NEW SOFTWARE FOR ENERGY SAVING CONTROL OF A TRAM VEHICLE

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Abstract
The paper deals with new software ensuring the tram vehicle ride according to the criterion of the minimum energy use. The tram is driven by vectorially controlled and field oriented three-phase induction motors. Traffic disturbances are taken into consideration and a tram ride can contain many cycles consisting of the starting, the running with the constant speed, the coasting and the braking.

Introduction
Nowadays energy saving within the tram traffic is very important. Many new solutions have appeared in this field, e.g. [1], [3 - 7]. Optimization of duration of the typical tram ride stages: the starting, the running with the constant speed, the coasting and the braking can decrease the energy use.

In the city, frequent changes of tram traffic conditions occur. The total and local, planned or unplanned speed limitations, intentional or unexpected stops, changes of the network voltage, changes of a size of the energy recuperation during the braking are typical for the tram city ride. Because of ride perturbations, the run between neighbouring tram stops can contain many cycles consisting of the starting, the running with the constant speed, the coasting and the braking. Sometimes these cycles can possess only some of above ride phases. The author of this paper has elaborated the original algorithms ensuring the minimum energy use taking the different tram traffic disturbances into consideration.

Application of vectorially controlled and field oriented three-phase squirrel-cage induction motors for tram drive ensures diminution of the weight and dimensions; also enlargement of the technical reliability is here important.

In this paper, the mathematical models both for the first part of the starting (constant magnetic flux, increase of the supply voltage at motor terminals) and for the second starting part (the rated motor supply voltage, decrease of the magnetic flux) have been presented. For the tram running with the constant speed, there was given the model ensuring the larger motor efficiency and better power factor. There was also described the optimization strategy giving the minimum energy consumption for the case of traffic disturbances and occurrence of many ride cycles. Exemplary tram ride with unplanned stop and calculation of the algorithm of the tram ride according to the criterion of the minimum energy use have been also presented.

Conclusions
For vectorially controlled and field oriented three-phase induction motors supplied from modern inverter systems, the author has elaborated new software determining the vehicle tram ride with the minimum energy use.

Within the new possibilities, traffic disturbances can be taken into account, e.g. the total and local, planned or unplanned speed limitations, intentional or unexpected stops, changes of a size of the energy recuperation during the vehicle braking.

The optimization of duration of the typical tram ride stages: the starting, the running with the constant speed, the coasting and the braking can decrease the energy consumption.

For traction three-phase squirrel-cage induction motors, it is interesting that the algorithm of energy saving tram traffic possesses both the phase of the vehicle running with the constant speed and the stage of the coasting.

Because of traffic perturbations, the tram ride can contain many cycles consisting of the starting, the running with the constant speed, the coasting and the braking. Some cycles can have only some of the above ride phases. The algorithm of the energy saving control must be constantly updated. Application of a computer makes possible forecasting of the subsequent energy saving ride with minimum energy use.

Elaborated algorithms of the tram ride at minimum energy use make possible to save about 20% energy in comparison with the ride basing only on subjective decisions of a driver.
References


