

## Modernization of electric drives laboratory at Kaunas University of Technology (KTU) and new training potential

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### Abstract

*At department of Control Technologies of KTU in order to provide the state of the art courses and laboratories in control technologies, it has been need to renovate and to modernise the Electric Drives Laboratory. This paper describes the modernisation way of the electric drive lab and compares the training potential of the new lab with former one.*

### Keywords

*Laboratory stands, electric drives, power electronics, control systems*

### Introduction

One of the fastest growing areas in engineering and technology are electric drives and their power electronic converters. Modern electric drives enable smarter utilization of electric and electronic systems. Such electric drives, in turn, help create a demand for increased use of electric and electronic systems. Electric drives and their power electronic converters are facilitating electric power transfer systems, which are replacing conventional mechanical, hydraulic and pneumatic power transfer systems. For all these applications, electric drives and their power electronic converters have real and significant potential for improving efficiency, reliability, performance and safety.

Fundamental part of university education creates connection of theoretical approaches with experimental or simulation methods for verification. Illustration of practical physical models is cardinal important for engineering experimental exercises, for comparing the computer simulation tasks with practical experiments and with real-time measured signals from technological aggregates. The improvement of theoretical findings is done by physical experimentation during the education process. The laboratory stands allow easy understanding of the theoretical electric drive principles; therefore big effort should be given for modernisation of electric drives laboratory.

Although many universities currently offer study programs in electric drives and control engineering,

the art of designing new laboratories are lagging far behind the growing industry needs for skilled engineers with hands-on experience. In Lithuania, there are only a couple of universities out of about ten offering the courseware's for electric drives, control systems and machines to undergraduate and graduate level. The department of Control Technologies at Kaunas University of Technology (KTU) keeps updating and modifying the teaching and training courses according to industrial needs.

The department of Control Technologies at KTU was established in 1995 and has a strong foundation for teaching electric drives and control systems to the undergraduate students from the faculty of Electrical Engineering & Control Systems.

The department possesses 6 laboratories equipped with modern electronic equipment and software to perform computer simulation, testing and evaluation of electric drives and control systems. Major equipment includes a programmable logic controller (PLC), a variable speed drive (VSD), an oscilloscope, and software such as: MATLAB and Centaurus. The department is also certificated from Modicon, Wonderware and Rockwell Automation.

At department of Control Technologies in order to provide state of the art courses and laboratories in control technologies, it has been need to renovate and to modernise the Electric Drives Laboratory. Facilities of this laboratory are advanced specialized experimental teaching set-ups for undergraduate students in control technology, electrical engineering, electric power systems and mechatronics programs.

### 1 New laboratory set-up

There have been raised some requirements for the laboratory stands and experiment contents with purpose to set up the new electric drive laboratory. Besides the basic requirements for the laboratory design [1, 2] specific requirements have been tendered:

- ✓ Plotting characteristics of DC and AC electric machines;

- ✓ Experimentation with the four quadrant DC electric drive;
- ✓ Stands with laboratory and industrial frequency converters;
- ✓ Experimentation with servo control unit.

Additional requirements:

- Possibility of manual and programme control of laboratory stands for electric drive characteristic plotting;
- Adequacy of physical laboratory model with real industrial apparatus;
- Minimization of dimensions, noise, power input, etc.;
- High safety requirements;
- Good dynamical responses of output signals (quick reaction);
- Unified input and output electrical signals (0-10 V, 4-20 mA);
- Availability of model function parts and their reasonable price;
- Good possibility of stand connection with computer;
- Experimental verification of theoretical knowledge with purpose to increase the quality of engineering education.

Three well known companies from Germany and Sweden have responded to our call. By running open contest, the German company “hps SystemTechnik” have offered the best prize to our request.

Fully equipped six laboratory stands (hardware and software) have been purchased from the “hps SystemTechnik” for experiments with the four quadrant DC electric drive, laboratory digital and industrial Micromaster frequency converters; for plotting characteristics of DC and AC electric machines; for experimentation with a servo control unit. The brief description of the equipment might be found in [4].

The laboratory experiments allow getting simple practical skills to operate and control the electric drives and power converters. The laboratory manuals provided by “hps SystemTechnik” are designed in a way that helps students to finish their reports during each lab session by simply filling out tables and sketching waveforms.

## 2 Equipment from *hps SystemTechnik*

The company “hps SystemTechnik” [4] since 1971 have been developing training systems in cooperation with universities, technical colleges, institutes and industry. In the wide market of training systems equipment, they are offering the laboratory stands for: Electrical engineering,  
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Electronics, Drive engineering, Control engineering, Power electronics end etc. The brief descriptions of the obtained stands are given in the following subsections.

### 2.1 Four Quadrant Drive stand

Four quadrant drives are used to control the speed of DC machines. The stand is designed in the way allowing clockwise and counter clockwise rotation in motor and generator operation. The control unit of the stand is presented in Fig. 1.

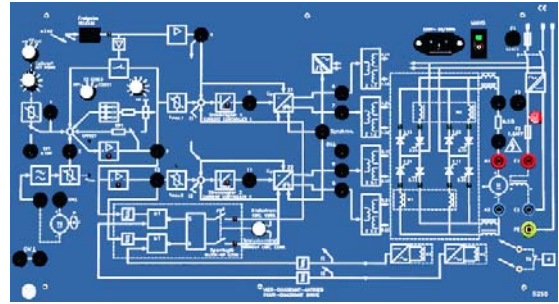


Fig. 1. Four-Quadrant Drive stand

Features:

- Compact construction for fast set-up;
- For machine sets of 100 W ... 1 kW;
- Circulating current and circulating current-free operation, switchable;
- Built-in controllers for current and speed;
- Optical indicator for thyristor switching states;
- Sockets for recording electrical parameters.

### 2.2 Plotting Characteristics of DC and AC Electrical Machines

This is the training system for plotting characteristics of DC and AC electric machines, manually and with PC. The stand assembly for plotting characteristics of electric machines is presented in Fig. 2.

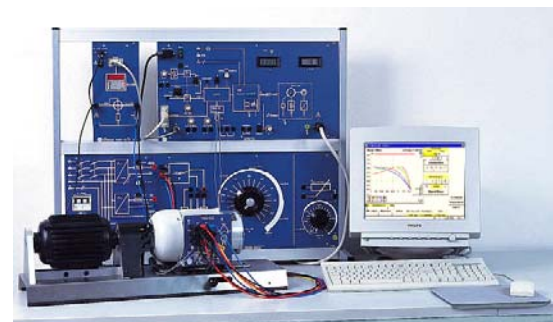


Fig. 2. Experiment assembly for plotting characteristics of electric machines

Main features:

- Measuring speed, torque and shaft output both in electric and generator operation;
- Recording load characteristics;
- Documentation and evaluation of the measuring results according to the recorded load characteristics.

"hps SystemTechnik" offers a modern, newly developed program for plotting characteristics of DC and AC machines. The software is displaying the speed-torque characteristics of motor with different work conditions (Fig. 3).



Fig. 3. Speed-torque characteristics of induction motor

### 2.3 Digital frequency converter

The digital frequency converter is a constant intermediate circuit voltage pulse converter composed of power unit, control block and terminal (Fig. 4). The potentials of the control unit and the power unit are electrically isolated from each other.

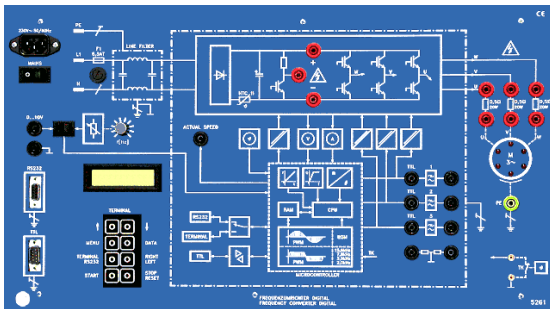


Fig. 4. Control unit of the frequency converter

Features of the stand:

- Designed for three-phase induction electric motors of 100 W ...1 kW;
- Four-quadrant operation;
- Control and parameter assignment of the frequency converter, as well as permanent monitoring and display of the operating state, are executed by the incorporated terminal or an external PC (RS 232 interface);
- Protection against overcurrent, overvoltage and undervoltage, excess temperature, short-circuit and earth fault;

- Simple control and parameter assignment by means of menu-driven terminal program.

The software allows external monitoring and control of the frequency converter (Fig. 5).



Fig. 5. Examples of U/F characteristic

### 2.4 Stand with industrial frequency converter

The control board consist of industrial Micromaster frequency converter produced by SIEMENS. Main functions of the stand are:

- Didactically prepared, EMC-proof connections;
- Sensorless vector control with adaptive electric model;
- Automatic parameter adaptation with loading changes;
- Digital PID control with freely adjustable parameters;
- Programmable input and output functions;
- Extensive protection functions against overload, short circuit and short to earth;
- Integrated brake chopper;
- Computer software with RS 232 interface.

### 2.5 Servo drive with AC servo motor

The teaching objectives of the stand are:

- Parameterisation of servo motors;
- Acquisition of measured servo motor values;
- Optimisation of controllers;
- Programming of positioning drives;

This is attained by special visualization software with following operation and display functions:

- Operation on speed and torque control;
- Positioning;
- Temperature control;
- Current and voltage control.

## 3. Comparison of former and new electric drive laboratories

The former laboratory was equipped by 11 stands that gave possibility of manual electric drive

characteristic investigation [3]. A generator – motor system was applied as a basic converter and a load mechanism for getting speed-torque characteristic of electric machines. Old construction DC voltage converter was used for the motors with capacity about 2kw. A capacity range of the used motors in the old lab was from 1.0 to 10.0kw as the previous laboratory has been designed with purpose: the students in the lab must feel themselves as working at industrial conditions (capacity of motors, noise, industrial measuring devices and industrial control switches).

Capacity of motors in the new laboratory is not exceeding 0.5kw and it lets to save electrical power during the laboratory works. Special safe connecting leads secure students from electrical shock during experiments. The characteristics of the electric drives may be gotten in open loop and closed loop systems.

A block diagram presented in the Fig.6 is general for the every stand of new laboratory.

All the computers in the lab are connected to the local computer network. This lets student to print the results of the experimentations on the laboratory printer. Laboratory network may be extended for the distance education and distance exercises of electric drives.

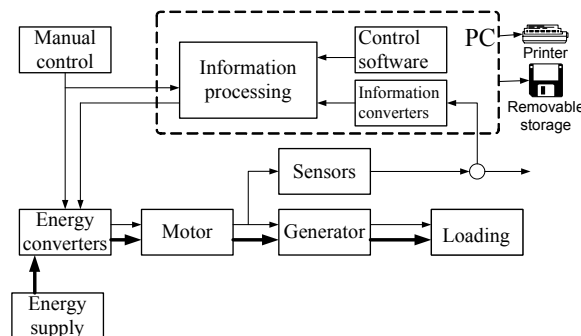


Fig. 6. General block diagram of the stands

The universal laboratory power supply unit from “hps SystemTechnik” provides all the necessary voltages used for the experiments: AC, three – phase AC, fixed and adjustable DC. The adjustable DC voltage source is not stabilised and it vary depending on the load. We see this as the disadvantage or fault of the universal power unit.

Special control units are used as energy converters. Running the experiments, the special brake units and universal power meters with display show all necessary measurements on the displays. In the case the computer is available, the units might be connected through RS232 interface for information transition.

The amount of stands employed in the new laboratory is less than in the old one. It is so because the DC motor with complex excitation is used instead of 3 usual DC motors with independent, serious and complex excitation.

The new four quadrant DC drive laboratory stand replaces two stands used in the former lab i.e. DC voltage converter – motor and the stand for closed loop system investigations.

A former stand used for the motor inertia moment investigation may be replaced by CASPOC modelling software [5]. The simulation package CASPOC is especially designed for simulation of Electrical Drives and Power Electronics .

The new laboratory has the possibility to be used not only as a play ground for the laboratory works of the electric drive course but also as a scientific research field for graduated student. The stands allow performing the investigations not only on the motor blocks but also on the power electronics used in the control units.

#### 4 Conclusions

- There is a strong connection between the laboratory and the lecture. A strong effort must be made to use the laboratory as a practical medium for reinforcing principles taught in lecture.
- Verification of theoretical findings with experimental stands allow easy understanding of aggregated part principles, measurement and control devices, signals character, dynamic responses and easier crossing to the real technological systems.
- As a result of electric drive laboratory modernisation, the new laboratory has additional advantages in compare with former one: electrical energy saving, good work safety, manual and programme control, visualisation of experiment results and distance learning possibility.
- The disadvantage of new laboratory is not stabilised voltage of the “hps SystemTechnik” universal power unit.
- Experiences from practical exercises in new laboratory will better interconnect the theoretical knowledge with practical experiences.

#### References

1. Diberardinis, L.J., Baum, J.S., and etc., *Guidelines for laboratory design: health and safety considerations*. Wiley – Interscience, 2001, 650 p. ISBN:0-471-25447-9
2. Cooper, E.C., *Laboratory design handbook*. CRC Press, 1994, 235 p. ISBN:0 849-38996-8.
3. Masteika, R., *Electrical drive laboratory works*. Kaunas, Technology, 1994, 87p. (In Lithuanian).
4. hps SystemTechnik, (<http://www.hps-systemtechnik.com>)
5. CASPOC: Power Electronics Software (<http://www.caspoc.com>)