Another constraint of STFT is related to the side-lobe levels of the window in the frequency domain, which leads to a decrease in the measured values of the RMS current of the har-monics and in some cases can even to hide the weak harmonics against the back-ground of strong harmonics. To improve the accuracy of the spectral analysis of the traction current, it is necessary to correctly choose the parameters of the win-dowed FFT.

In the work the correct choosing of the windowed FFT parameters to achieve the necessary time and frequency resolution of the traction current spectral analysis in accordance with the requirements of regulatory documents has been investigated.

Dynamic range of the traction current harmonics for AC TC is 46 dB for fre-quency band 21-29 Hz, 55 dB for frequency bands of TRC-3, and 60 dB for fre-quency bands TRC-4 (for TC 200 A).

The requirement that the duration of the harmonics defined by the standard can-not exceed 0.3 s, together with the restriction on the values of the frequency and time resolutions, should also be taken into account when selecting the window type, especially in the frequency range from 19 Hz to 58 Hz, which contains very closely spaced harmonics, which are specified by the standard.

For the spectral analysis of traction current, four types of windows were select-ed: rectangular, Hann, Hamming and Blackman windows with duration of 0.3 and 1 s. For a sampling frequency of 27500 Hz and a window length of 0.3 s, the fre-quency resolution is 0.27 Hz for a rectangular window, 0.54 Hz for Hann and Hamming windows and 0.81 Hz for Blackman's window, which is consistent with the requirements of the specifications.

The results of spectral analysis of traction current showed that the frequency resolution of harmonics, and accordingly the relative error in determination the frequency and the RMS value of harmonics is lower for high frequencies in spec-trum.

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WAVELET BASED DETECTION OF SIGNAL DISTURBANCES IN CAB SIGNALLING SYSTEM

The problem considered in the work is concerned to the methods to reveal and identify the signal disturbances occurred in the railway cab signaling system caused by electromagnetic interference from traction current. The continuous automatic locomotive signalling system (ALSN) is a type of cab signalling systems that provides track status information to the train cab and uses the rails as a continuous communication channel between track and train. To ensure the reliability of the transmission of ALSN commands to the train cab, the basic parameters of the coded current are periodically checked for compliance with certain requirements during planned test trips of a specially equipped railway car-laboratory. The ALSN signal is received by the coils of the car-laboratory and recorded by computer. Then an operator visually analyzes the recorded signal to detect problem segments with interference exceeding the limit level what requires a lot of time and does not provide the necessary accuracy.

The purpose of this work is to investigate the effectiveness of the proposed algo-rithm for the automatic revealing and identifying of electromagnetic interference in the ALSN signal, based on discrete wavelet packet transform, wavelet packet ener-gy Shannon entropy and an artificial neural network for EMI classification.

To automate the detection and identification of the ALSN signal disturbances, the following algorithm has been proposed. At the first stage, the wavelet packet energy Shannon entropy is used to reveal problem segments of ALSN signal. At the second stage, a detailed analysis of the ALSN signal using DWPT is performed to determine the type and parameters of interference at the revealed problem seg-ments.

By using three-level DWPT decompositions of ALSN signals the features of main signal disturbances have been extracted. The wrong number of pulses in the ALSN signal is proposed to detect by a relative number of pulses (RNP). Long-term electromagnetic interference with amplitude exceeding the permissible level can be revealed by the relative energy (REN) of the DWPT coefficients in the wavelet decomposition nodes. To detect sharp pulses in the ALSN signal, it is pro-posed to use the kurtosis of the DWPT decompositions coefficients of signal.

To classify the ALSN signal disturbances the three-layer feed-forward artificial neural network with three input nodes, a hidden layer, four output nodes and sig-moid function neurons was used. The overall mean square error of the trained neu-ral network is 0.031043 and the testing and the validation curves have similar characteristics which is an indication of efficient training.

The performed investigations have confirmed the effectiveness of the proposed algorithm of computer processing of ALSN signals for revealing and identifying of the ALSN signal disturbances.

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FAULT DIAGNOSTICS OF THE NEUTRAL SIGNALLING RELAY ARMATURE

Signalling relays are used for safety critical and safety related applications in railway signalling systems, so they should be properly maintained and periodically tested to ensure their safe and reliable performance. During relay test sets the oper-ating voltage, contact and coil resistances, switching time etc. should be measured. Most tests are performed manually.

The aim of the work is the investigation of the application of the wavelet trans-form for fault diagnostics of the neutral signalling relay.

For investigations there were taken ten different signalling neutral relays in op-erable condition. The dependences of transient current in relay coil on time during relay energizing at different applied voltages with subsequent de-energizing by short-circuiting of the coil have been measured.

Analyses of the transient currents were performed by using of segmentation of the relay current characteristics. The transient currents at the first and third seg-ments that corresponded to unmovable anchor, increased with time approximately as the exponential function.

The time constants calculated by fitting of the transient current at first segment by using of the exponential function were practically independent on contact springs faults but strongly depended on condition of relay coil and magnetic circuit. Such behavior allows us to conclude that time constants for first segment can be used for monitoring of relay electromagnetic system condition. The faults caused by defects of armature and contact springs led to the appearance of additional features on the second segment of the transient current which corresponded to the movement of the armature

During the armature movement, contacts and springs mechanically connected to it are bent. As a result the some tiny features appear at the second segment of the relay transient current. For analysis such non-periodic non stationary signals the wavelet transform is widely and successfully used last two decades.

The features (spikes) at the relay transient current curve which correspond to contact springs faults were clearly distinguishable by using wavelet transform modifications (CWT, DWT, DWPT), which allowed us to clearly extract fault fea-tures. The relative differences in values of spikes for DWT and DWPT energy plots were caused by different scale parameters used in these transforms.

Since the number and amplitude of spikes on DWPT energy plots increased with increasing of armature and contact springs faults, it allows us to use single in-tegrated parameter for the fast monitoring of the relay armature and contacts condi-tion. It was shown that for these purposes can be used the WEPSE of transient cur-rent, which values increased with the increasing of the faults in relay contact springs.

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USING A HYBRID NEURO-FUZZY SYSTEM FOR DIAGNOSING COMPLEX OBJECTS

In determining the technical condition of the complex technical facilities major critical factor is the time of the decision to localize faults. Using a hybrid diagnostic system with a neurofuzzy network knowledge base provides decision support in situations for which the diagnostic algorithm is not known and is formed from the initial data in the form of production rules. To automate the process of accumulating knowledge in a diagnostic system, it is advisable to use object sensors, with which the values of diagnostic parameters are measured. Advances in wireless technologies have enabled to make use of wireless sensor networks (WSN) for to measure the values of the controlled parameters. There is a wide variety of WSN applications, such as environment monitoring, scientific observation, emergency detection, field surveillance, structure monitoring, and so on. In those applications, hundreds or even thousands of sensor nodes are assumed to be deployed in the target fields.

One of the most important types is tolerance control, which sets the relationship between the values of the controlled parameter and established in a certain way the boundaries (tolerances) in its deviations. For tolerance control, an object with parameters is suitable, the measurement results of which are within the specified tolerances, and unsuitable - with parameters, measurement results which are not within the specified limits. Boundaries are established by experience or calculation for the values of the parameters of an object at which it is able to perform specified functions, maintaining its performance for the required time under certain conditions. The value of the operational limits is established by the instruction manual or other relevant documents for those parameters of the object, which are monitored under operating conditions.

Let us consider the effectiveness of control of a certain object for one parameter X, the state of which is characterized by its numerical value. We believe that in order to establish compliance with the norm, statistical processing of the results is required.

Tolerance control allows you to assess the quality of an object without measuring the exact value of the parameter X. Examples of a parameter can be controlled within certain limits, temperature, humidity, etc.

We consider the values of X as a random variable with the distribution density f (X). Let an operability condition be specified for the object, at which X should be in the range $a<x<b$. If this condition is met, X is in the tolerance region and H0 is serviceable. If this condition is not met, then the object has a fault H1

A feature of modern diagnostic system (DS) for