2020 INFORINO
Moscow, Russia
14-17 April, 2020

Virtual Laboratory of Electric Motor in the Discipline of "Electrical Engineering and Electronics"

Anton Stoliarov

Authors:

1. A.A. Stoliarov
National Research University "MPEI"
Moscow, Russia
StoliarovAA@mpei.ru

2. V.I. Kiselev
National Research University "MPEI"
Moscow, Russia
KiselevVI@mpei.ru

3. E.V. Kuznetsov
National Research University "MPEI"
Moscow, Russia
kuznetsovev@mpei.ru

Virtual Laboratory of Electric Motor in the Discipline of "Electrical Engineering and Electronics"

For several years, a purposeful work has been carried out at the Department of Diagnostic Information Technologies at the National Research University MPEI to create a set of electronic educational resources for the discipline Electrical Engineering and Electronics for the preparation of bachelors in the non-electrical fields for three institutes:

Institute of Thermal and Nuclear Energy (ITNE);

Institute of Energy Efficiency and Hydrogen Technologies (IEEHT);

Institute of Power Engineering and Mechanics (IPEM).

The discipline's work program includes the section "Electric machines", the study of which provides for laboratory work. At the department there are laboratory stands with electric machines, on which laboratory work is carried out in order to research and study by students the operational properties of electric machines. However, these laboratory stands are expensive, require constant monitoring and repair, and equipment quickly becomes obsolete.

List of designation:

VLW — virtual laboratory work;

EM — electric motor;

DCM — DC motors;

IM — induction motor;

TSM — three-phase synchronous motor;

CM — computer model.

Virtual Laboratory of Electric Motor in the Discipline of "Electrical Engineering and Electronics"

VIRTUAL LABORATORY OF ELECTRIC MOTORS

To improve the quality and effectiveness of the educational process, the Department developed VLW on EM, which provide the following features:

— to conduct experiments that are not possible on a real stand (for example, in emergency conditions or with overloads of EM);

— expand the range of research tasks, conduct experiments that are impossible in the laboratory due to the lack of the required special electrical devices and measuring instruments (for example, fast dynamic processes and unstable modes, experiments with changing the frequency of the supply voltage);

— provide individual work of students and high-quality verification of results;

— automate the processing of experimental information, speed up the experiment and increase its accuracy;

— receive and display on the computer screen in visual form significantly more complete information about the parameters, properties, characteristics and modes of the EM than can be obtained from measuring instruments at the laboratory stand;

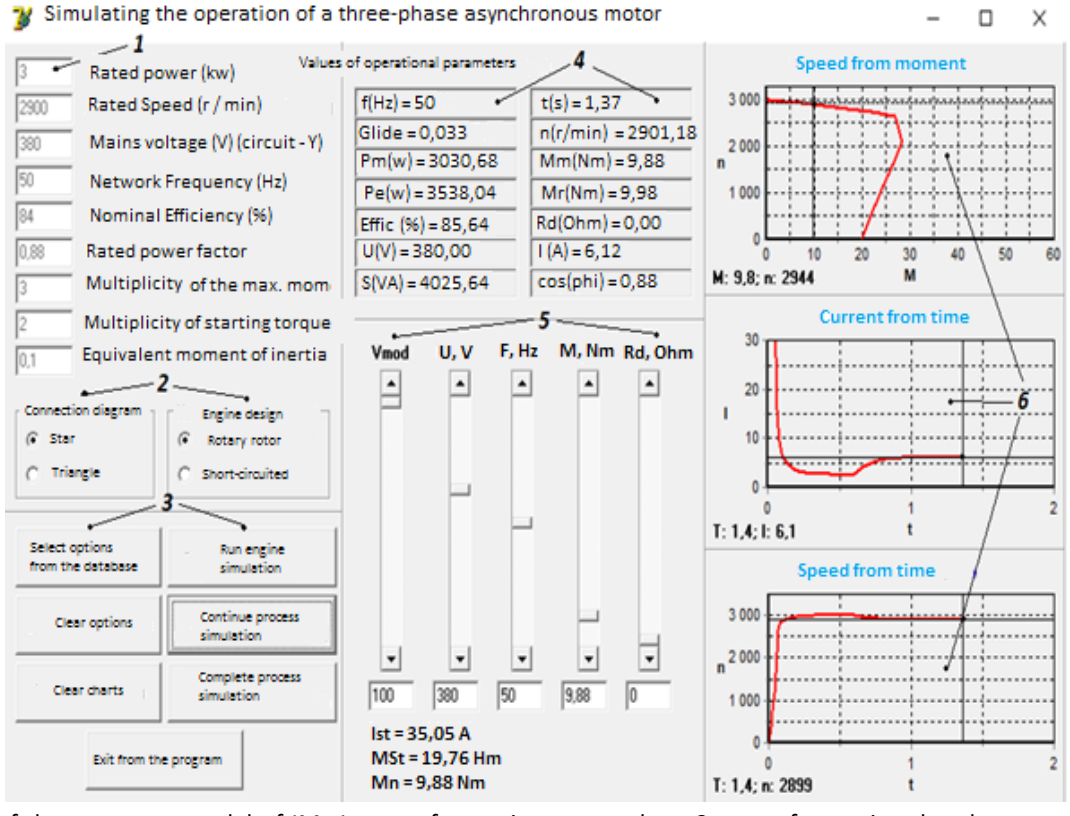
— to promote the student's independent work by providing an alternative research program;

— use modern means of processing information and control results;

— generate a document - an electronic report on the results of laboratory work.

VLW developed by DCM, IM и TSM. Each VLW has two types of software: a modeling program interface and a laboratory work interface.

Virtual Laboratory of Electric Motor in the Discipline of "Electrical Engineering and Electronics"

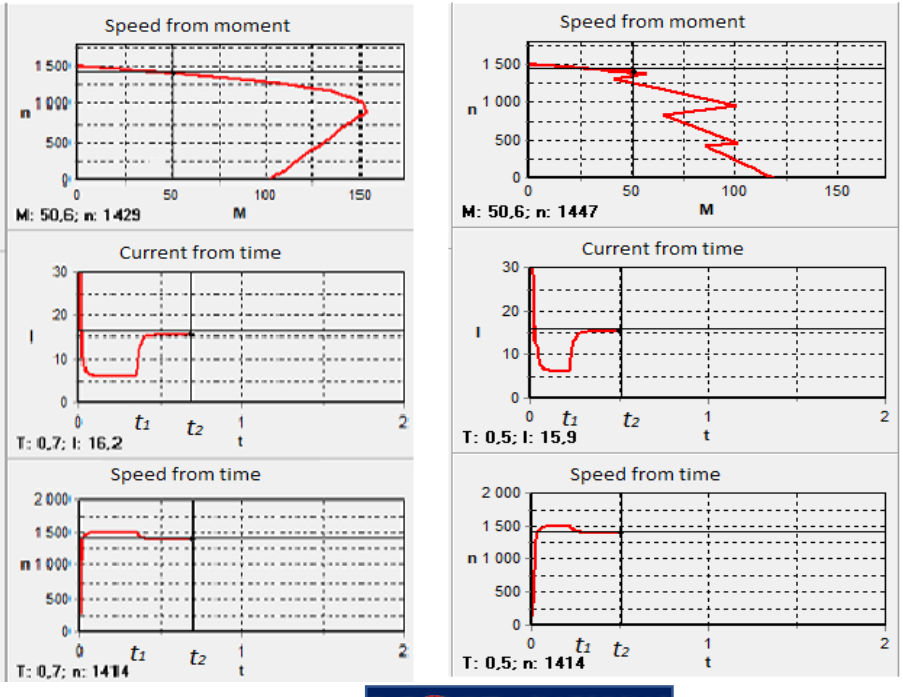


View of the main window of the computer model of IM: 1 - area for setting source data; 2 - area for setting the phase connection diagram of the stator windings and rotor design; 3 - control area; 4 - display area of the current values of the main operating parameters; 5 - area for adjusting operational parameters; 6 - display area of graphical dependencies.

Virtual Laboratory of Electric Motor in the Discipline of "Electrical Engineering and Electronics"

MODELING IM

As an example, left figure and right figure shows the dependency graphs obtained by simulating the starting processes of the IM with a squirrel-cage rotor (left figure) and with a phase rotor (right figure) without load (0-t1), then the motor is loaded with a rated torque (t1 –t2).



Virtual Laboratory of Electric Motor in the Discipline of "Electrical Engineering and Electronics"

COMPUTER MODEL FEATURES

CM allows you to explore the following modes of operation IM:

— Start: direct connection to the electrical network; at low voltage; switching stator windings from a triangle to a star; using a starting rheostat in the phase rotor circuit.

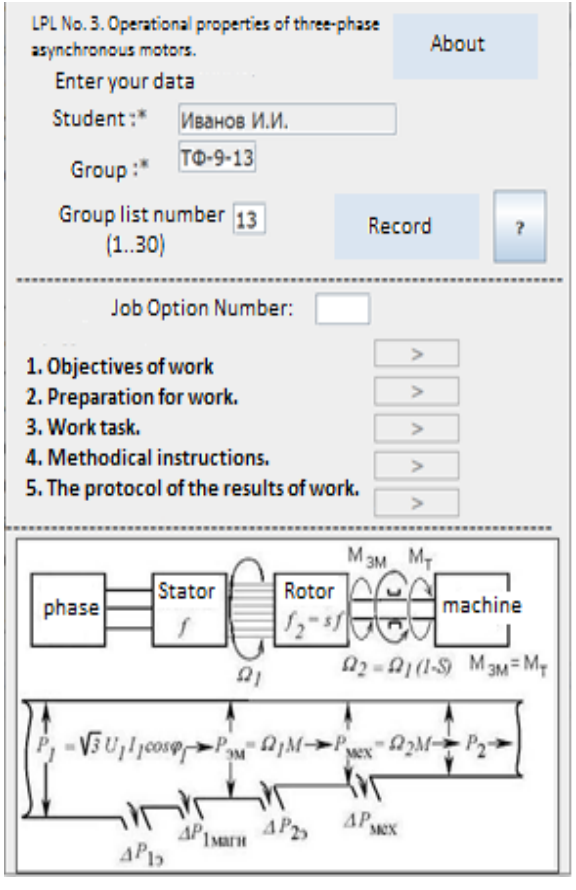
— Changing the moment of resistance on the shaft.

— Speed control: by changing the voltage of the power source; change in voltage frequency; the inclusion of an adjustment resistor in the phase rotor circuit.

State registration certificates received for EM simulation programs.

CM for DCM and TSM are constructed in a similar way and allow to study the main operational properties of EM.

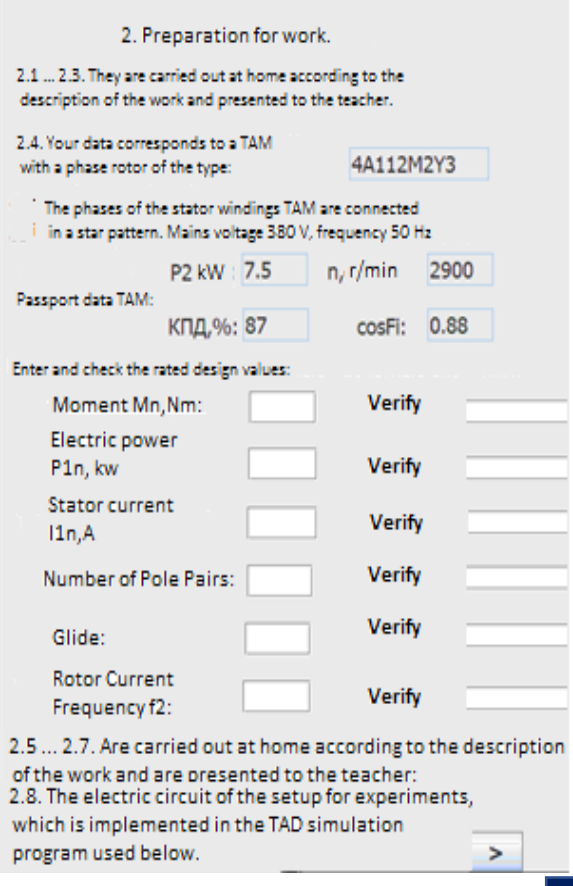
Virtual Laboratory of Electric Motor in the Discipline of "Electrical Engineering and Electronics"



VLW Interface Programs was made in the JAVA 2 language in the Integrated Application Development Environment NetBeans (IDE). They allow you to provide a complete individuality of tasks and independent work of the student.

Each VLW contains: goals of work, preparation for work, work assignment, guidelines for performing work, protocol of results. To go to the corresponding section, press the button to the right of the section name.

Virtual Laboratory of Electric Motor in the Discipline of "Electrical Engineering and Electronics"

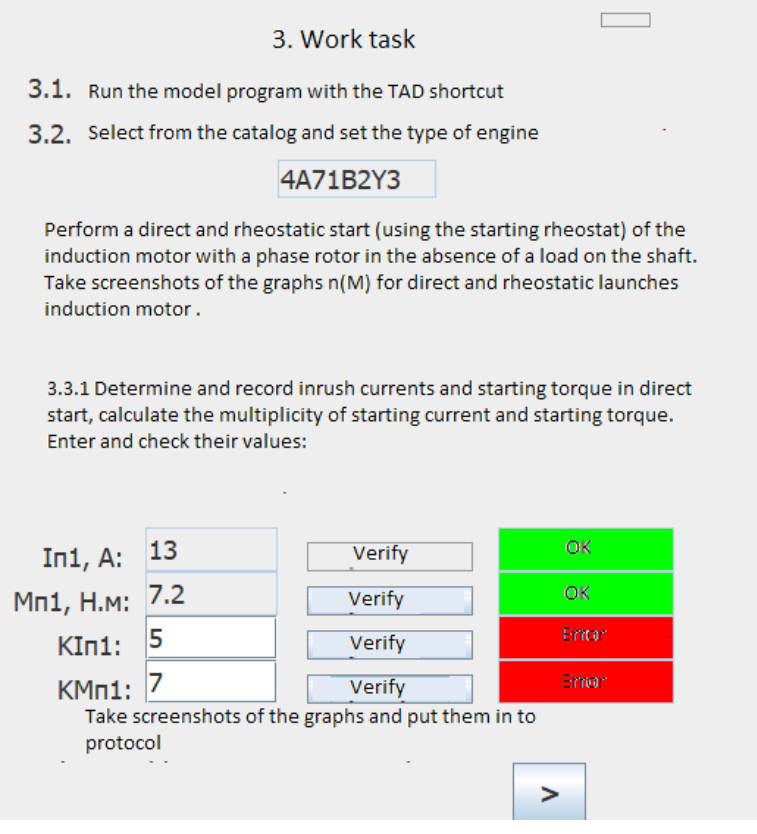


VIRTUAL LABORATORY INTERFACE

PREPARATION FOR WORK

After registration, the student enters, upon request, the calculation results at the homework preparation stage corresponding to the number in the group list and checks their values. According to the result of the check, a comment is displayed (Correctly / Not Correctly). The results of the verification are entered into the protocol of results, which the student can open for viewing.

Virtual Laboratory of Electric Motor in the Discipline of "Electrical Engineering and Electronics"



To carry out the work task, the computer model of the IM is loaded and the motor type is selected from the database corresponding to the option number.

The main points of the work assignment:

- study of the launch of the IM with squirrel-cage and phase rotor;

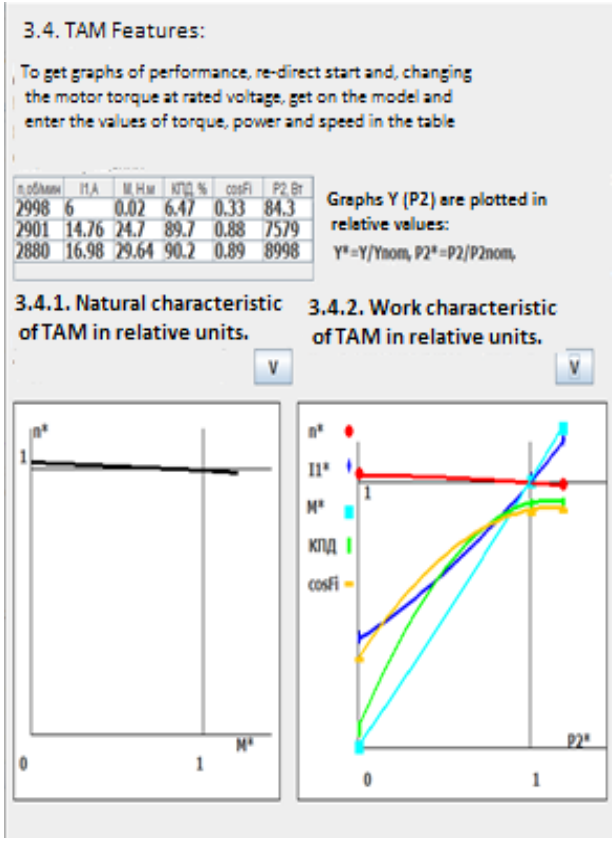
- getting of mechanical and work characteristics;

- the study of ways to control the speed.

The interface for each item of the task provides for the verification of the results of the study of IM.

As an example in figure shows one of the items of the working assignment related to the study of the launch of IM with a squirrel-cage rotor, and in next slide by building a natural mechanical characteristic and work characteristics.

Virtual Laboratory of Electric Motor in the Discipline of "Electrical Engineering and Electronics"



n,об/мин	I1,A	M,Н.м	КПД, %	cosFi	P2, Вт
2998	6	0.02	6.47	0.33	84.3
2901	14.76	24.7	89.7	0.88	7579
2880	16.98	29.64	90.2	0.89	8998

Characteristics are built on the three values of the variables obtained at the CM.

When constructing, the quadratic approximation is applied.

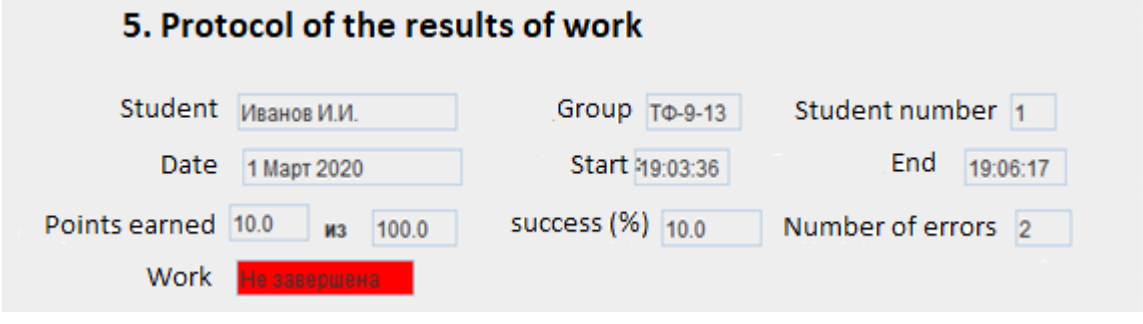
Virtual Laboratory of Electric Motor in the Discipline of "Electrical Engineering and Electronics"

VIRTUAL LABORATORY INTERFACE

PROTOCOL OF WORK RESULTS

Based on the results of the VLW, a results protocol is generated (Fig. 8), which indicates:

- Name of student.
- Group number.
- Date, time of the beginning and end of the work.
- Points received.
- Results:% of correct answers; how many mistakes are made



INFORINO 2020

Moscow, Russia
14-17 April, 2020

Thank you for attention!

Speacker's contacts:

Anton Stoliarov
National Research University "MPEI"
StoliarovAA@mpei.ru

IEEE

NATIONAL RESEARCH UNIVERSITY

CROC