Modifying different parameters, you can choose different color drawing data, labels etc. For each parameter (temperature, pressure, wind and precipitations) creates a separate file (fig. 4).

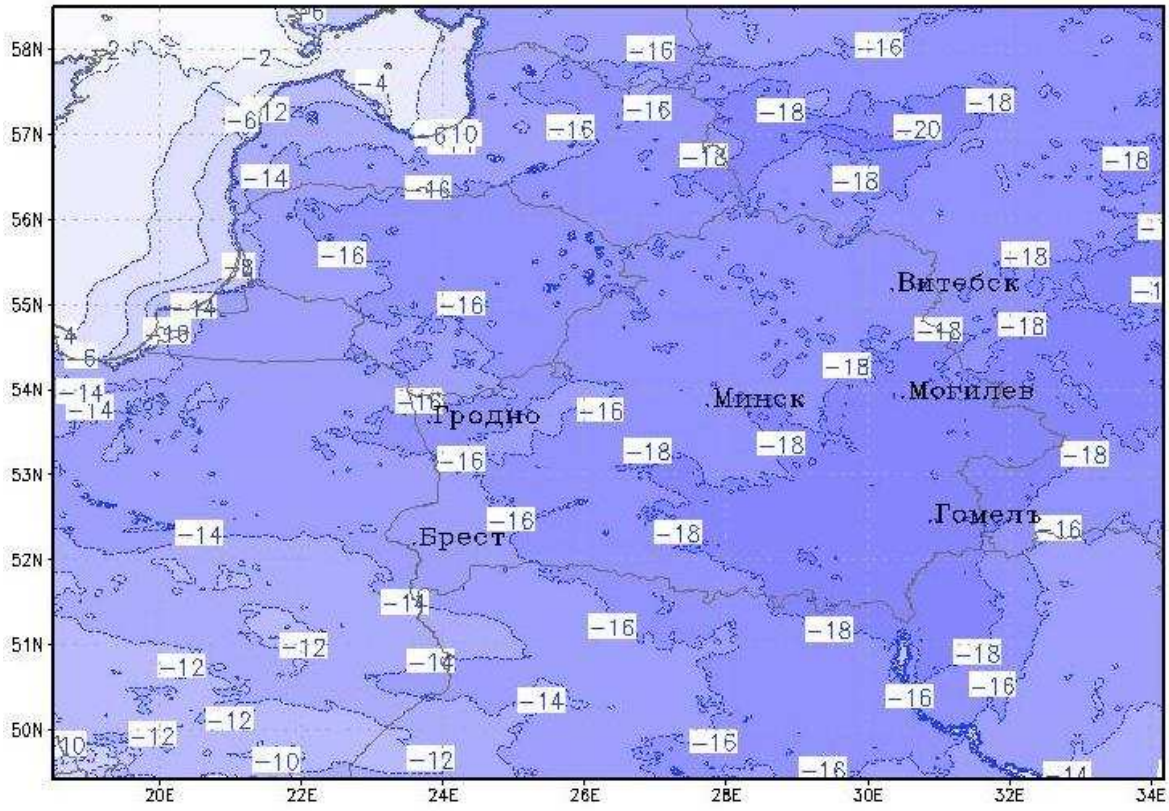

Fig. 4. The result of the work model WRF

The WRF model allows to automate the process of modeling of weather and obtain the necessary information for weather prediction. Being free software, WRF used in scientific and practical purposes in different countries of the world and is continuously developed.

REFERENCES

1. Methods for forecasting weather / [Electronic resource] – Mode of access http://primpogoda.ru/ – Date of access: 10.01.2014.
2. Wrf model users page / [Electronic resource] – Mode of access http://www.mmm.ucar.edu/wrf/users/ – Date of access: 20.11.2013.
3. The Weather Research and Forecasting Model / [Electronic resource] – Mode of access http://www.wrf-model.org/index.php – Date of access: 10.09.2013.

UDC 621.313.333

ELECTRIC DRIVE FED FROM BATTERIES. ANALYSIS AND MODELING OF PROCESSES

STANISLAU VARATNITSKI
Belarusian National Technical University, Belarus

The paper reviews the work of induction motor with three-phase inverter feeds by batteries, which can be used in electric vehicles. Simulation model and transients are presented.

Many manufacturers around the world are investing heavily in the development of electric vehicles, fueled by a steady rise in prices of petroleum products, the need to reduce emissions from the car and the development of energy storage devices, power consumption technologies. The term "electric vehicle", or "electromobile" refers to a vehicle that is driven by one or more electric motors.

This electric motor can be powered by rechargeable batteries, solar batteries or fuel cells. The most widespread construction is electromobile powered by battery. Battery requires regular charging, which can be supplied from external power sources, by recovering the braking energy and from on-board electric generator.

For better representation let's show a kinematic scheme (fig. 1).

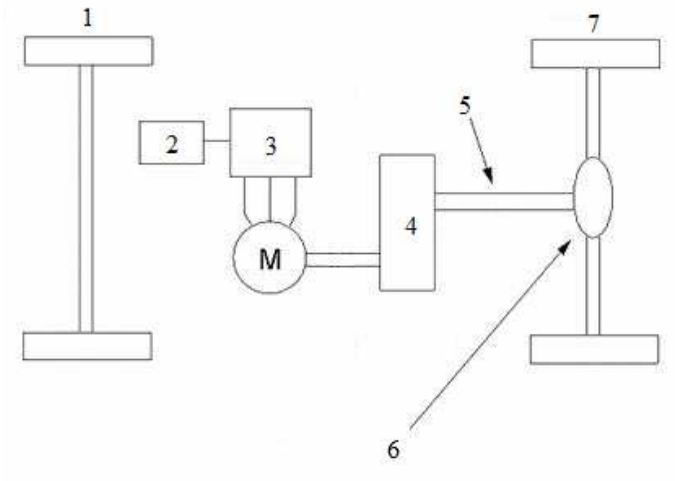

Fig. 1. Kinematic scheme of electric vehicle: 1 – front axle; 2 – batteries; 3 – voltage inverter; M – induction motor; 4 – gearbox or transmission; 5 – main gear; 6 – mechanical differential; 7 – rear axle

As part of this work recuperative braking was reviewed. Graphs that display modes of traction motor were obtained. The next operation mode of traction drive was simulated in the simulation environment Matlab. These modes are:

- acceleration to the rated motor speed;
- work at the rated speed;
- freewheel;
- braking to a low speed;
- low-speed operation;
- final braking.

We are most interested in freewheel mode and braking mode, because they provide energy recovery, i.e. is charging the batteries. Another important factor is the using of pulse-width modulation, which makes working electric drive system to the real conditions.

It was assumed that the selected motor can be installed on a passenger bus MAZ-203. So the engine power 160 kW and synchronous rotation speed 1500 rev/min was adopted according to preliminary calculations [1]. Parameters of the accumulator batteries system were adopted as follows:

Li-ion, nominal voltage 550V, capacity 240 A*h, 100% charge level.

The total voltage of 550 V is obtained from a plurality of cells, each rated voltage of 3.7 V [2]. It is about 149 battery cells. In a subsequent study it is planned to make the calculation and simulation of low voltage induction motor, so that it could be used in passenger vehicles.

But for the bus this choice is justified because the number of batteries will also depend on the electrical energy consumption. And priority will be accounting depending on the distance traveled by electric buses on a single charge.

Let's analyze the work of the resulting model.

This model (Fig. 2) illustrates simulation of a three-phase inverter and discrete three-phase pulse width modulation (PWM) generator. This circuit uses the Battery block of Electricdrivelib™ library [3]. It models a 550 V, 240 Ah Li-ion battery, connected to a Universal bridge. Battery voltage, state of charge (SOC), Motor speed and Motor current signals are available at the output of the block and plotted in Scopes.

The system consists of three-phase PWM voltage source. The Discrete 3-phase PWM Generator block generates pulses for carrier-based PWM converters. Set of three-phase sinusoidal voltages a, b and c is applied to the input of Uref. Time variation for the amplitude, phase and frequency of the fundamental can be pre-programmed. The signal of Phase Locked Loop block is applied to the input of wt. Inverter uses specified power electronic devices are IGBT/Diode pairs [4]. The inverter feeds asynchronous machine (squirrel-cage). All parameters of this motor are calculating in m-file.

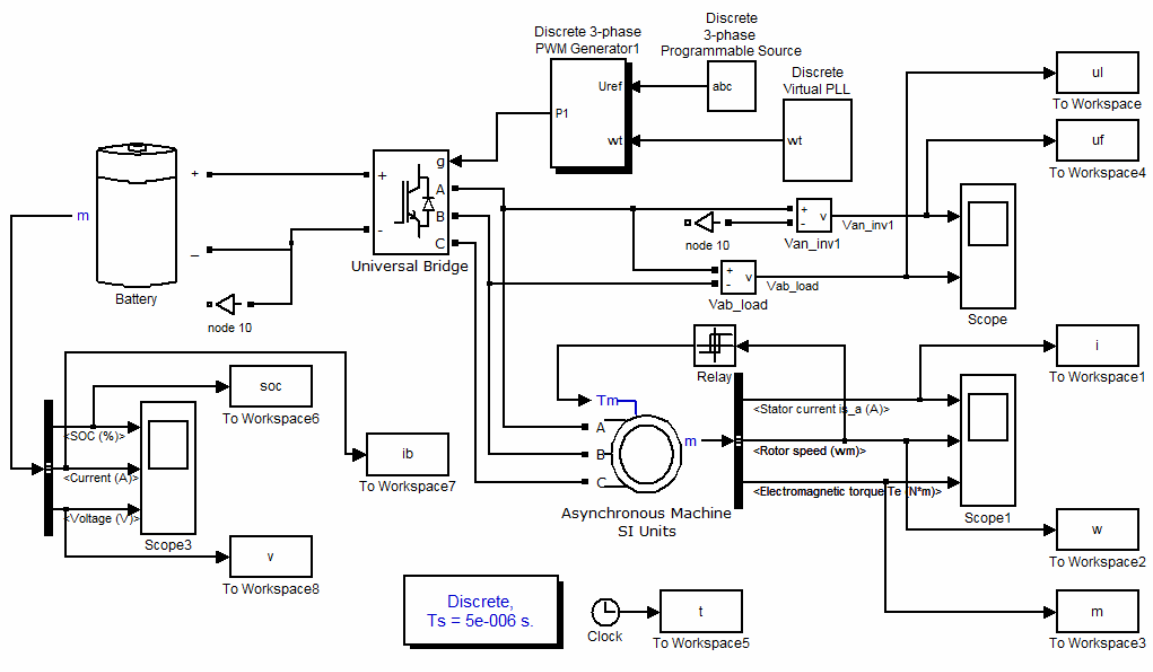

Fig. 2. Three-Phase Three-Level PWM Converter

Demonstration: At t = 0 s the driver pushes the accelerator pedal accelerates the motor to full speed;
At t = 2 s bus moving on the constant speed;
At t = 3 s start the freewheel mode freewheel mode and bus moves inertially until the speed drops by 20%;
At t = 4 s the driver pushes the brake. The motor speed reduce to speed is equal 10 % of nominal;
Followed by work at reduced speed and braking to zero.
The obtained characteristics are shown below (fig. 3, 4, 5, 6, 7, 8, 9).

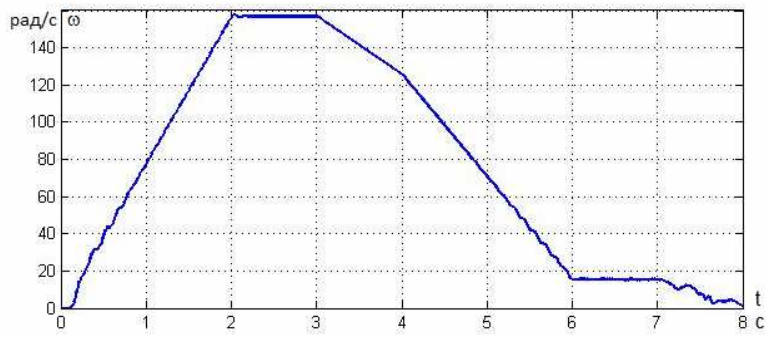

Fig. 3. Motor speed

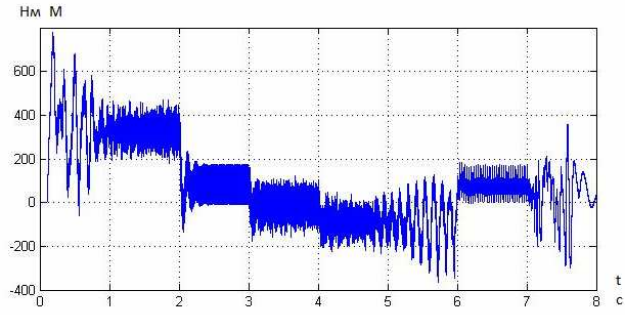

Fig. 4. Motor torque

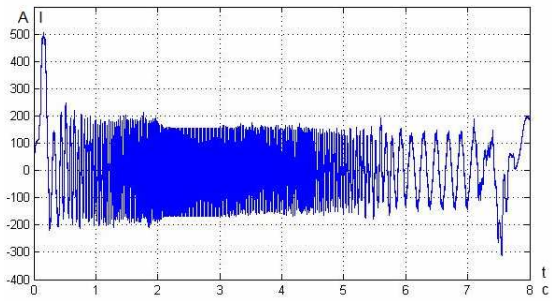

Fig. 5. Stator current during start up

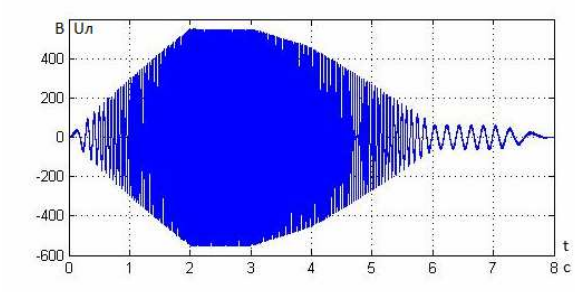

Fig. 6. Line voltage of the motor

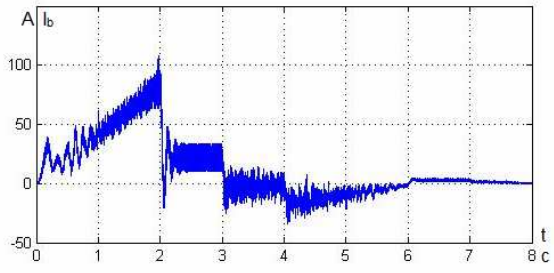

Fig. 7. Battery current

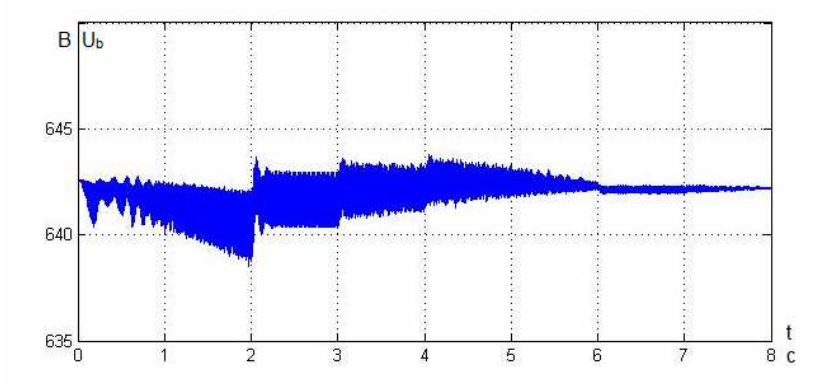

Fig. 8. Battery voltage

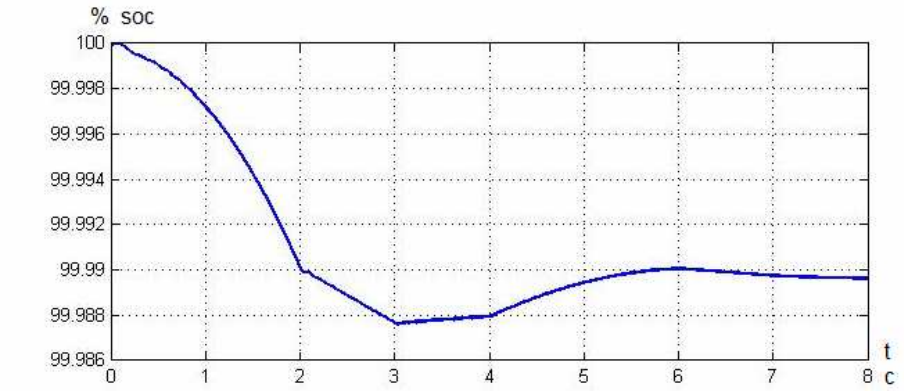

Fig. 9. Battery SOC

Presented simulation model is a suitable tool to study transients of induction motor driven from voltage inverter and accumulator batteries. On the obtained graphs, we can see the change in velocity of the engine, its torque, and most importantly can observe the process of charging the battery at freewheel and braking. Pulsations of torque and speed are due to the fact that scalar model and pulse-width modulation were used.

REFERENCES

1. Фираго, Б.И. Учебно-методическое пособие к курсовому проектированию по теории электропривода для студентов специальности 1-53 01 05 "Автоматизированные электроприводы" / Б.И. Фираго. – Минск : БНТУ, 2005.
2. Shepherd, C.M. Design of Primary and Secondary Cells – Part 2. An equation describing battery discharge / C.M. Shepherd // Journal of Electrochemical Society, – 1965. – Vol. 112. – P. 657 – 664.
3. Tremblay, O.A Generic Battery Model for the Dynamic Simulation of Hybrid Electric Vehicles. Vehicle Power and Propulsion Conference / O. Tremblay; L.-A. Dessaint; A.-I. Dekkiche. – 2007. VPPC 2007. // IEEE. – 9-12 Sept. 2007. – P. 284 – 289.
4. Mohan, N. Power Electronics: Converters, Applications, and Design / N. Mohan, T.M. Undeland and W.P. Robbins. – John Wiley & Sons. Inc., New York, 1995. Section 8.4.1.