$$C(a,b)=\int_{-\infty}^{\infty} s(t)a^{-1/2}\psi\left(\frac{t-a}{b}\right)\mathrm{d}t,$$

wherein $C(a,b)$ – wavelet coefficients; a – scale parameter; b – time parameter; $\psi_{a.b}$ – basis function.

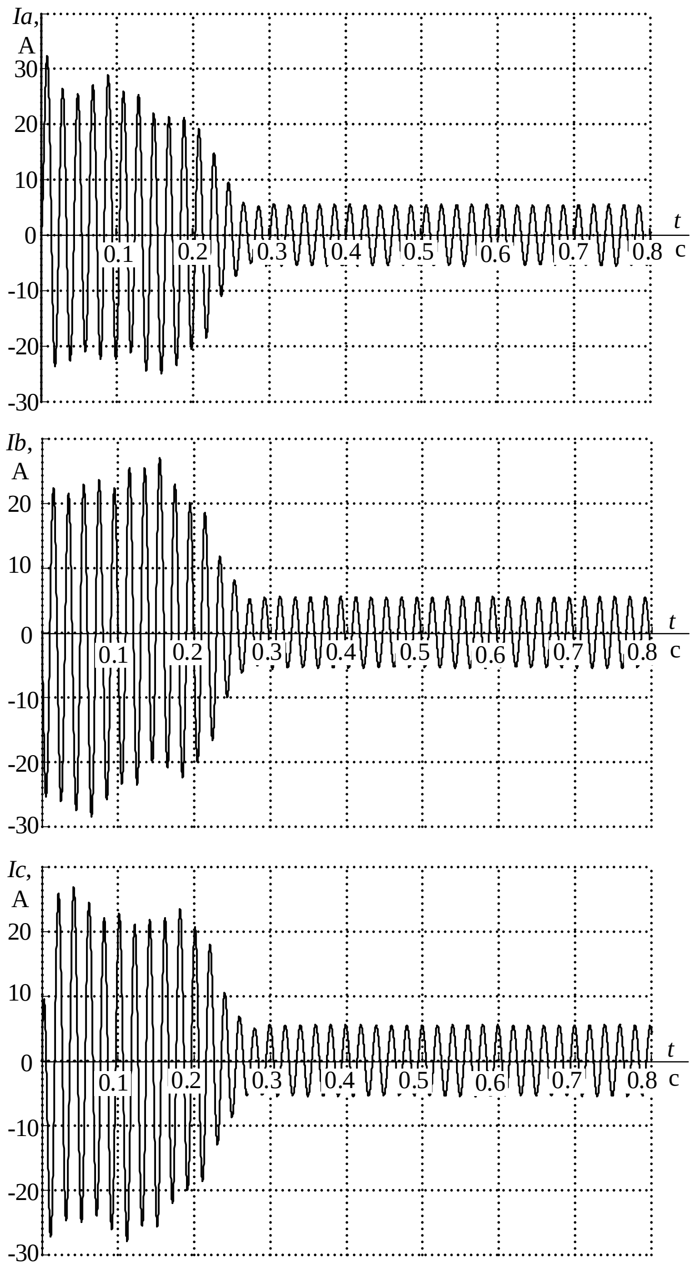


Fig. 1. Waveform of the induction motor phase currents in the presence of cracks in the rotor winding bar

Higher values a correspond to low frequency, lower values b - high frequency [5].

The finiteness condition restricts the set of functions which can be used as wavelets:

$$C_{\psi} = \int_{-\infty}^{\infty} (|\psi(\omega)|^2 / \omega) d\omega < \infty$$

As the basic functions can be selected any functions, including intermittent, pulse, trigonometric functions, etc. The wavelets number used in the signal decomposition determines a decomposition level. The Haar wavelet was used in the analysis of experimental data. The comparative analysis showed that the significant differences of the stator phase currents with damage and without damage are not revealed.

The distortion is transmitted through the magnetic field and the magnetic field is common to the whole machine. Then it was decided to carry out wavelet analysis for resulting module of stator currents, which can be find by the next formula:

$$i_s = \sqrt{\frac{2}{3}\left(i_A^2 + i_B^2 + i_C^2\right)}$$

wherein i_A, i_B, i_C – instantaneous values of the stator windings currents.

Fig. 2 shows the resulting module of stator currents during the induction motor start-up with damage (fig. 2,b) and without damage (fig. 2,a). As it can be seen from fig. 1 and fig. 2 the distortion caused by the bar breakage are small in phase currents and are more informative in the resulting module of stator currents.

The resulting vector of stator currents module was decomposed into components with using the Haar wavelet and then recovered by a procedure of inverse wavelet transform from coefficients of the respective decomposition levels.

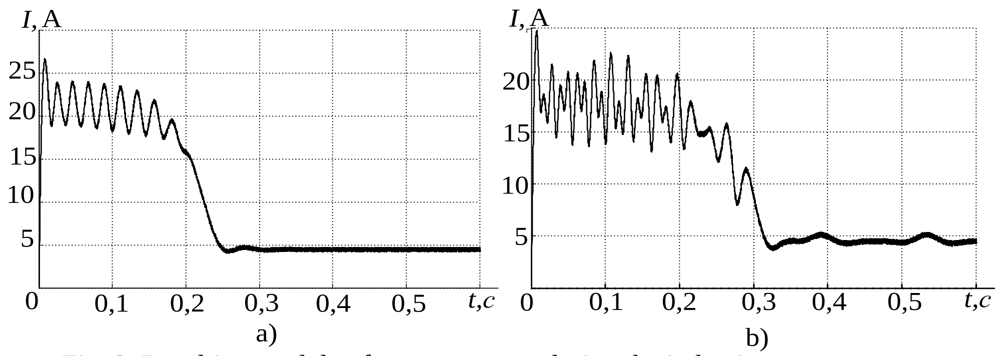
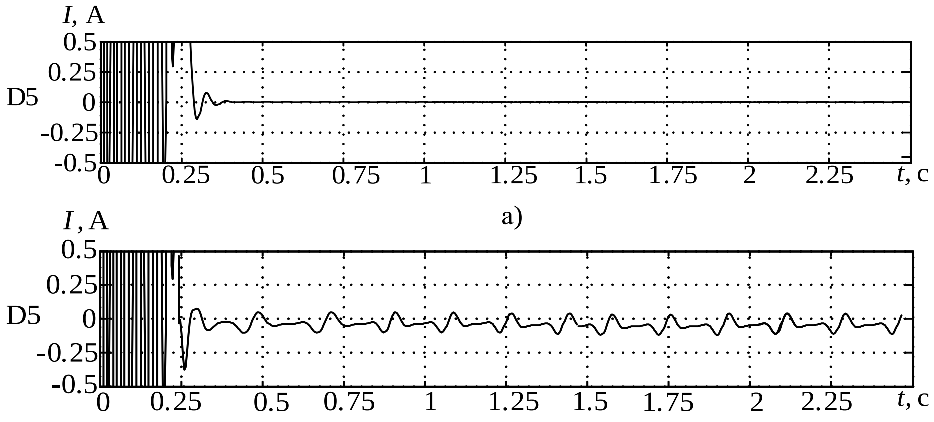


Fig. 2. Resulting module of stator currents during the induction motor start-up: a - without damage; b - with damage

Fig. 3 shows graphs of the fifth component signal decomposition unit resulting stator currents (D5). In the other coefficients changes were not observed.



б)

Fig. 3. Graphs of the fifth component signal decomposition unit (D5):
a - without damage; b - with damage

D5 component responds to breakage of rotor bar and its ripple amplitude increases with increasing number of broken bars, which serves as a unique diagnostic sign of a defect presence.

Conclusion

Using the wavelet decomposition into components in the analysis of stator currents to identify a damage in the induction motor rotor winding is more informative than the spectral analysis.

The wavelet decomposition of stator currents resulting module is preferable, because in this case, the information sign of a damage is more pronounced than with wavelet decomposition of individual phases currents.

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Scientific supervisor: E.O. Kuleshova, Ph.D. of Department of Power Grids and Electrical Engineering, Tomsk Polytechnic University.

TIME CONSTANT OF THE APERIODIC COMPONENT OF THREE PHASE SHORT-CIRCUIT ANALYSIS

A.S. Varavin, N.M. Kosmynina
Tomsk Polytechnic University
Institute of Power Energineering; Department of Electric Power System

The time constant of the aperiodic component short-circuit - electromagnetic time constant that characterizes the decay rate of the aperiodic component of short circuit current. This value is important for the choosing a variety of equipment in power plants and substations, relay protection.

Therefore, there is need precise values of the this time constant for different points in any section of circuit with short-circuit. There are tables in reference book with the values of this time constant for the different versions of the devices, but they are may be invalid. In this paper will be analyzed short-circuit mode at the power station and will be defined damping time constant for the sources compared with the reference data.

Calculation of parameters of a short-circuit is performed using GTCURR programm for the power scheme shown in Fig.1.

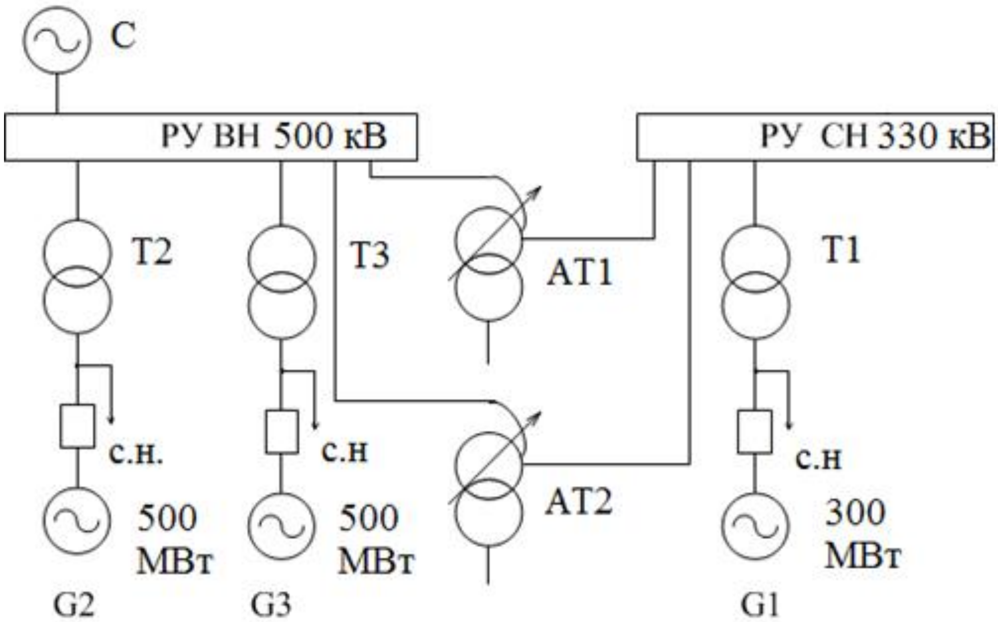

Fig. 1. Station structural scheme