Abstract
After modifying the power supply system on the railway section it was put into test operation. One freight train was driven along section and current and voltages measurements were conducted in each electric traction substation. The obtained measurement results were analysed and compared with the simulation results of the developed software for train movement simulation. Maximum simulated results deviate from the maximum measurement results in the range of 3.2% in the worst case scenario. Maximum observed deviations between simulation and measurement results do not exceed 17.8%.

1. Introduction
In the planning/design of new railway lines, electrification or modification of power supply of the existing railway lines [1], the planned increase in transportation (increase the flow of railway lines, increasing the weight of the trains, the introduction of new locomotives with greater tensile power), the question is the appropriate infrastructure for power supply. The infrastructure for power supply of the 50 Hz AC railway system consists of electric traction substations (ETS), contact network (CN) and sectioning facilities, [2]. To determine the optimum position and installed power of the ETS it is necessary to:
1. Simulate the movement of trains, at any time, based on a planned timetable, to determine the position of trains and the active and the reactive power taking from the CN;
2. Calculate the present value of current and voltage in the contact network, apparent power load of ETS, apparent mean 15 minutes power, active power, reactive power, power factor l, heating (over temperature) of the contact wire etc. [2].

Estimation of energy consumption for electric trains is widely applied to the planning/design of power supply systems and the study of optimal driving strategies. Research on optimal driving strategies requires higher precision than power system planning/design since the latter usually takes the worst case scenario to consider safe margins.

Train movement simulation and the calculation of electric situation in the traction power supply system are the problems which are practiced by many authors, [3], [4]. In [5] Majumdar proposed four main stages of train movement including (1) acceleration, (2) balancing, (3) coasting and (4) deceleration. He showed that the total energy consumed in train operations is the product of force and displacement. He used coefficients for converting the work done in ton-km into electric power units. Majumdar also proposed a statistical method for estimating energy. In [6] Goodman developed single train and multi train simulation programs.

The voltage received by a train will vary with position and the simultaneous action of other trains in multi train model, while it remains a constant in a single train model. This is the main difference between two models in estimating energy consumption. Goodman considered detailed factors in his model, including substation, feeder cable and volt-drop, etc. In [7] the design of an electric train network simulator is described. The proposed software aims to help designing electric train power supply networks. It consists of two combined simulators namely a run time simulator and a network simulator. There are also commercial software for train movement simulation and the calculation of electric situation in the traction power supply system, [8], [9]. Many authors have studied the problem of energy consumption for electric traction. In [10] Martin discussed simulation in general. He showed 5% extension on run time can produce energy savings up to 20% on a suburban system, similar as in [11]. In [12] author developed a model which estimates power consumption at high precision with 2% deviation from a real situation. It is found that reducing maximum speed and tactfully performing coasting can reduce energy consumption about 7% ~ 20%. In [13] two models for estimating energy consumption of single train operation are presented. Paper [14] describes the work of simulating and analysing dynamic traction power supply system. It is based on dependent train movement in conjunction with traction power supply system simulation to establish a panorama view of the features.
This paper describes new software developed for train movement simulation and a comparison of simulation results with measurements.

6. Conclusions
Software, partly shown in this paper is primarily intended for designing electric traction infrastructure. Maximum simulated results deviate from the maximum measurement results of all 3.2% in the worst case scenario. Maximum observed deviations between simulation and measurement results do not exceed 17.8%. By comparing the simulation and measurement, the results show how developed software works quite well for the intended purpose.

Electric traction, besides representing unbalanced load (compound in two phases of 110 kV network) also affects on the voltage quality in the 110 kV network due to non-sinusoidal currents which diode locomotives take from the network.

7. Future work
Further development of the present software goes in the direction of the simultaneous simulation of the train movement and the traction load flow calculation.

This will take into account the value of the voltage centenary in each train and the influence of the voltage to the speed-traction effort curve.

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References