Student Workshops for Practice-Oriented Education

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1 Introduction

During the last decades great changes have taken place in electrical industry. On the one hand time to market was reduced considerably, on the other hand more and more complex systems have to be developed instead of components. Both of these developments caused changes in the way in which engineers have to perform their jobs and ask for additional skills of engineers.

In education on electrical engineering the requirement of the new skills is not considered at conventional forms of courses. In lectures the subjects of the course are teached by the professor and students are in a passive role, mainly hearing, sometimes asking questions - hopefully. In exercises students are active in solving problems which are related to the subjects they have learned in the lectures. Doing exercises is learning by active doing. But exercises are most effective when done in person or in a small group of two or three people in which everybody shares actively in solving the problem. Thus, exercises should not be performed with division of labour, not in teamwork. After all, at laboratory a group of two or three students has to prepare, to carry out and to record experiments following a predetermined course. At laboratories students practice executing a small project in a small team, but - and this is typical for laboratory - all students are working on the same task the course of which was not planned by them personally but by other people.

When discussing goals of education in electrical engineering with industry and asking for the competencies graduates of universities should be skilled in, two things are most frequently asked for: Profound technical knowledge and ability to work in a team. In order to impart the capacity for teamwork and creativity student workshops have been introduced in the studies of electrical engineering at the University of Paderborn several years ago.

2 Goals and general aspects of student workshops

At student workshops participants have to solve a greater problem and to develop a functioning device or system within a limited time. To keep the limited time the problem is divided into several tasks which are handled by several teams. At the student workshops students shall learn not only technical expertise, but first of all communicative competence and soft skills shall be put across.

Students attaching workshops shall learn the following skills:

- Investigating a problem and partitioning the problem to practical tasks.
- Defining interfaces between the different tasks.
- Solving a special task in a small team of cooperating persons under consideration of the requirements.
  (a) of the whole project and
  (b) of interface definitions.
- Summarizing the results of a task in oral presentations and in a report on the project.

At the Institute of Power Electronics and Electrical Drives of the University of Paderborn several student projects have been carried out at which the following procedure has proved itself.

3 Course of student workshops

Preparations performed by the institute:

- Choice of a problem for the student workshop

  With regard to the interest in gaining students for the institute and other aspects it is convenient to choose topics for student workshops which are close to the research activities of the institute.

  The problem to be solved must be neither too small nor too extensive considering the available time. It must be suitable for partitioning into tasks. Normally for the tasks knowledge from different fields of elec-

trical engineering is required and of special interest are problems at which students of electrical engineering have to cooperate with students from other faculties, e.g. mechanical engineering.

In power electronics or electrical drives normally an apparatus or an experimental system has to be developed which is related to the research activities of the institute and demonstrates relation to industrial practice.

According to our experience the time to be spent by the students for a workshop should be one week of full-time work in the laboratory and additional time for documentation.

- Check of feasibility

  In advance to the student workshop a solution of the problem is realised by the institute to check the technical feasibility and the time required for the development.

  At this stage it is also checked which devices are required for realisation and have to be provided for the workshop. To offer as much flexibility as possible to the participants of the workshop, different components and/or devices should be provided to allow for different solutions of the problem.

  Also relevant literature on the subject of the workshop and on the devices required for realisation of the system is collected.

  When announcing the workshop a limit for the number of participants is advisable: According to our experience at least 12 and not more than 20 students should join a workshop and cooperate in 4 or 5 teams.

Work performed by the students

- Opening of the workshop, course of the first day:
  - At the beginning of the workshop a short introduction on the problem to be solved and to the tools available at the institute is given by the staff of the institute. In accordance with situation at industry a deadline is established at which the development should be finished.
  - Afterwards a period of brain storming takes place. In this period the students collect and discuss different approaches for solving the problem while the personnel of the institute has an observing role.
  - Following is a decision on the approach that shall be realised during the workshop. At this step an intervention of the institute's staff may be necessary because the alternative chosen may be inexpedient or it may require devices which are not available or too expensive.
  - At the next step the project has to be divided in several tasks which shall be solved by different teams. To each team a member of the institute is assigned looking after the students.
  - Subsequently the teams have to be formed.

    This can be done by choice of the students under consideration of the requirements of the tasks and the different capabilities of the people.

    Depending on the tasks to be solved in the workshop it may occur that no special knowledge is required and every student is able to work on each task. In this case the constitution of the teams can be drawn by lot. By doing so each team is expected to consist of a good mixture of students with differing competence. Furthermore the danger of excluding some persons from existing groups is minimised and - just like teamwork in industry - everybody is forced to cooperate with other people whom he or she could not choose.
  - Finally each team starts its special task by developing an outline for the own work. An important part is to debate what interfaces to other tasks have to be considered and have to be defined in cooperation with other teams.
- Daily program during the workshop
  - At the beginning of every day a session takes place at which all teams present the results of the preceding day's work. These sessions are very important with regard to different aspects:

    First, students learn to present their results to other people. Of course, the explanations must be understandable not only for the experts of the own team but for all members of the workshop. Preparing the presentations becomes a special challenge when students of other faculties join the workshop. With regard to the goal of the workshop it is important that not the same student performs all presentations of his team, but every student should do this job at least once.

Second, listeners get information not only on the results that other teams have achieved but also on the problems the other teams had to solve and how they managed the problems. Again multi disciplinary workshops prove to be especially instructive and enriching.

Third, presentations offer an excellent opportunity to recognise interface problems which have to be eliminated afterwards.

From experience emerged that the motivation of the students is encouraged considerably when all the staff of the institute demonstrates interest in the workshop and joins the presentations.

- During the day - and frequently far into the night - the teams are working on their tasks and bilateral meetings are arranged when required.
- At the end of every day the results achieved during the day are summarised for being reported the next morning.

- Last day of workshop

  At the end of the workshop the partial results of the teams have been brought together and the device or system to be developed is finished (or almost finished).

  The result of the workshop is presented by the students at a final presentation the date of which had been fixed at the beginning of the workshop. For the motivation of the students which kept working hard for one week acknowledgement should be shown by all the staff attending the final presentation of the result and a small celebration organised by the institute is a good idea giving great motivation to the students.

- Documentation

  During the week (or two weeks) following the workshop the teams have to record their work and to combine it to a documentation which complies with industrial standards.

4 Examples

Two examples of student workshops shall be reported which differ with regard to the subject of the workshop and the composition of participants: In the workshop on power electronics only students of electrical engineering participated while the workshop on electrical drives was also suited for students of mechanical engineering.

4.1 Student workshop on power electronics, „Development of a Switching-Mode Audio-Amplifier“

At this workshop an audio-amplifier with 100 W rated power and 20 kHz bandwidth had to be developed. The input voltage was established with 40 V DC and the impedance of the loudspeaker was 8 Ω. To make use of knowledge of the lecture on power electronics the amplifier should be of the switching-mode type. 13 students of electrical engineering attended the workshop.

On the first day an introduction of one hour was given by members of the institute. After two hours of brainstorming and conceptual decision making the participants decided to divide the problem into the following tasks:

1. Power electronics stage
   - Calculation of stress quantities of the semiconductor devices by use of MathCad.
   - Determination of the switching losses by calculation and by measurement at an amplifier which had been realized by the institute in advance.
   - Choice of transistors.
   - Design, realisation and test of drive circuits, construction of power stage.
   - Design of cooling system.
   - Documentation.
2. Signal processing
   - Conceptual design of signal processing electronics.
   - Conceptual design of pulse width modulation and control.

- Choice of devices and design of controllers.
- Realisation of interface to CD-player
- Documentation.

3. Filter design
   - Adjustment to the methods of filter design and to use of related tables.
   - Design of different filters and comparison by simulation with MathCad.
   - Realisation of a suitable filter and of magnetic components required.
   - Measuring of the filter by use of an impedance analyser.
   - Documentation.
4. Design of control
   - Measuring of the loudspeaker by use of an impedance analyser.
   - Modelling of power converter and loudspeaker for design of control.
   - Design of control and design of controllers.
   - Simulation of the controlled system.
   - Commissioning of the controllers including design of operational amplifiers.
   - Documentation.

Every morning a meeting of one hour took place at which the results of the preceding days were reported and the further proceeding was discussed.

Every evening all teams met to check problems and to agree what shall be reported the next morning.

At the afternoon of the last day when the amplifier was finished last measurements were done and work places were cleaned up before the final presentation and discussion took place. At this occasion the staff of the institute also asked for criticism and suggestions for improvement. The workshop closed in the evening with a social gathering.

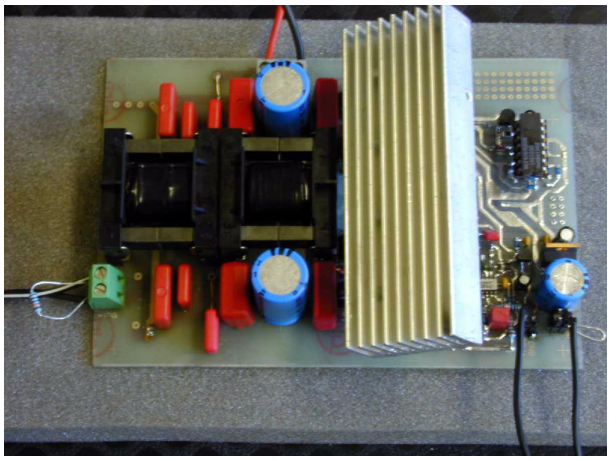

Fig. 1: Switching-mode audio-amplifier

4.2 Student workshop on mechatronics „Conversion of a Model Railway to a Linear Motor Drive“

This workshop was animated by a railway project in which six institutes belonging to three departments of the University of Paderborn are involved, see http://NBP-WWW.upb.de/. The workshop was open for students of electrical and mechanical engineering.

The problem to be solved was to gear the waggons of a model railway with a linear motor. In advance the waggons and rails as well as suitable linear motors and power converters were provided. With regard to expense only one power converter and two stator elements, but permanent magnets for each waggon were bought. The loop was designed such that always at least one waggon is on a stator and can drive the train.

13 students joined the workshop, 5 studying electrical engineering, 4 studying mechanical engineering and 4 studying a combination of mathematics and engineering.

The students formed three teams which had to solve the following tasks:

- Modification of the under-carriage:

  First, the wheel gauge had to be enlarged because the stators of the linear motors were wider than the standardised wheel gauge.

  Second, with regard to the normal forces which are applied by the linear motor the under-carriage was strengthened.
- Modelling and simulation of the system for controller design:

  The mechatronic system was modelled and simulated under consideration of an elastic two-mass system.

Especially at modelling the system the students could profit from the interdisciplinary teamwork: Knowledge from different dispciplines had to be put together.

- Design of measuring and control:

  To achieve smooth acceleration and speed of the train a speed control of the elastic mechanical system had to be implemented by use of a PC-controlled DSP-system.

  Also an underlaid current control had to be established which was implemented in rotor-oriented coordinates. For this purpose the hardware of the power converter could be used.

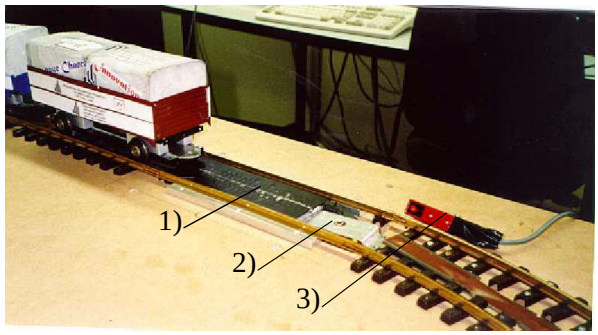

Fig. 2: Linearmotor-driven modell railway
1) stator, 2) bar-code sensor, 3) light barrier

The actual values of speed and position which are required for speed control and orientation of the coordinates were derived from bar-code sensors which were mounted on the tracks and were used to sample signals from grid patterns that were fixed below the waggons.

The control had also to manage the cooperation of the power converter with the two stators of the linear motor. By use of relais the stators are fed alternatingly depending on the position of the train which for this purpose is measured by light barriers.

During the workshop the students had to make use of different software tools for simulation, controller design and realtime implementation of the control algorithms.

When the workshop was finished a well functioning model of railway driven by a linear-motor was created. During the next months it was frequently used to demonstrate the typical features of linear-motor driven railway systems like the capability of climbing steep slopes which will cause slipping with normal railway systems.

Fig. 3: Linearmotor-driven modell railway and participants of worksho

5 Conclusion

Student workshops are very attractive for students because on the one hand they offer a kind of job variation during studies and on the other hand they provide an opportunity to practice an industrial style of working.

For the institute student workshops stand for a lot of work for preparation. But normally the efforts are profitable because students not only gain competences which are not got across at lectures, exercises and laboratories but they also get a lot of motivation causing more interest in their studies and better results at examinations.

For the institute student workshops are ideal opportunities to arouse students' interest in the institute's field of research and a good chance exists that students who have joined a workshop will make their diploma thesis in the same field and in doing so support the research activities of the institute.