Abstract
The article presents the problem of application of a traction inverter control strategy consisting in selective elimination of harmonics (Selective Harmonic Elimination – SHE) for shaping the spectrum of traction current. The objective of this method is to reduce the conducted disturbances generated by a traction vehicle to the level below admissible values. The selection of the order of harmonics being eliminated from a voltage spectrum influences the values of the remaining voltage harmonics, hence the harmonics spectrum of current consumed from a DC network. The presented study aimed at developing the SHE method to the extent enabling its implementation to the real drive system. The article describes the results compared with limits existing in PKP (Polskie Koleje Państwowe – eng. Polish State Railways), however the presented methodology can be successfully employed for any applicable limits in DC electric traction systems.

Description of the problem
The problem of disturbing influence of traction vehicles in the track circuits of a rail traffic control system was thoroughly examined and described in a number of publications [2],[5],[10],[18],[24]. The article deals with the problem of application of the traction inverter control strategy consisting in selective elimination of harmonics (Selective Harmonic Elimination -SHE) [11],[17],[22] for shaping the spectrum of traction current. The objective of this method is to reduce the conducted disturbances generated by a traction vehicle to the level below admissible values [3],[4]. SHE method implemented into a traction drive system allows for elimination of the selected harmonics from the spectrum of voltage supplying traction motors \(V_{out}\) [20]. Content of harmonics in traction current \(I_d\) consumed by a traction vehicle from a supply system depends directly on the voltage harmonics spectrum \(V_{out}\). The selection of the order of harmonics being eliminated from a voltage spectrum \(V_{out}\) influences the values of the remaining voltage harmonics, hence the harmonics spectrum of current consumed from a DC network \(I_d\). In the articles [15],[16], the authors presented the concept of SHE method modification consisting in replacement of selected harmonics elimination with reduction of harmonics to the set level (Selective Harmonic Reduction - SHR). Based on the results of conducted simulation tests, it was shown that the SHR method offers broader possibilities for control of traction current \(Id\) harmonics values. Previous experience of the authors has shown that the SHR method gives positive results that allow for such selection of inverter key switching strategy, so it does not generate disturbances in the frequency ranges used by SRK devices. In previous publication the authors presented an overview of possibilities related to the SHR method application for traction purposes on the basis of a selected operation point of a drive system model. This paper describes the study extended by the analysis of the SHR method effectiveness in a full range of traction inverter frequencies, as it is in the case of vehicle's start-up. Additionally, some limitations related to this method and resulting from the admissible frequency of inverter's keys connections were taken into account.

Conclusions
The paper discusses the problem of the SHE method application and the possibility of using reduction of the selected harmonics instead of their elimination for the purpose of traction drive control. The implemented method would aim at limiting traction current harmonics to the level defined in the relevant regulations while maintaining traction drive parameters, such as drive torque and rotation speed. The results of simulation tests showed that by expanding the SHE method to the SHR method, as proposed by the authors, it is possible to select for any operation point of inverter drive system such set of switching angles, which would allow for fulfilling both, the criteria of compatibility as well as drive related criteria. Furthermore, factors determining the realizability of the calculation results, such as a maximum frequency of inverter’s power transistors switching were taken into consideration. Materials presented in this article also prove that applying only the SHE method is insufficient. The similar approach, taking into account definition of the optimization problem was presented in [1],[8]. However factors applied in these works were re-
lated with the AC side of the inverter, not to the DC side, what is the main goal of presented paper.

The aim of the conducted studies was to develop the SHE method to the extent enabling its implementation to a real drive system. It requires to continue the research towards including many factors occurring in real systems, such as: various levels of supply voltage, abrupt changes of load torque, changeability of fixed drive torque, etc. It also calls for development of various sets of inverter’s keys switching strategies using the method similar to the described one as well as establishment of an algorithm allowing for smooth change between the sets together with the change of drive operation point. Naturally, the proposed strategy should cooperate with the currently used strategies for vector control. This method might also be applicable as an intervention method implemented in drive operation ranges, in which it is known that the commonly used methods cause the generation of disturbances for track circuits. The article describes the results compared with limits existing in PKP (Polskie Koleje Państwowe – eng. Polish State Railways), however the presented methodology can be successfully employed for any applicable limits in DC electric traction. Moreover, it is essential, in further work, to take into consideration influence of the parameters of the traction substation to avoid the possibility of resonance conditions between the propulsion system and power supply [7].

References


[18] A. Szelał, M. Patoka Issues of low frequency electromagnetic disturbances measurements in traction vehicles equipped with power electronics drive systems,


