EDUCATIONAL IMPACT OF THE IEEE FUTURE ENERGY CHALLENGE STUDENTS COMPETION

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Abstract – Electric motor drive technology is constantly evolving and expanding to new applications. Advanced electric motor drives are capable of an increased performance because of the availability of low cost, high throughput DSP devices capable of monitoring and controlling the motor output. Under conditions of the IEEE Future Energy Challenge students contest, MiniDrive team of undergraduates from School of Electrical Engineering, University of Belgrade has taken on the task of creating innovations in motor that would provide the user with a significant savings in both energy and operating cost through an improved efficiency. This paper presents the educational impact of the contest. Bringing and implementing technical innovations, teamwork and technical documentation, the project made a significant advantage for undergraduate participants, who actually won the contest first prize.

1. INTRODUCTION

Each two years 4 basic *IEEE* sections in the field of Power Engineering make an open call for Competition for all of the Universities throughout the world expecting the students to develop new energy solutions through their work and innovation, but to be aware of manufacturability and practical use of what they bring as a final prototype.

Students World Contest: **Future Energy Challenge** (http://www.energychallenge.org) is organized in order to bring innovations in the field of Energy Science and to attract more and more students to think on the way of saving the energy.

Energy saving is a modern trend in electrical engineering, experiencing a great boom in last decades. Reasons are constant rise of energy prices and awareness of limited energy resources on Earth. Saving electrical energy is of outmost importance since it is the purest form of energy that can be easily converted to any other form. According to some data, electrical drives in the developed world consume between 60% and 70% of all the electric energy produced in these countries. Some of these motors are in houses of each one of us, in our blenders, vacuum cleaners, washing machines, air-conditioners and usually we pass by them without even noticing them. Everyone household has at least one these appliances, so just imagine what amount of energy they consume and what amount of money as well.

The aim was to encourage development of technologies and to bring dramatic improvements to low-cost single-phase motor systems for home use, to incorporate practicality, manufacturability and affordability into competition process, improve education through development of innovative team-based solutions to complex based solutions to problems. The technical goal was to construct adjustable speed motor system costing less than US $40 for a 500 W unit, achieving maximum efficiency and operating requirements while maintaining acceptable levels of performance, reliability, and safety.

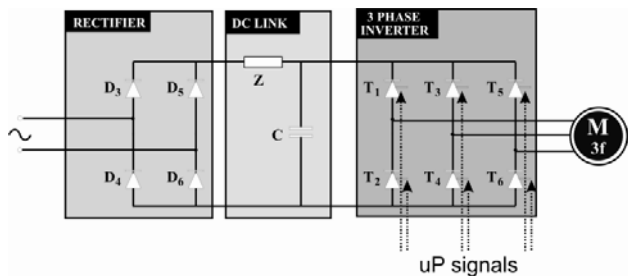


Fig 1. *Typical topology of Digital Control Drive system*

The direct requirement on Students World Contest was to develop a final product - single-phase adjustable speed drive with 500W rated power and 1500rpm rated speed, which would allow continuous speed control in 150-5000 rpm range with efficiency higher than 70%. The **MiniDrive team** was fully developed in Laboratory for Digital Control of Electrical Drives at the Faculty of Electrical Engineering, by undergraduate students from the Power Engineering, Electronics and Automation and Control departments of this faculty. The prototype is based on a three-phase induction motor (Tesla's motor), with complete electronics integrated in the motor box; sensor less control algorithm performed on a low cost RISC microcontroller; digital display for speed and error code information and IrDA communication with a Pocket PC.

2. DEVELOPING THE PROJECT

A vision to make a motor prototype - final product that will satisfy technical requirements set by the organizers, strongly committed us to organize the whole process of leading and managing the group of not so experienced undergraduate students. But on the other hand, very active Laboratory of Digital Control of Electrical Drives, University of Belgrade, inspired us to achieve in our objective, because of lots of successful projects done by graduate students in last 10 years.

The first step of a project was to make an objective or goal in one or two sentences that describe what the project is intended to accomplish. Based on the great experience and lots of documentation we found in the Laboratory, from the very beginning we knew how our final product will look like. Normally, this won't be a problem because we know the general purpose of the project. An objective statement for our project was:

The MiniDrive prototype is an upgraded digitally controlled single phase 500W unit asynchronous motor-drive with innovations in easy control and energy efficiency.

Based on previous practical experience, we knew the topology of our Digital Control Drive System, but in order to meet set requirements, we need to develop, test and implement numerous innovations starting from electronics, communications and power supply.

The basic knowledge gained through the faculty is a good foundation for further designing work. By working on in this International competitive project, students get an opportunity to feel all the phases has to go through in order to reach a solution. At the same spot a number of students from various departments of School of Electrical Engineering are gathered around the same assignment to act as a team.

Each one of the students has his area of work on the project and can realize the necessity of each other member, and understand that without mutual cooperation the goals cannot be reached. By working on a project of this kind, students can present their own creativity and also get the opportunity to improve their knowledge of the particular subject. Since the problems we are dealing with are very up-to-date in electrical engineering, partial project results can be used as a basis for graduation works, as well as for papers for some seminars, conferences or workshops. Another project result is student's introduction to development of all the needed project documentation as well as introduction to writing conference papers because it is something they haven't come up to in the regular course of their studies.

It was important to explain to students that such serious project needs a good strategy, strict *schedule*, implemented measured *quality* and well defined *costs*. This point of view was very new for undergraduate students, so they need to upgrade what they learned during basic studies and implement it on practical project.

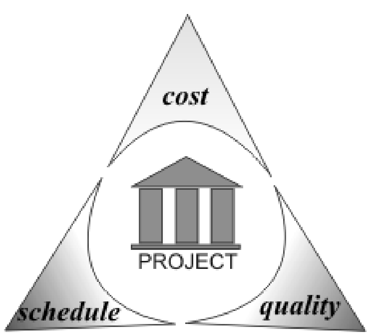


Fig 2. *"Bermuda Triangle" of Projects in Engineering*

3. RUNNING THE PROJECT

The requirements of the Power Electronics Projects are always the same: more efficiency, less expanses and consumption, higher level of communication with other electrical devices, bigger working autonomy of devices etc. Running the project of generating one Power Electronics device, from the beginning to the functional prototype, is not easy at all. It is a process that can take several months, sometimes years, and it takes lots of practical research approaches with the same objective.

After describing the whole process and procedures to achieve the appropriate prototype, it is necessary to divide a project onto less difficult *activities*. If any of these are still too complex to easily organize, it is necessary to break them down also into another level of simpler descriptions, and so on until make them possible to manage everything. Thus our one complex project is organized as a set of simple tasks which together achieve the desired result - a functional prototype.

In planning this project, we were trying to follow the well known simple steps: if an item is too complicated to manage, it becomes a list of simpler items - work breakdown structure. Planning is the act of determining what needs to be done when. The simplest plan is “We will have the project finished by August the 1st.” Unfortunately, unless the project starts after August the 1st, such a “plan” is doomed because, until the completion date, there is no way to tell whether the project is on track.

The MiniDrive project was a great mixture of Power, Electronics, Automation, Programming and Communication, so technically we need to make lots of research in several directions. Decomposition is the process of breaking down an activity into smaller chunks. *Hierarchical* means that the decomposition proceeds top-down by defining the major components of the project, then breaking each component into smaller pieces. The process continues through successively lower levels until the activities are “small enough.” With some practice, this top-down approach ensures that all activities will be identified. The result is the work breakdown structure. Because of that, first we divided the whole project into four big activities:

1. **Simulations and testing**
2. **Hardware research**
3. **Software research**
4. **Marketing with Fund Raising.**

Simulations are used to predict the expected problems and to check functionality of the whole concept, but also to try to set the main principles of control algorithm. So, the drive had to be very precisely modeled, with the least neglects possible, in order to obtain parameters of the control algorithm that would ensure the requirements of the project are met. Simulations bring first preliminary results upon which is possible to make other steps.

Hardware research activity includes process of issues which resulted by original hardware setup that was the basic part of the whole drive system. Hardware research was maybe the most difficult activity, with a lot of separate tasks – subtasks like: generating Auxiliary power Supply, Inverter, DC link, Rectifier and EMI filter, implementing the Power Factor Control (PFC), designing the Control circuit with all the protections, do the termic design... And at the end choosing the components, making the printing electrical circuit and assembling the elements onto the board.

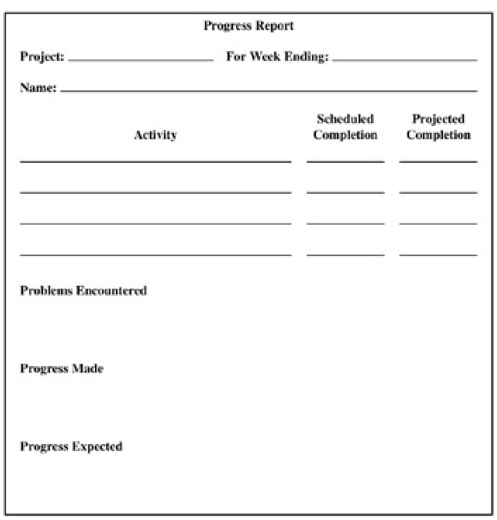
Software research activity mainly includes process of programming the control algorithm, A/D conversion and protection, PWM signals that drive the inverter, communication among devices and necessary protections. But also, there was a great doubt about choosing the right processor, so, apart of programming, members of software group should present advantages and disadvantages of proposed devices in order to make a decision which to use later on.

Marketing with Fund Raising brings a great responsibility in giving publicity to the team and attracting the financial institutions and companies for sponsorships. First step is to make a proper Project Proposal that consists of project goals, principles, rough description and financial plan. An internal system for communication among the entire group is the second step, so, all MiniDrive members can send and accept necessary information about the project: news, tasks progress, eventually changing the plan, questions, technical descriptions…

Running a project is simple: Meet all activity completion dates, and the project is on track; miss one, and you are in trouble. Keeping the project on schedule, therefore, means ensuring that all activities finish on time and that all milestones are met.

Regardless of how we tracked progress, we were trying to keep on some principles that make MiniDrive team more effective, so we were formal. When we wanted to find out how people are doing, we never asked casually and never depend on an oral response. We knew that there is nothing wrong with casual conversation, but when we really want to find out what is happening with the activity progress, there is only one effective way: To ask all team members for a formal weekly status report.

All students/participants on the project needed to fill a weekly progress report, so the progress can be measured. In Fig 3. one example of progress report is presented, where each activity has scheduled and projected completition. Also, each student have to imply encountered problems, expected weekly progress and actual – made progress.


Progress Report

Project: ______________ For Week Ending: ______________

Name: ______________

Activity	Scheduled Completion	Projected Completion

Problems Encountered

Progress Made

Progress Expected

Fig 3. *Example of weekly progress report*

This is very new way of doing the practical projects, although students didn't even think this way, there were plenty of time for practicing. We made sure all team members understood that when they say an activity is complete, it is complete. No further time may be booked against it, no more work may be done on it, its product advances to the next stage of the project.

Gantt charts are useful tools for planning and scheduling projects. It helped us to assess how long the project should take, determine the resources needed, and lay out the order in which tasks need to be carried out. Gantt chart was useful in managing the dependencies between tasks, but also when the project was under way - for monitoring its progress.

Student could see his own role on the project, and how his individual result implement into whole project brings the entire project.

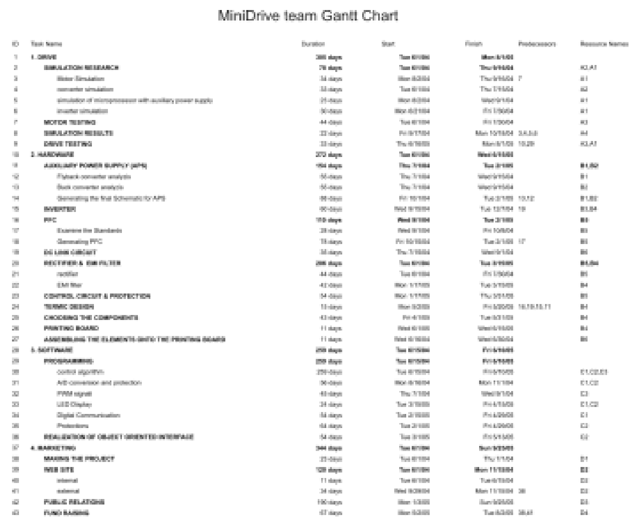


Fig 4. MiniDrive team Gantt chart

So, after several deadlines and required progress reports the final prototype was made. Progress of each of four groups was implemented into final product presented in Fig 5. After several tests and needed modifications almost all requirements given by organizers were met.

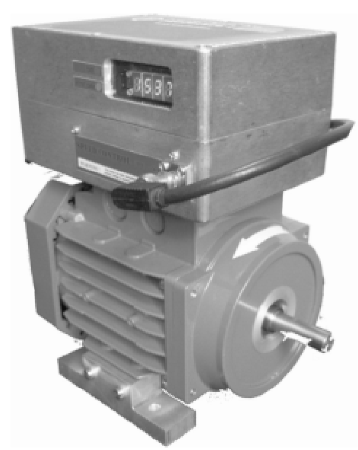


Fig 5. MiniDrive Digital Control prototype

The final step of the project was to calculate the costs, make final project report, generate safety regulations and make users manual. That is valued experience which put students into the users' situation, so now they need to predict what is needed to be written to make an easy use of the product. An example of User Manual is presented in Fig 6.

Fig 6. MiniDrive's User Manual

Projects in electrical engineering are always complex with a multitude of variables. Most application implementations cut across multiple business units, each with their unique business requirements.

4. CONCLUSION

Electric motor drive technology is constantly evolving and expanding to new applications. Advanced electric motor drives are capable of an increased performance because of the availability of low cost, high throughput DSP devices capable of monitoring and controlling the motor output. Under conditions of the IEEE Future Energy Challenge students contest, MiniDrive team of undergraduates from School of Electrical Engineering, University of Belgrade has taken on the task of creating innovations in motor that would provide the user with a significant savings in both energy and operating cost through an improved efficiency. This paper presents the educational impact of the contest. Bringing and implementing technical innovations, teamwork and technical documentation, the project made a significant advantage for undergraduate participants, who actually won the contest first prize.


Belgrade University, Serbia & Montenegro:

Belgrade reaches final stage in the Future Energy Challenge

University of Belgrade Student Branch Mini Drive Team.

EVERY OTHER year, four IEEE societies (Power Electronics, Industry Applications, Power Engineering and Industrial Electronics) run a worldwide Future Energy Challenge drive with characteristics that comply with strict standards. The most important criteria is the production price that should be under US$40.

The competition allows

Fig 7. An article published in IEEE Region 8 Magazine

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