LABORATORY WORKBENCH FOR EDUCATIONAL PURPOSES

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Abstract: This work deals with the development and implementation of new laboratory device for laboratory exercises in electric drives. Reasons and requirements for this workbench are evaluated. In the next section a prototype design of laboratory stand is introduced. Finally the possibilities of extending and use in other subjects and applications are given.

Keywords: EEICT, power stage, control unit, driver, electric drives, laboratory stand

1. INTRODUCTION

The problem nowadays is reduction of the amount of practical training. This situation leads to the decrease of general practical knowledge and skills. Low level of knowledge impairs future jobs at companies and industries. For this reason it is necessary to increase volume of practical and laboratory teaching. This is in contradiction with the requirement to reduce the cost of teaching. It follows that to ensure quality teaching in sufficient numbers, demands on teachers and on laboratory equipment must be increased. One possible solution to this problem is the introduction of a parallel teaching in laboratory exercises. In parallel learning is it possible to conduct laboratory work with one teacher and students work individually at identical workplaces.

These facts lead to the development and implementation of a unified workplace for laboratory exercises in large numbers, which must be as universal and cheap as possible. The optimal solution is the following laboratory workbench, which will be presented in this article.

2. REQUIREMENTS OF LABORATORY STAND

Laboratory workplace for educational purposes will be operated mainly by students. This fact leads to the definition of basic workplace requirements. The most important requirement is safety of the device. Due to this a safe voltage level was chosen to supply the laboratory stand. Another requirement is to prevent unauthorized and illegal operations. Unauthorized manipulations could result in damage or complete destruction of a part of the workplace. In laboratory practice, this is often a result of improper handling by students. For this reason, it is necessary that the entire laboratory workbench must be very durable. In the event of damage or failure of any component, it is necessary to replace the faulty part and repair it. These requirements greatly facilitate unification of the laboratory stand. Unification of parts allows simplifying the design of the entire workplace in a compact element and extends variability of device. An example is the use of processor board, which is already used in more applications and projects.

Because it is a workplace to support teaching in laboratories of electric drives, entire device must be made clearly. Students can gain more knowledge and experience in the design of electric drive - electric engine with the inverter and control unit as a whole device. Laboratory stand for support of education must be designed to meet all requirements of laboratory exercises and should work in two basic modes.

- In bachelor's degree program, students discover the basic parameters of electrical machines. Students also perform measurements on a DC motor and design current controller and speed controller. A control panel is used for operation of the laboratory stand.
- In master's degree program, students in addition to previous tasks implement vector control of induction machine. Computer software Freemaster is used for operation of laboratory stand.

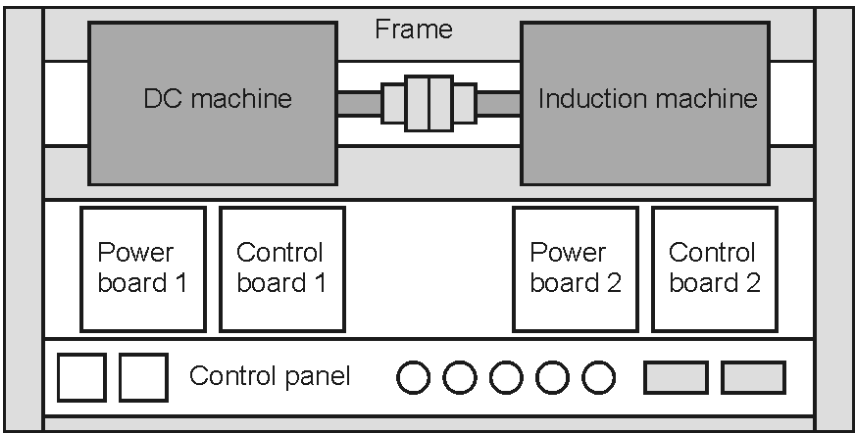

Fig. 1 Block diagram

3. PRACTICAL REALIZATION

This universal workbench is formed by an aluminum frame on which all of the components necessary for the function of the laboratory stand are mounted. There are mainly two machines and boards with power and control electronics. A machine set, consisting of a DC machine and an induction machine, is fixed on the frame. DC machine is designed for 24V with output power of 400W. Induction machine is designed for 3x24V with output power of 180W. The machines are connected by a flexible shaft coupling. A resolver for measuring speed and rotor position is mounted on the shaft of the induction machine. Both machines are supplied from a transistor inverter controlled by Freescale microcontrollers. The DC motor can be replaced by another type of machine which has the same mounting, such as a synchronous motor.

3.1. POWER STAGE

The power part of the laboratory stand is realized by two identical boards. Each board contains DC link capacitors and three-phase inverter from MOS-FET transistors produced by Semikron. For current measurements, the board has two sensors manufactured by LEM. These sensors are mounted in phase A and C of the three-phase inverter. Only one current sensor is used in the power stage which supplies the DC machine. If necessary, a second current sensor can be added. The power board can also be used for other applications. The board is designed for 100V and 80A.

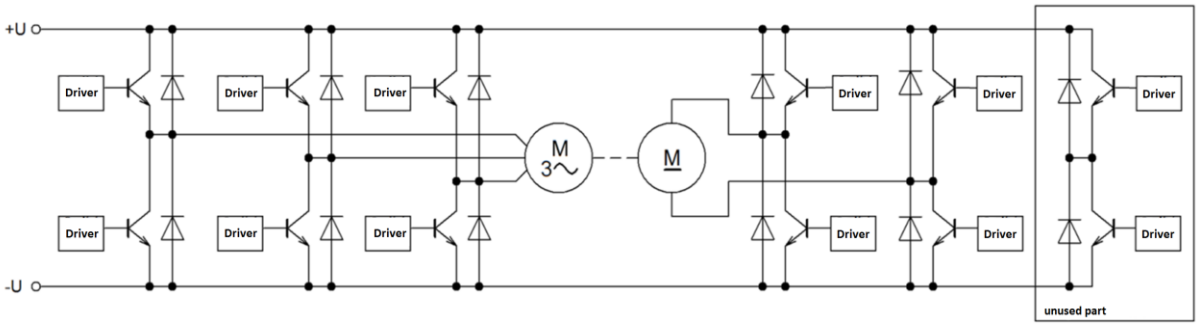

Fig. 2 Power stage

3.2. CONTROL UNIT

The control part is designed to control all the functions of the laboratory stand. It contains all the electronic components needed for proper operation of the entire workplace. Two power boards are used in the laboratory stand – for this reason, it is necessary to use two control units.

The control unit is composed of the following units:

- Processor unit
- Motherboard
- Drivers

Processor board is the main control part of the laboratory stand. The unit provides all the control and regulation commands to achieve the desired functions. The entire laboratory stand comprises a total of two units. Each unit is controlling one power stage, which is connected to the respective machine. The most important component of this unit is a processor produced by Freescale Semiconductor. This is a microcontroller, which includes all the circuits necessary for its operation, such as digital inputs / outputs for processing the buttons and switches installed on the control panel, analog converters and interface for serial communication. A circuit for communication over USB is on this board. A position (speed) signal of engines from resolver, which is installed on the shaft of the induction machine, is also coupled there. The most important part is the PWM outputs for controlling drives. LEDs are connected on PWM output signals for monitoring the activities of these signals, and the operation of the inverter control. For controlling basic functions, three switches are placed on the board. This unit is very versatile and fully programmable due to the design of the processor board.

The motherboard serves as the main interface unit for all board contained in a laboratory stand. It ensures the continuity of all devices that work together. The board produces the required logical dependencies. It includes power circuits for all control circuits and drivers. A circuit for position (speed) sensing from resolver is placed on the motherboard. This unit also provides measurement of analog signals - currents and voltages. To ensure high durability of the entire laboratory stand, there are circuits which can block PWM signals and handle fault signals. Additional circuits are used to evaluate other signals and connect these signals to the input of processor boards. Input and output connectors for communication between two control units, control panel and for encoder output are also located on the motherboard. The processor unit and MOS-FET drivers are mounted on this board.

To ensure transmission of control signals to the transistors, MOS-FET drivers are used. Driver provides galvanic isolation between control and power section. Driver performs switching of the transistor based on the control signals and the protection of the transistor using saturation protection. Driver must be very small, simple and reliable.

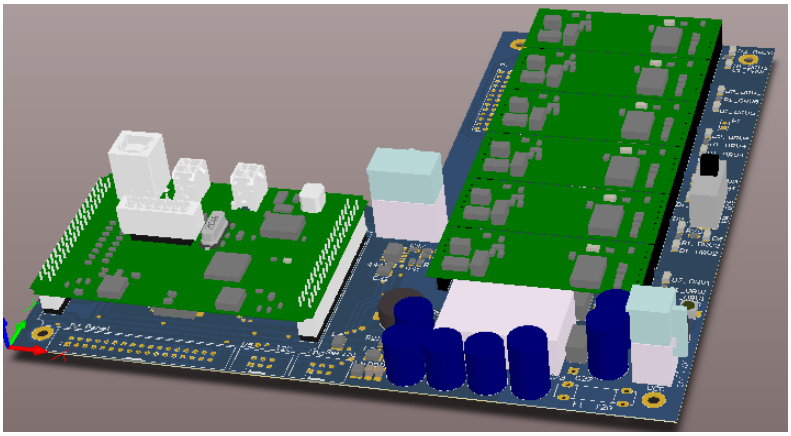

Fig. 3 Control unit

4. OTHER OPTIONS

Workbench for educational purposes can be extended or customized for another application. If necessary, the DC machine can be replaced by a synchronous machine. This modification leads to further laboratory experiments and use in the classroom. Prototype versions of the laboratory workbench will be completed by a control panel. The panel will be used to control the whole laboratory stand using buttons and switches. Analog signals can be entered by potentiometers. A four line alphanumeric display which displays all of the settings and the overall status of the device will placed on the control panel. In the future, the workbench will be completed by a computer using control program with a graphical user interface for easy operation, and which will replace oscilloscope.

Universal design of laboratory workbench allows using some components in other applications. Power stage with the control unit can be used as a compact device in various industrial applications and other projects, which are solved at department of power electrical and electronic engineering.

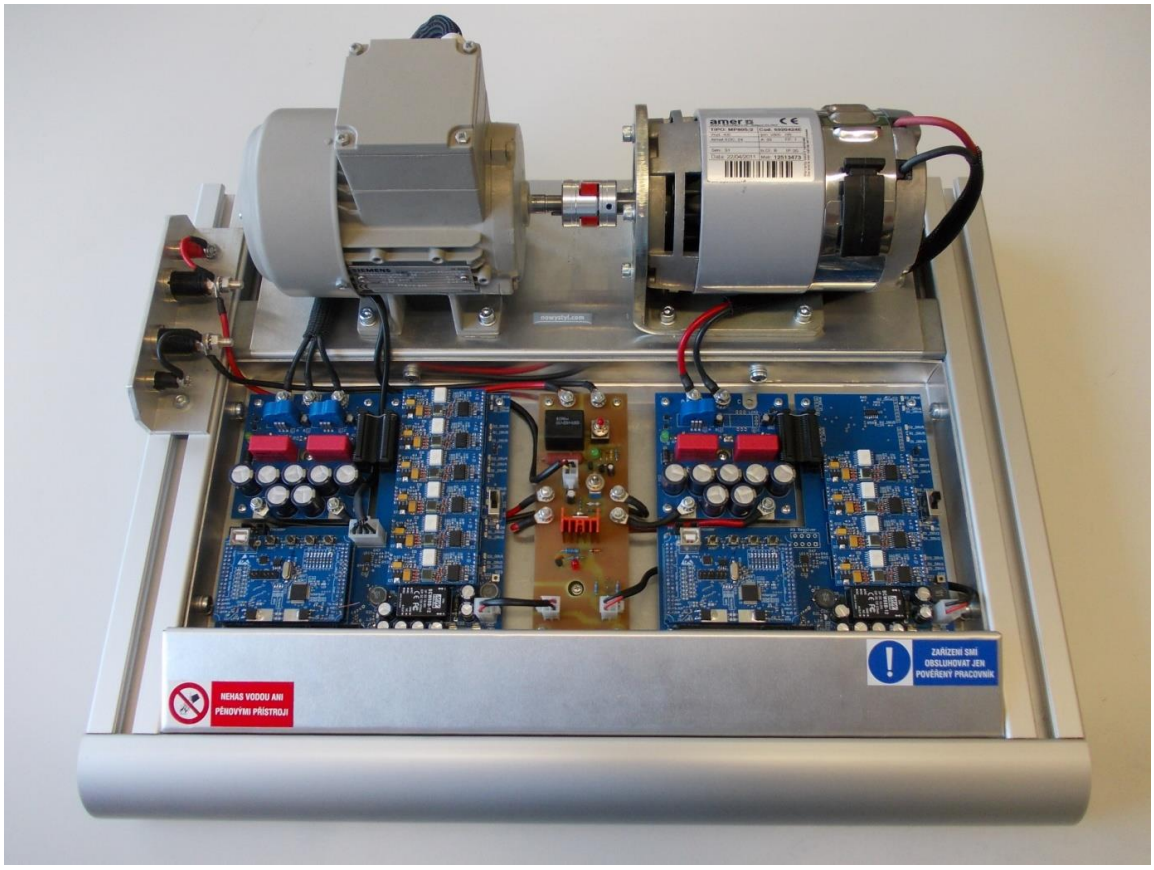

Fig. 4 Laboratory workbench

5. CONCLUSION

This laboratory workbench presents innovation in teaching of electrical drives. The introduction of this device into the laboratory exercises will reduce the cost of teaching. The workbench can be used in other subjects, which is taught at department of power electrical and electronic engineering, for example electrical machines or microprocessor technology. The advantage is the use of one universal device for all applications in the laboratory exercises in electric drives.

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