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ENSURING OF THE TRAIN MOVEMENT SAFETY IN THE ERTMS/ETCS

European Rail Traffic Management System (ERTMS) was defined by the first European Commission (2001/260/EC) decision as the combination of the European Train Control System (ETCS) and the Global System for Mobile Communication - Rail (GSM-R). The ETCS as element of ERTMS provides two principal functions: Automatic Train Protection (ATP) and Cab Signalling. Automatic Train Protection is the system that automatically applies the train brakes if a driver does not keep the train's speed below the specific trackside safe limits for the train's current location and operating conditions.

Cab Signalling is the system that displays information inside a train cab about the current status of the track ahead. To do so the ETCS onboard computer must predict the decrease of the train speed in the future, from a mathematical model of the train braking dynamics and of the track characteristics ahead. This prediction of the speed decrease versus distance is called a braking curve.

The ETCS on-board computer calculates in real time braking distances, which will also be used to assist the driver and to allow him to drive comfortably, by maintaining the speed of the train within the appropriate limits.

ETCS is based on an a set of braking curves, computed in real time and depending on different physical parameters (estimated speed of the train, track profile, train acceleration, etc.).

Today the ETCS specifications lay down the basic principles for the braking curves and the associated information displayed to the driver, but there is still no harmonized method to compute them. In the absence of any requirement, the algorithms of the ETCS on-board suppliers lead to different braking distances for a given type of rolling stock. This makes the engineering of the ETCS trackside not only dependent on the pure performance of the rolling stock braking system, but also on the ETCS on-board supplier. For cross border trains, the differences through national rules require the implementation in the ETCS on-board of several national braking curves. It can obviously induce increased costs (software design, cross acceptance tests, software upgrade necessary whenever a national parameter is amended).

The purpose of this article is to present an overview of the ETCS braking curves according to the European specifications, including the following main aspects: basic principle to ensure of the train movement safety, the main types of ETCS braking curves, the input parameters for braking curve calculation, construction of the emergency brake deceleration, and guaranteed emergency brake deceleration.

There have been considered in the work the main ETCS braking curves and the supervision limits of the EBD braking curves, the movement authority, the end of authority, the most restrictive speed profile, the supervised location and others.

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DISTRIBUTION OF THE TRACTION CURRENT HARMONICS IN RAILS

To ensure the electromagnetic compatibility (EMC) of new types of rolling stock with signaling and radio communication systems, they are subjected to an acceptance procedure that includes the EMC tests in accordance with European and national regulatory standards and norms.

The aim of the work is to establish mathematical and computer model for distribution of traction current harmonics in AC direct feeding traction network with multiple vehicles in feeder zone. This model is an evolution and simplification of models represented earlier [1]. The results of the work have been used during tests of new types of trains [2].

A mathematical and computer model of traction current harmonic distribution in traction network with multiple vehicles in feeder zone has been established. The traction network was represented as series-connected multipoles, corresponded to longitudinally uniform network areas which are modeled with MTL equations. The model has been simplified as follows. The lines with equal or close to each other potentials are represented as a single line with equivalent electrical parameters. The disturbing vehicles are modeled as sinusoidal current sources with several set of frequencies that are represented by current vector. Only return current harmonics with frequencies that lie in frequency range of track circuit receiver were considered.

The distribution of the traction return current harmonics was computed for direct feeding traction network 1x25 kV AC electric railway system with twoside ESS and with 1 to 5 vehicles in feeder zone.

The maximum interference from trains is in the areas nearest to trains and near the point of connection of return feeder to rails (at ESS terminals). The traction harmonic current in rails are increased with increasing of train number in feeder zone and with decreasing of the rail-to-earth conductivity. The interference at 25 Hz in the rails area near the ESS for one locomotive in feeder zone don't exceed a limit value of 1 A even in unfavorable operation conditions for the rail-to-earth conductivity equal 0.02 Sm/km. If number of trains are increased (from 1 to 5) the interference at 25 Hz also increased and it values exceed the limit current of the interference in rails at 25 Hz.

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AUTOMATION OF THE DETECTING DEFECTS IN MOVABLE ARMATURE OF THE SIGNALLING RELAY

The purpose of the work is to develop a method for revealing of the movable armature defects of a signalling relay based on the measurement of the transient current when the relay is turned on and off with subsequent currents' processing using wavelet transform.

The time dependences of transient currents during relays switching have been investigated for relay in various technical conditions: in operable condition, as well as with artificially created defects (bends) of contact springs [1,2]. The measured data have been analyzed in the time and frequency domain using the wavelet transform modifications (CWT, DWT, DWPT).

The analysis of the transient currents was carried out using segmentation of the current characteristics of the relay. At first and third segments, which corresponded to unmovable anchor state, the transient current increase with time during relay switch-on approximately as the exponential function. The time constants of the current were calculated by approximating of the measured currenttime dependences by exponential function.

The presence of defects in the movable armature of the relay practically hadn't effect on the values of calculated time constants.

However, these values strongly depended on the technical condition of the relay magnetic circuit and the relay coil, as well as on the voltage applied to the coil terminals. This behavior of the relay time constant on the first segment of the relay current characteristic makes it possible to use this parameter for monitoring the technical state of the electromagnetic relay system.

Defects of the armature and contact springs led to the appearance of additional features at the second segment of the relay transient current curve, which corresponded to the movement of the armature. The magnitude of these features on the current curve depended on the value of bending of the relay's contact spring. The width and appearance time of the features at the second segment of the current-switching curve correspond to the non-simultaneous switching of the relay contacts. To determine the amplitude (energy) of these features (peaks) on transient current curve, their duration and the times of appearance, the wavelet transform was used. The results of investigations confirmed the possibility of determining the defects of the relay movable armature by using wavelet analysis of the second segment of the relay transient current characteristic.

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AC IMPEDANCE OF R65 TYPE RAILS ON 1520 MM TRACK IN THE AUDIO FREQUENCY RANGE

Knowledge of the exact AC rail impedance in a wide frequency range is necessary for designing and modeling audiofrequency track circuits, determining of the return traction current distribution in rails of high-speed railways, etc. Results of the rail impedance investigations were published in papers of Carpenter and Hill, Mariscotti and Pozzobon [1] and others. A theoretical analysis of frequency dependence of rail impedance is based mainly on the so-called Carson/Pollaczek model or simply Carson’s method that was proposed almost simultaneously by Carson and Pollaczek. Based on Carson’s work [2],

In this work the comparative analysis of the calculating methods for AC impedance of R65 type rails of a track 1520 mm gauge in the audiofrequency range have been performed.

Results of AC rail impedance measurements and theoretical description of frequency dependence of impedance for wires above lossy ground are briefly reviewed. Mathematical formulation of Carson's method and the complex image method proposed by Deri with co-workers for impedance of transmission lines were represented. The impedance of running rails of R65 type on the track of 1520 mm gauge have been calculated by using Carson's method and the complex image method. Due to the insufficient amount of literature data concerning